EDITORIAL

Welcome to the first issue of *The International Journal of Agricultural Management*, or IJAM for short.

One way of defining IJAM would be in terms of its origins, combining the strengths and reputations of the *Journal of Farm Management* and the *Journal of International Farm Management.* The former was the British old stager, with more than forty years' service under its belt, wise and experienced but perhaps a little tired. The latter was an energetic youngster by comparison, making good use of new communication technologies and catering much more for the wider community of agricultural and associated professionals across the world. By bringing them together under a new name, the strengths could be built on and the weaknesses minimised to create something bigger and better.

To think merely in these terms would be missing the real point, though. The new journal reflects a determination on the part of its two sponsoring organisations – the Institute of Agricultural Management and the International Farm Management Association – to provide an authoritative reference point for agricultural and rural land managers and associated professions, wherever they operate. The task faced by these professionals is both more critical and more complex than it has ever been, with the requirement for businesses to be sustainable in environmental and social terms, as well as providing a living for their owners and employees in an unpredictable economy. They deserve the best in terms of scientific, economic and technical updating, and we intend to provide just that.

There will be challenges. The target readership includes farmers and farm managers, growers, land managers, environmentalists, consultants, advisers, administrators, educators, researchers, students and those who formulate and/or implement government policy for rural areas. Each group has different needs and interests, and a delicate balance will be needed between learned articles meeting high academic standards (likely to be based on theory and research) and more applied, practice-oriented contributions (though still of high professional standard). Not everyone will appreciate the international sweep of IJAM, as opposed to a single-country orientation, but we hope most will quickly appreciate the enormous benefit of learning from our fellow professionals around the world. Looking 'over the fence' – seeing how others deal with the same problems in different circumstances – is a wonderful stimulus to creativity and innovation in management (*viz* the powerful impact of Nuffield and other travel scholarships over the years).

In preparing this issue we have leaned heavily on the output of the International Farm Management Congress in New Zealand in March 2011, in order to get us off the starting blocks quickly. The Proceedings of the Congress include an abundance of valuable papers deserving a wider audience. First, though, we have introductions to the two sponsoring organisations by two stalwarts of IAgrM and IFMA respectively, Richard Cooksley and Philip James. In the one refereed paper in this issue (there are many more in the pipeline for future issues), Daniel May addresses the issue of innovative capacity in agricultural business, and the factors that influence it in turbulent market conditions. From the IFMA Congress, we have papers on the relative strengths of agricultural sectors in South Africa; adoption of record-keeping by farmers in Ghana (with perhaps some lessons for similar efforts in richer countries); technology transfer in New Zealand; the work of the Canadian Farm Business Council (wouldn't the rest of us like one of those...?); and financial analysis in the USA.

We are keen that IJAM should include a variety of article types (see www.tinyurl.com/64pdky4), including short professional updating pieces. The first of these, by Peter Kettlewell, addresses the economics of using film antitranspirant on wheat. Last but not least, the first of our book reviews, a UK-based text on taxation of diversified farm businesses: not exactly bedtime reading, perhaps, but a valuable reference.

A journal is only as good as its authors, so please take a look at the call for papers. As well as one-off papers in the various categories, we are aiming to produce occasional issues built around a specific theme. Calls are under way for issues relating to internet and social media in agricultural management, and agricultural marketing in a global economy, and we would be glad to hear further proposals, via editor.ijam@gmail.com.

I would finally like to pay tribute to the other members of the Editorial team, John Gardner (NZ) and Carl Atkin (UK) who have played a vital part in developing the new journal, and who have provided constructive criticism and reassurance at the appropriate moments. We are delighted at the quantity and quality of offers to serve on the Editorial Board (see www.tinyurl.com/5w3kjus), and are grateful to its members for both the prestige they lend the Journal, and their willingness to advise and to review contributed articles.

Martyn Warren

1

ORGANISATIONAL PROFILE

The Institute of Agricultural Management (IAgrM)

RICHARD COOKSLEY[1]

Background

The Institute of Agricultural Management is one of the two organisations which are working together to bring you the new International Journal of Agriculturaral Management. The Institute originally started as the Farm Management Association in 1965, following an idea which came from a suggestion at the 1963 Oxford Farming Conference for a need for a professional farm management body.

Milestones in the Development of IAgrM

- 1963: Derek Pearce (when Chairman of the Oxford Farming Conference) suggested the need for a professional farm management body;
- 1963: Bob Starling wrote to 20 leading farm managers suggesting the formation of a Farm Management Association;
- 1964: Meeting in Mitre Hotel, Oxford (during Oxford Farming Conference), which appointed a steering committee;
- 1965: Inaugural Meeting of the 'Farm Management Association' in the Café Royal, London on the 6th April;
- 1965: First National Conference which was held in Harrogate with the title of 'The Outlook';
- 1967: The first issue of the journal '*Farm Management'* was published;
- 1971: The Farm Management Association was instrumental in the formation of the International Farm Management Association (IFMA);
- 1971: First IFMA Congress staged at Warwick University by Farm Management Association members;
- 1978: The Farm Management Association became a 'special interest group' of The British Institute of Management and was renamed the 'Centre of Management in Agriculture' (CMA);
- 1987: CMA became independent of the British Institute of Management;
- 1992: The 'Institute of Agricultural Management' was formed within the Centre of Management in Agriculture;
- 1995: The Institute of Agricultural Management became the parent body, containing the Centre of Management in Agriculture;
- 2004: The Institute held its 40th annual National Farm Management Conference and celebrated its 40th year;
- 2010: A new grade of 'Professional' member of the Institute was formed;
- 2011: After publishing the 'Farm Management Journal' since 1967 the Institute joins with the International Farm Management Association to publish the International Journal of Agricultural Management.

The Institute today

The Institute is the management organisation for those engaged in farm management in the UK and is funded almost entirely by membership subscriptions. It runs the Annual National Farm Management Conference and organises a number of other events including a National Farm Visit. Until 2011 IAgrM has published the Journal of Farm Management four times a year since 1967, and periodically produces publications of management interest such as the biannual Farm Managers Survey 'Their Jobs and Their Pay'.

As well as the national organisation there is a number of local branches, each with its own programme of meetings and farm visits.

The Objectives of the Institute of Agricultural Management are:

- To promote high standards in the business and practice of management in Agriculture;
- To promote training in management understanding, skills and experience;
- To encourage the provision and attainment of professional qualifications in the principles and practice of agricultural management.

The Institute fulfils these objectives by:

- Being a focal point for those who work in agricultural management;
- Promoting the status of Farm Management as a profession;

[1] Director, Institute of Agricultural Management

- Publishing a quarterly journal and other management literature;
- Holding conferences, workshops and farm visits;
- Providing information on management and ancillary courses available in agriculture and associated industries;
- Encouraging local discussion and contact through a network of local branches;
- Co-operating with any other organisation and/or sectors of the economy to enhance farm management generally;

IAgrM and the Future:

Agriculture and the requirements of those who work within the industry continue to change and IAgrM will continue to develop and adapt to the needs of its members.

The membership of IAgrM is unique in the UK, and possibly in Europe, covering virtually all areas of management within agriculture and related industries. As well as farmers, farm managers, students and others engaged directly in management in agriculture and associated rural businesses, persons in other groups associated with management in agriculture in its widest sense, such as consultants, advisors, academics research workers etc are also welcome to apply for membership.

A new grade of Professional Member (P.Agric) has been formed, a formal recognition of professionalism within agriculture and the rural sector, providing accreditation of members' competency. This grade of membership requires provision of ongoing confirmation of continuing professional development by submission of CPD (Continuing Professional Development) records.

For further information on membership and other IAgrM activities please contact the IAgrM offices at: IAgrM, Portbury House, Sheepway, Portbury, Bristol, BS20 7TE, UK. email: enquiries@iagrm.org.uk, url: Website: www.iagrm.org.uk

About the author

Richard Cooksley originally trained as an electrical engineer but made the change from engineer to general management. He has some 35 years' knowledge of the agricultural, animal feed manufacturing, feed materials processing, biomass and storage industry within the UK and overseas having held a number of senior rôles.

He is Director of the Institute of Agricultural Management, Board Member of the Society for the Environment and provides a secretariat service for the Bristol Corn & Feed Trade Association and BIAC (British Institute of Agricultural Consultants). He has a number of interests outside the industry, one of which is giant onion growing and another is being a member of the Portishead International Ski Team.

ORGANISATIONAL PROFILE

The International Farm Management Association (IFMA)

PHILIP JAMES

Origins, Ethos and History

The IFMA has its roots in the upsurge in Farm Management interest in the 1950's, particularly in the USA and Western Europe. Prior to that time the interest in agriculture had been in the maximum production of crop and livestock products to relieve food shortages, almost irrespective of the economics of that production.

During the 1950's the pendulum swung towards the sustainable economic production of food, and new methodology was developed, principally in the USA and Europe to support the economic aims of farmers. The UK was at the forefront of this new thinking, and in addition to developing new aids for the industry, voluntarily set up a Farm Management Association (FMA) to discuss agricultural management, and the new developments of the time. Crucially the FMA was open to all; farmers, extension workers, scientists and academics, the agricultural industry suppliers and Government agencies. So, amongst other things, the FMA had a 3 day conference each year, to review the national and international agricultural scene, to pick up the latest management developments and to receive farmer's reports of their management experiences. These conferences were well attended and highly prized by participants throughout the spectrum of the farming industry.

By the early 1970's, the FMA was sufficiently confident in its ability to mount major conferences for its Council to suggest the staging of an International Congress in the UK. It would include high profile international speakers from International organisations and National governments, prominent advisors/academics to expound on their management approaches and techniques in a small group format, much informal discussion, and crucially, visits to see a variety of farming enterprises in the locality. An extensive social programme was also a high priority. Everyone who came was accorded equal status. Thus, the First International Farm Management Congress was held at Warwick University, England in July 1971, with over 300 participants.

The format for the Congress (which has endured to this day), was:

Day 1: Plenary sessions with international and national speakers
Day 2: Farm visits in small groups by coach, with a wide range of options.
Day 3: Group sessions on topical farm management techniques / developments.
Day 4: More group sessions plus half day of visits to agribusiness locations.
Day 5: Wind up plenary sessions on national & international issues.

Amongst this general format, most future Congress programmes provided space for a review of the national farming scene and national farm policy. There were receptions to civic and other functions, a formal banquet, and opening and closing ceremonies. An additional programme for accompanying persons, additional to the farm visits was also a necessary part of the Congress. Finally, at each Congress there was a General Meeting of IFMA which was open to all.

The first Congress was considered a success by most, and in the UK we thought that this was the end of the matter. However others thought differently, and the Canadians, principally from Ontario, offered to stage the next Congress at Guelph University in 1974. During this Congress participants thought that it would be beneficial to have an international organisation to arrange further Congresses and provide contacts with those interested in farm management in different countries. Accordingly a short meeting was convened and an executive committee elected, with the remit to arrange future Congresses and promote interest in farm management around the world. The Executive Committee elected were :-

Chairman:	Frank Paton, UK
Vice Chairman:	Kenneth Lantz, Canada
Secretary /Treasurer:	Philip James, UK

A brief constitution was drawn up setting out IFMA objectives, membership arrangements, and the organisation of the association, including election procedures, and meetings. Expressions of interest for future Congresses were sought from participants and after considerable activity by the Executive and others; Hamburg in Germany was selected for the 3rd Congress in 1977. Thereafter, Congress venues were sought, or emerged as a result of known contacts and dialogue with participants of previous congresses.

Past congresses

To date 18 Congresses have been held in almost every continent. Their dates and location are as follows:

1st	1971	United Kingdom: Warwick University. *The inaugural farm management congress*.
2nd	1974	Canada: University of Guelph, *Emerging issues for farm managers*.
3rd	1977	Germany: Hamburg Congress Centre (no specific theme).
4th	1980	Israel: Moshav Shoresh, Jerusalem. *The role of agriculture in society.*
5th	1983	Kenya: Kenyatta International Conference Centre, Nairobi. The role of farm management in food production.
6th	1986	USA: Hyatt Regency Hotel, Minneapolis. *Farm management in practice – Managing future food systems.*
7th	1988	Denmark: Bella Centre, Copenhagen. *Farm management in practice – the challenge of change.*
8th	1991	New Zealand, Palmerston North and Christchurch. (no specific theme).
9th	1993	Hungary: Hotel Agro, Budapest. (no specific theme).
10th	1995	United Kingdom: University of Reading. *The World of Farm Management – An International Exchange.*
11th	1997	Canada: University of Alberta, Calgary. *Managing into the 21st Century.*
12th	1999	South Africa: Holiday Inn, Durban. *Think globally, farm locally.*
13th	2002	The Netherlands: Papendal Sports Centre, Arnhem. *Feed the world - Please the consumer - Maintain the environment.*
14th	2003	Australia: Burswood Convention Centre, Perth. *Farming at the Edge.*
15th	2005	Brazil: Royal Palm Plaza Hotel, Campinas. *Developing entrepreneurship abilities to feed the world in a sustainable way.*
16th	2007	Ireland: Cork University College. *A vibrant rural economy – The challenge for balance.*
17th	2009	USA: Illinois State University, Bloomington/Normal, Illinois. *Agriculture: Food, Fibre and Energy for the future.*
18th	2011	New Zealand: Methven Resort Hotel, Methven, Canterbury, South Island. *Thriving in a Global Market: Innovation, Co-operation and Leadership*

Although the basic format for the Congress program was established from the very first, various refinements have taken place over the years, according to the wishes of individual Congress organisers and the reactions of participants. Principal amongst these was the introduction and inclusion of contributed papers of both intellectual merit and/or practical hands–on farming experience, which was introduced for the New Zealand Congress of 1991. Other countries have added their own particular flavour either to the programme content or the 'farm' visits. Similarly the accompanying persons' programme has been subject to variation, as for example in Hungary in 1993, when participants cooked goulash in some of the best Budapest hotels.

Organisation and Funding

Very early on a network of continental representatives, interested in farm management, was identified to assist the Executive in the selection of speakers, potential Congress venues and to encourage potential participants to future Congresses. These persons formed the first Council, and their representation was confirmed at informal regional meetings held during each Congress. Over time this representation was subject to more formal election procedures by those attending from particular regions. A more detailed constitution was prepared and eventually ratified in 1999, and further minor revisions followed. The latest version was approved in 2009.

Funding of IFMA was particularly difficult in the early years and relied heavily on sponsorship arrangements by the host countries and personal contacts of the Executive Committee members. Personal subscription to IFMA were tried in the early years, and apart from some support in Illinois USA, met with little success. The numerous currencies and the expense of converting small amounts into £ sterling, made the operation unviable, and the Association carried on with practically no funds for several years. Some Congresses donated surplus balances to the Association, but it was not until the 10th and 11th Congresses in the UK and Canada respectively that the Association had any significant reserves. Even then these were not sufficient to support necessary Executive travel to potential host countries to firm up the Congress arrangements. Subsequently the Irish organisers of the 16th Congress provided much-needed additional funds, and following the high attendance at the 18th Congress in New Zealand funding should be further sustained .

The 10th Congress in the UK in 1995 provided the first significant funds for IFMA, the money having been voted by the British Organising Committee of the Institute of Agricultural Management. The Canadian Organisers of the Calgary Congress in 2007 augmented these funds, so that it was then possible to provide a pump priming loan of £5,000 ($7,780[1]) to future Congress Organisers. This proved hugely beneficial to those willing to host a Congress and is still being made available.

The advent of the ifmaonline.org website enabled a viable Membership Plan (Scheme) to be launched using a secure online payment system to encourage members to join and renew their membership at anytime.

The Journal of International Farm Management

A Journal of International Farm Management was envisaged very early in the development of the Association. Several papers were commissioned at nil cost, and 2 volumes of the journal were produced. However the logistics of posting these issues to an international audience, which was in a continuous stage of fluctuation, and receiving the appropriate subscription for the journal, proved insuperable for the meagre staff resources of IFMA. It was not until the internet came

[1] Approximate currency conversion as at November 1995

along, and a website was produced that the worthwhile production of the journal became a reality in 2005. It also required the activities of a dedicated editor to make this happen – a role which John Gardner in New Zealand has filled admirably.

Personalities

Although in all organisations personalities change over time, IFMA has been fortunate in the stability of key members. Initially, in 1974 Frank Paton, a practising UK farmer, and Philip James, a UK Government agricultural management advisor were appointed as President and Secretary/Treasurer. They stayed together in these key posts until 1991 when Frank Paton's ill health prevented him attending the New Zealand Congress. Frank was succeeded by Malcolm Stansfield of Reading University, England, who had also been a practising farms manager. When Malcolm retired at the 16 Congress in Ireland in 2007, he was succeeded by John Alliston, the Dean of Agriculture at the Royal Agricultural College, England.

Philip James remained as Secretary/Treasurer of IFMA up to the 14th Congress in Perth, Western Australia in 2003 – almost 30 years since the first Congress in the UK. His position as a Farm Management Advisor in Reading and London had resulted in may fruitful contacts around the world, which were especially beneficial to IFMA. His retirement brought Tony King onto the scene as Secretary and Treasurer. Tony's arrival coincided with the upsurge in World Wide Web interest and usage, which he has made full use of, both to convey Congress, Journal and subscription information around the world, but also to put IFMA firmly on the Internet map. His efforts will hopefully attract a wider audience to the excellent Congresses, and also improve IFMA finances so that more can be done to develop farm management activity around the world.

Vice Presidents have always been important to IFMA. The first, Ken Lantz of Ontario, Canada, provided much dynamic support and sound advice to an infant organisation. He was later joined by Joel Muasya, from Kenya's Ministry of Agriculture, who added a further dimension to IFMA. Ken Lantz was succeeded by Rusty Firth of New Zealand, and Joel Muasya by Dan Smith of the USA. Rusty and Dan, both experienced Farm Management practitioners, brought insights into the farm problems of grassland farmers in New Zealand and the small farmers of S. Carolina, USA, in addition to their wide contacts. Rusty was followed by Rob Napier of New South Wales, Australia – a widely travelled management advisor and teacher, adding yet another dimension to the expertise within IFMA. More recently Dan Smith was succeeded by Jim McGrann (Texas A&M in 2007) and has been followed by Damona Doye (Oklahoma State Uni. in 2011)

Council members were also widely drawn. The objective was, and is, to have active members on each continent, who would promote both the ethos of IFMA and future Congresses within their own areas. IFMA has been well served over the years by Council members, several of whom have staged a Congress in their own country.

The Future

Thirty five years ago the organisers of the first Farm Management Congress could have had no idea that the arrangements and format developed then would have survived virtually intact for 18 Congresses which have spanned the globe. It is a tribute to the original planners, and those who have carried on since then, that IFMA remains such a highly regarded organisation, well respected around the world. Now that the financing is improving, there is no reason why IFMA should not enjoy similar success for the next 35 years.

About the author

After studying at Seale Hayne College, Philip James (p.james92@btinternet.com) joined the Norfolk Agricultural Committee as District Officer in North Norfolk; then progressed into Government Advisory Services NAAS and ADAS, serving in the Eastern Counties, South-East England and London. Original interest in crops resulted in many experiments & trials, including publications of nutrient needs of Lucerne, and its use as a dried product primarily for carotene. Moved into Farm Management Advisory work in 1963, and developed Small Farmer (Business Management) Scheme, Gross Margins and other Business Management Systems for use in advisory work. Staged a national series of Computers in Agriculture demonstrations in the early '80's, and when Senior Business Management Advisor in London, played a large part in the farm management side of the (then new) Environmentally Sensitive Areas (ESA's).

Retired from ADAS in 1987, becoming part-time Director of The Institute of Agricultural Management (formerly known as FMA and then CMA) until 1999, when honoured with their Farm Management Award. Following First International Farm Management Congress in Warwick in 1971, became Secretary of the International Farm Management Association in 1974, handing over in 2003 to Tony King.

Philip lives with his wife Marion near Reading, England. They have 2 daughters, and 6 grandchildren now mostly grown up and seeking their own way in life.

Understanding innovation in a dynamic agricultural business environment: a multivariate approach

DANIEL E. MAY[1], GRAHAM J. TATE[2] and LESLIE WORRALL[3]

ABSTRACT
Researchers have identified a number of drivers of innovative capacity in rural areas such as farmers' participation in social and commercial networks; farmers' participation in collaborative alliances; farmers' level of education; and farm-size. The present article extends this traditional research with the objective of determining whether these drivers also favour innovative capacity in turbulent market conditions (i.e. dynamic business environments) caused by policy changes. A probit analysis based on a proposed model of innovation revealed that not all these drivers were significant. Moreover, it was found that the capacity to innovate was also influenced by psychological variables.

KEYWORDS: Networks; Innovation; Dynamic Business Environments; Policy Change

1. Introduction

The capacity to innovate or innovative capacity (IC) is defined by Wang and Ahmed (2007) as "a firm's ability to develop new products and/or markets, through aligning strategic innovative orientation with innovative behaviours and processes (p. 38)". Researchers have recognised that firms who have this capacity can develop profitable innovative activities allowing them to create wealth and competitive advantage in dynamic environments (see, for instance, Lawson and Samson, 2001; and Wang and Ahmed, 2007). It is for this reason that a number of investigators have studied and identified important drivers that help firms to develop IC in dynamic environments. Some of them correspond to participation in social and commercial networks; participation in collaborative alliances; individuals' willingness to change; and managers' level of education; among others (see Section Two for a formal description of these drivers).

It is interesting to note that most of the academic works studying the capacity to innovate in dynamic environments have only linked market dynamism with technological improvements. However, little attention has been paid to policy reform as a destabiliser of the business environments. In this respect, Eisenhardt and Martin (2000) describe two types of markets: (i) moderately dynamic markets; and (ii) high-velocity markets. These authors explain that "moderately dynamic markets are ones in which change occurs frequently, but along roughly predictable and linear paths. They have relatively stable industry structures such that market boundaries are clear and the players (e.g. competitors, customers, complementers) are well known (p. 1110)". In contrast, "high-velocity markets are ones in which market boundaries are blurred, successful business models are unclear, and market players (i.e. buyers, suppliers, competitors, complementers) are ambiguous and shifting (p. 1111)". Researchers in general have analysed moderately dynamic and high-velocity markets in terms of the nature of the development of new manufacturing processes and technological improvements. The reason is because it was originally recognised the need for an expanded paradigm to understand how competitive advantage can be achieved in dynamic markets by high-technology industries (Teece *et al*., 1997). For example, industries characterised by an accelerated technological improvement such as Asian manufacturers have been linked to high-velocity markets (Burgelman, 1996). In contrast, industries characterised by a predictable and frequent change in terms of new product development processes such as the computer industry have been associated with moderately dynamic markets (Eisenhardt and Tabrizi, 1995).

The fact that the traditional research on IC in dynamic business environments has mainly linked market dynamism with technological improvement but not with policy changes has an important implication. That is, high-velocity markets have been associated with accelerating technological improvements. However, a policy change can be considered as single exogenous shocks rather than an accelerating change. As a consequence, the drivers of IC identified by the

[1] Department of Rural Affairs\Environment, Harper Adams University College, UK.
[2] Department of Enterprise and Strategic Management, Business School, University of Wolverhampton.
[3] Coventry University Business School

traditional research could not necessarily be applied to help farmers to develop IC in turbulent conditions post-policy reforms. For example, it is possible that relevant information obtained from social and commercial networks cannot diffuse at the needed speed to quickly generate highly profitable innovative responses to a policy shock. This is because the acquisition of new information not only depends on the existing network, but also on the ability of firms to improve the depth, quality and diversity of inter-organizational networks (Conway, 1997; and Macpherson *et al*., 2004). Therefore, an existing network in a pre-reformed condition could not have the links needed to obtain relevant information to develop profitable innovative activities in response to a policy change, and these links could not necessarily be formed at the needed speed. This is supported by recent evidence obtained in the UK. For example, a significant number of sugar beet farmers of the West Midlands region in the UK (ESBF) innovated in low profitable crops (e.g. oilseed rape and oats) in response to the Sugar Regime reform introduced by the European Union on 20th February 2006 even when participating in different commercial networks (May *et al*., 2011). Moreover, these farmers were also producers of other traditional crops such as wheat and barley when the reform was implemented. As a consequence, they used the same machinery and similar agricultural practices in the production of the new traditional crops adopted to replace sugar beet. They also used the same commercialisation channels to sell these new crops (i.e. free market and contract with specific retailers). This implies that the introduction of these crops did not involve innovation in terms of technology or marketing practices.

The objective of the present article is to gain an understanding of the factors that favour IC in turbulent market conditions generated by policy reforms. In particular, it is argued that in these conditions the capacity to innovate is affected by a number of factors including behavioural considerations that affect farmers' willingness to change. In order to test this hypothesis, a holistic multivariate model of innovation that integrates possible drivers of innovation in dynamic business environments was designed and applied to a sample of ex-sugar beet farmers of the West Midlands region of the UK (ESBF). The reason for using this study case is because the market condition in this region after the Sugar Regime reform was considered as turbulent in terms of the definition of high-velocity markets of Eisenhardt and Martin (2000) given above: (i) the market boundaries of sugar beet in the West Midlands region was blurred because the sugar beet factory in this region was closed; (ii) successful business models to adjust in response to the closure of the factory were unclear; and (iii) market players were ambiguous and shifting (the principal buyer of sugar beet in the West Midlands region disappeared; and sugar beet competitors replaced sugar beet with other alternatives). The aim was to use this model to explain why these farmers adopted a low profitable innovative strategy to adjust in response to the Sugar Regime reform.

The paper is organised as follows: Section 2 provides a literature review on drivers of IC that have been identified by different researchers. These drivers were used as explanatory variables in the empirical analysis of this investigation. Section 3 shows the proposed holistic multivariate model; Section 4 explains the methodology used in the research; results are presented in Section 5; and finally, Section 6 concludes the paper.

2. Drivers of Innovative Capacity

According to Delmas (2002), the capacity to develop IC depends on the ability to absorb and assimilate relevant external information. Some researchers argue that this information can be found in networks related to new markets and within the supply chain (Macpherson *et al.*, 2004; Wang and Ahmed, 2007; and Harryson *et al*., 2008). It is for this reason that participation in formal and informal social and commercial networks (i.e. interaction and communication with suppliers, customers and retailers in the market place) has been considered as playing an important role in the development of IC in rural areas (Boahene *et al.,* 1999; and Virkkala, 2007). For example, farmers can be informed about new profitable crops adopted by producers in other areas when socialising with retailers in the market place. They can also be informed about market opportunities by farmers who are linked with specific retailers. This was confirmed by a farmer in the sample who innovated in a highly profitable crop before the SRR. This farmer (who had his farm in the West Midlands region) had a collaborative alliance with a partner located in Nottinghamshire. This alliance allowed them to produce a joint volume of carrots that was demanded by a retailer located in this county. Having contact with this retailer offered the farmer a useful channel to identify potential market opportunities and also to identify new crops adopted by growers in Nottinghamshire.

Researchers have also identified other factors that could eventually affect farmers' capacity to innovate in dynamic business environments. In particular, two different types of tactical alliances have been found to help firms to adjust in these environments because they can be formed relatively quickly in response to technological change. One of them, referred to in this article as *informational tactical alliance*, corresponds to alliances that facilitate the diffusion of the information that is needed to innovate in turbulent conditions. According to Hagedoorn and Duysters (2002), these alliances can help firms to increase negotiation power. This, in turn, allows these individuals to enter in new markets and to obtain the information that is needed to innovate. For example, retailers can offer access to markets of highly profitable crops only to farmers who are able to guarantee a determinate volume of production. Informational tactical alliances can help farmers to get access to these markets by pooling their production and, in this way, to obtain relevant information that could be used for innovation (e.g. learn from retailers about technologies adopted by other producers to increase the productivity of the farm or to produce other highly profitable crops). The other type of tactical alliance, referred to in this article as *investment tactical alliance*, corresponds to alliances that help farmers to innovate in dynamic environments in activities that demands high capital expenditure (e.g. shared ownership of expensive machinery used for the production of highly profitable crops). The reason is that these alliances offer the opportunity to spread the risk of this form of investment (Stiles, 1995).

Another factor that has been identified as a driver of IC is farm size. For example, Boahene *et al*. (1999) found that large-scale farmers had more access to bank loans and this strongly increased their chance of innovation in response to exogenous shocks in comparison to small-scale farmers.

Capacity to innovate in dynamic conditions can also be affected by less obvious channels related to socioeconomic and behavioural characteristics affecting farmers' strategic decisions. This is because IC also depends on ''behavioural innovativeness'' which refers to individuals, teams and managers' incentives to change or willingness to change (Wang and Ahmed, 2004). Willingness to change, in turn, is influenced by socioeconomic and behavioural considerations (Morgan, 1986; and Metselaar, 1997). For example, a farmer who values family farm tradition is probably less willing to innovate in new non-traditional technologies or enterprises. Regarding socioeconomic factors, researchers have identified farmers' education as a relevant one. According to Knight *et al*. (2003), farmers' education affects their attitudes toward risk. In particular, these researchers found that farmers who received formal education (i.e. years of schooling of the household head including primary and secondary education) were more willing to innovate because they were less risk averse.

Regarding behavioural factors affecting willingness to change, the present research adopted two approaches that have been used to study behavioural aspects of farmers' strategic behaviour: the multiple goals approach and the theory of planned behaviour. The multiple goals approach argues that farmers consider economic and non-economic goals when making their decisions (see for instance Gasson, 1973; and Solano, *et al*., 2001). The theory of planned behaviour, on the other hand, was proposed by Ajzen (1985) and establishes that intention is a good predictor of behaviour, and that intention is determined by attitudes, subjective norms and perceived behavioural control. That is, a person will have an intention (motivation) to behave in a particular way when she/he has a positive attitude towards this behaviour (i.e. attitudes), when the people who are important to him/her think that he/she should perform this behaviour (i.e. subjective norms), and when the person has the conviction that she/he will successfully execute a behaviour leading to a particular outcome (i.e. perceived behavioural control). Researchers have used the theory of planned behaviour to identify the underlying determinants of farmers' behaviour (Beedell and Rehman, 2000; Zubair and Garforth, 2006). In the case of innovation, it is possible that farmers' willingness to change also depends on their goals, attitudes towards different aspects of the farming activity, perceived behavioural control, and subjective norms.

In summary, there are eight main factors that were identified as potential drivers of innovation in dynamic environments: (*i*) participation in networks; (*ii*) formation of tactical alliances; (*iii*) farm size; (*iv*) farmers' level of education; (*v*) farmers' goals; (*vi*) farmers' attitudes towards different aspects of the farming activity; (*vii*) farmers' perceived behavioural control; and (*viii*) subjective norms. Following Morgan (1986), Metselaar (1997) and Wang and Ahmed (2004), the last five factors would affect farmers' capacity to innovate through willingness to change.

While these drivers have not been linked to turbulent conditions caused by policy changes, they were considered as potential explanatory variables in the empirical analysis developed in the present investigation.

3. The proposed multivariate model

A farmers' decision making framework that integrates the multiple goals approach and the theory of planned behaviour was developed by Bergevoet *et al*. (2004). This integrative framework is referred to as a multivariate model. The multivariate model proposed in this paper extends the contributions of Bergevoet *et al*. (2004) with the objective of determining whether farmers' capacity to innovate in turbulent environments generated by policy changes is explained by the eight factors described in the last section. This model is presented in Figure 1. As shown in this figure, willingness to change was considered as a mediating variable between IC and behavioural variables. This model was designed to test the following hypotheses:

H1: Farmers' capacity to innovate in turbulent business environments caused by policy changes is affected by farmers' participation in social and commercial networks.
H2: Farmers' capacity to innovate in turbulent business environments caused by policy changes is affected by farmers' participation in collaborative alliances.
H3: Farmers' capacity to innovate in turbulent business environments caused by policy changes is affected by farms' size.
H4: Farmers' capacity to innovate in turbulent business environments caused by policy changes is affected by farmers' level of education.
H5: Farmers' capacity to innovate in turbulent business environments caused by policy changes is influenced by farmers' goals.
H6: Farmers' capacity to innovate in turbulent business environments caused by policy changes is influenced by farmers' attitudes towards different aspects of the farming activity.
H7: Farmers' capacity to innovate in turbulent business environments caused by policy changes is influenced by farmers' perceived behavioural control.
H8: Farmers' capacity to innovate in turbulent business environments caused by policy changes is influenced by farmers' attitudes toward subjective norms.

4. Material and methods

According to DEFRA (2011) statistics, the number of sugar beet growers in the West Midlands region in 2005 was 592. 48 ex-sugar beet farmers of the West Midlands region (ESBF) were sampled which correspond to 8.1 per cent of this total and had a 100% response rate. This sample was collected over a period of six months starting in January 2008. Farmers were visited by the authors in their working place and were asked to fill a questionnaire during the visit. The data collection method was based on a combination of cluster,

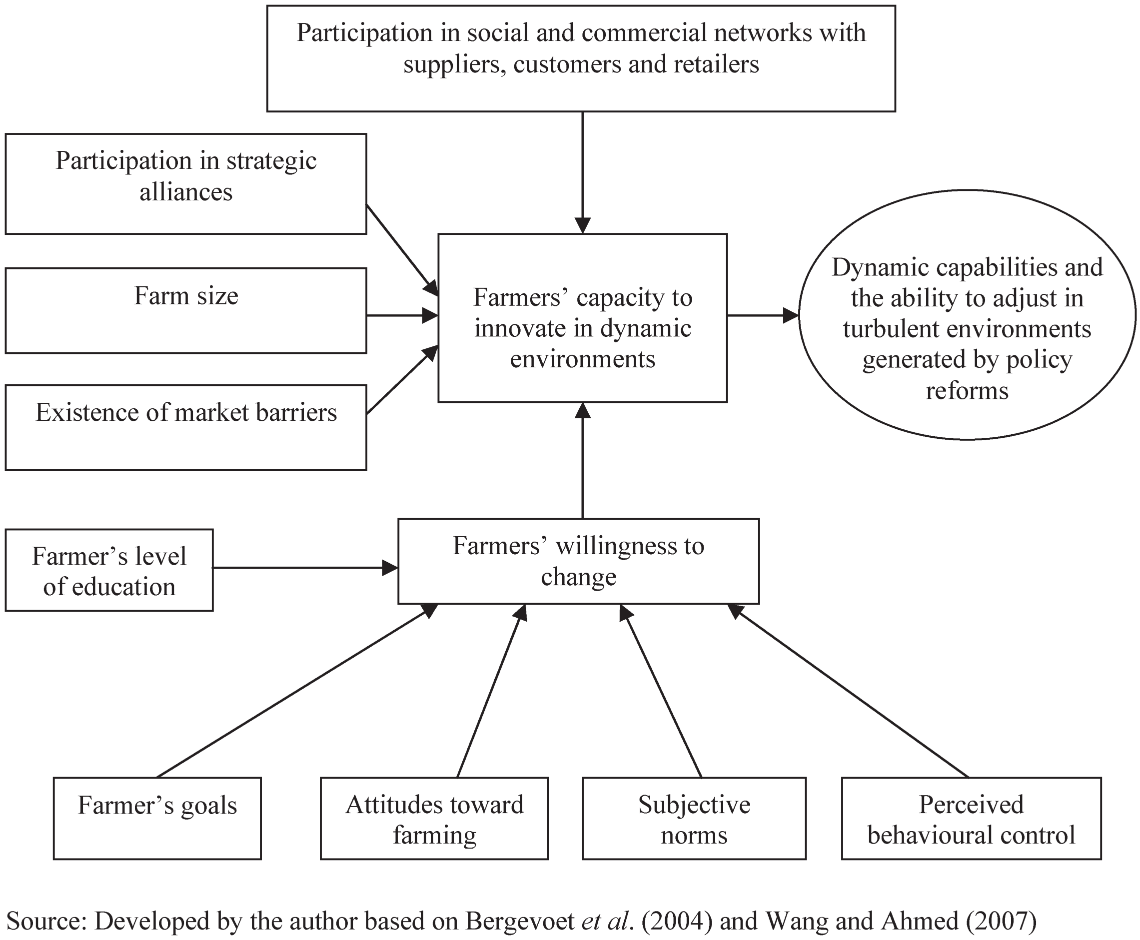

Figure 1: Multivariate model of innovation in dynamic business environments
Source: Developed by the author based on Bergevoet *et al.* (2004) and Wang and Ahmed (2007)

stratified and snowball sampling techniques. The reason for using them was that there was not a list of ESBF available in the public domain. Before adopting these techniques, different unsuccessful attempts to obtain a random sample were made. The first attempt was to send a letter to the British Sugar Corporation requiring a list of ESBF. However, this Corporation did not reply. A second attempt was to approach the British Sugar Corporation by email requiring the list of ESBF. Since no reply was obtained, it was decided to look for other sources. One of them was the National Farm Union (NFU) located in Telford. This Union did not have a list of ESBF. However, the head of the NFU send an extensive invitation to the members to participate in the project by means of the NFU newsletter. Unfortunately no farmer responded the invitation. Finally, it was estimated the cost of sending an invitation to all the farmers of the West Midlands Region. Since the number of farmer holdings in this region is approximately 27,200, it was found that the cost of this strategy was prohibitively high given the budget of the project.

The sample cluster was selected considering the most relevant counties of the West Midlands region in terms of the number of ESBF. They corresponded to the counties of Shropshire, Worcestershire, Herefordshire, Staffordshire and surrounding areas accounting for 48%, 15%, 14%, 12% and 11% of the total sugar beet farm holdings in 2005, respectively. The sample considered relatively similar proportions for these counties in terms of the number of farmers that participated in the investigation accounting for 46%, 15%, 13%, 15% and 13%, respectively. A similar approach was adopted by the Rural Business Unit of the University of Cambridge and The Royal Agricultural College (2004) but in terms of regions rather than counties. The sample stratification was made considering the size of the farm in terms of the number of hectares. It was not possible to find official statistics on this variable. Nonetheless, a criterion was established based on the opinions of the 10 farmers that formed the pilot sample. The precaution was taken to include a balanced number of farmers to the classes defined by this measure. Table 1 shows the sample distribution for each county considering these criteria.

The snowball technique was developed separately in each relevant county. As a result, it was possible to find a number of ESBF that is consistent with the sample cluster strategy defined above. Given the difficulty of gathering data from primary sources, given the small population of ESBF, and given the limited budget supporting the present research, the sample used in this study was considered as appropriate in this context.

A questionnaire was used to collect the relevant data on: (*i*) farmers' capacity to innovate after the incorporation of the Sugar Regime reform (SRR); (*ii*) the importance that farmers attributed to tactical alliances

Table 1: Sample distribution of farm sizes for each county ***Table B1: Sample distribution of farm sizes for each county***

	FARM SIZE (Percentage)		
COUNTY	Small < = 200 ha	Medium 200 < 600 ha	Large > = 600 ha
Shropshire	30	52	18
Worcestershire	37	50	13
Herefordshire	17	66	17
Staffordshire	0	83	17
Rest	40	40	20
Whole sample	**27**	**56**	**17**

as tools to reduce market risk after the SRR; (*iii*) the importance that farmers attributed to tactical alliances as tools to increase negotiation power after the SRR; (*iv*) farmers' participation in networks after the SRR; (*v*) farm size; (*vi*) different statements on farmers' goals, attitudes toward farming, perceived behavioural control, and subjective norms; and (*vii*) farmers' level of education (i.e. formal agricultural training such as Bachelor degrees or diplomas obtained from either colleges of universities). A five point Likert scale was used for questions included in (*ii*), (*iii*) and (*vi*). A dummy variable was used to reflect farmers' education. Likewise, a dummy variable was adopted to reflect farmers' participation in networks. The statements on farmers' goals, attitudes toward farming, perceived behavioural control, and subjective norms included in (*vi*) were adopted and adapted from Willock *et al*. (1999) and Bergevoet *et al*. (2004). The questionnaire was pretested with ten farmers in a previous pilot investigation. The statements included in the questionnaire are presented in the Appendix.

A probit analysis was used to identify the drivers that explain farmers' capacity to innovate in dynamic business environments. The reason is because capacity to innovate was captured using a binary choice: I am able to innovate vs. I am not able to innovate. These individuals were explained by the authors of this article the meaning of innovation used in the research. This meaning was based on the definition provided by Wang and Ahmed (2007) for production innovativeness. Product innovativeness is defined by these authors as the novelty of new products introduced to the market in a timely fashion. Using this definition, farmers had to report that they were able to innovate. The authors of the present article ensured that all participating farmers applied the same definition of innovation during the survey. Farmers who responded that they had the capacity to innovate after the implementation of the SRR were assigned a value equal to one. In contrast, farmers who responded that they did not have this capacity were assigned a value equal to zero. The variable p_i summarises this information. That is, $p_i = 1$ for farmer *i* means that this agent responded that he/she had the capacity to innovate after the implementation of the reform. Conversely, $p_i = 0$ for farmer *i* means that this agent responded that she/he did not have the capacity to innovate. The probit model is presented as follows (see Dougherty, 2007, and Davidson and Mackinnon, 1993):

$$p_i = \int_{-\infty}^{Z} \frac{1}{\sqrt{2\pi}} e^{-\frac{1}{2}Z^2} dZ \qquad (1)$$

where Z is a linear combination of the importance that farmers attributed to tactical alliances as tools to reduce market risk (*TA1*); the importance that farmers attributed to tactical alliances as tools to increase negotiation power (*TA2*); farmers' participation in networks (*Net*); farm size (*Size*); farmers' level of education (*Edu*); and statement reflecting behavioural considerations associated with farmers' goals, attitudes toward farming, perceived behavioural control, and subjective norms (B_i). Considering all these variables, the linear combination Z was defined as:

$$Z = \beta_0 + \beta_{SA1} TA1 + \beta_{SA2} TA2 + \beta_{Net} Net + \beta_{Size} Size + \beta_{Edu} Edu + \sum_i \beta_i B_i \qquad (2)$$

The probit model was estimated using Maximum Likelihood.

5. Results and discussion

Of the farmers in the sample, 39.6% responded that they had the capacity to innovate when the Sugar Regime reform was incorporated. In contrast, 60.4% of these farmers responded that they did not have this capacity.

In order to test hypotheses H1, H2, H3, H4, H5, H6, H7 and H8, the probit model described in equations 1 and 2 was estimated. The estimated model is presented in Table 2. This table shows that the attitude *I regularly negotiate with suppliers and buyers*; the perceived behavioural control *I don't make plans because they don't work out in reality*; the subjective norm *The increasing amount of regulation interferes with my plans for the future*; and the variables *Collaborative alliances to reduce market risk*, *Collaborative alliances to increase negotiation power*, *Farmers' education* and *Farm's size* were all significant. As a result, the hypotheses H2, H3, H4, H6, H7 and H8 were supported, and the hypotheses H1 and H5 were rejected by the data. This finding suggests that the capacity to develop IC in post-policy turbulent conditions not only depends on some typical drivers identifying by the traditional research (e.g. collaboration, farm's size and farmer's education), but also on behavioural factors that were assumed to affect IC though farmers' willingness to change.

On the other hand, it is interesting to note that participation in networks was not significant. This

Table 2: Regression model for innovative capability ***Table B2: Regression model for innovative capability***

Variables	Dependent variable: *Pi* ($n = 48$)	
Intercept	−17.51**	[−2.41]
I regularly negotiate with suppliers and buyers	3.93**	[2.53]
I don't make plans because they don't work out in reality	−2.32***	[−2.70]
The increasing amount of regulation interferes with my plans for the future	1.07**	[1.97]
Collaborative alliances to reduce market risk	−2.42**	[−2.13]
Collaborative alliances to increase negotiation power	1.95**	[2.03]
Farmers' education	3.9**	[2.46]
Farm's size	−1.01***	[−2.77]
R^2	0.6	
S.E. Regression	0.33	

*$P < 0.1$, **$P < 0.05$, *** $P < 0.01$, *z*–ratios in parenthesis

implies that farmers' participation in networks did not explain farmers' capacity to innovate in the turbulent condition caused by the SRR. As mentioned in the introduction, it is possible that relevant information obtained from social and commercial networks did not diffuse at the needed speed to quickly generate innovative responses to these policy reforms.

The analysis and interpretation of the variables that were significant are provided as follows.

a) I regularly negotiate with suppliers and buyers

According to Table B2, farmers who had a more active participation in the supply chain had higher chance to develop IC in response to the SRR. This indicates that it was not network participation itself what provided these individuals the capacity to develop IC in this turbulent condition, but the intensity by which these individuals interacted with different actors in their social and commercial networks. It is possible that the information that is needed to innovate can be obtained easily when this intensity is high. This is indeed supported by some researches. For example, Conway (1997); and Macpherson *et al*. (2004) argue that the acquisition of new and relevant information not only depends on the existing network, but also on firms' ability to improve the depth, quality and diversity of inter-organizational networks.

b) I don't make plans because they don't work out in reality

According to Table B2, this variable decreased the probability of developing IC in dynamic environments. This result was reflective of farmers who did not have full control over their resources. If they had, then they would have made plans. This lack of control over resources could be coupled with a lack of capacity to innovate. In other words, this result suggests that farmers who had limited control over their resources were less prepared both to make plans and to innovate in response to exogenous shocks.

c) The increasing amount of regulation interferes with my plans for the future

According to Table B2, this variable increased the probability of developing IC in dynamic environments. A possible explanation for this result is that farmers who had faced increasing regulation had developed the skills to overcome this barrier by means of innovation. But these skills can be considered as a positive externality for the development of IC in turbulent environments caused by policy reform. It is also possible that through the process of innovation, these farmers encountered new regulatory constraints. For example, the main purpose of the Rural Development Regulation introduced in the CAP reform Agenda 2000 was to promote development and innovation in rural areas. This regulation could have motivated farmers to develop innovative activities. However, it is possible that these individuals found regulation constrains associated with the existence of rigid institutional arrangements through the process of innovation. In this respect, Dwyer *et al*. (2007) argue that the initiatives for innovation and sustainable rural development included in the Rural Development Regulation have not been sufficient to ensure their effective application because they have not been accompanied by institutional adaptation.

d) Collaborative alliances to reduce market risk

According to Table B2, this variable decreased the probability of developing IC in dynamic environments. This result is surprising and unexpected. As mentioned in the literature review, this type of alliance can help innovation that demands high capital expenditure because they offer the opportunity to spread the risks of this form of investment (Stiles, 1995). But the result obtained in the probit analysis indicates the opposite. A possible explanation for this result is that farmers who faced capital constraints were unable to invest in innovative activities, even when reducing market risk by means of the formation of strategic alliances. As a consequence, the formation of these alliances did not favour innovation. This possibility was inferred from informal conversations with the farmers in the sample. Most of these individuals argued that producing some highly profitable crops requires specific and expensive machinery. This means that they needed this technological innovation to produce these crops. But they were unable to invest in this machinery because they had capital constrains (difficulty in obtaining loans). This suggests that farmers who faced capital constraints did not have an incentive to form alliances with the purpose of developing innovation that demands high capital expenditure. Actually, no farmer in the sample was involved in this type of collaboration.

e) Collaborative alliances to increase negotiation power

According to Table B2, this variable increased the probability of developing IC in dynamic environments. This result is consistent with the argument given in the literature review. That is, the formation of this type of tactical alliance can help firms to increase negotiation power allowing farmers to enter in new markets and to obtain the information that is needed to innovate. This was indeed verified by some farmers in the sample. For example, a farmer in the area of Worcestershire was able to replace sugar beet with beans and peas by forming an alliance with a group of farmers located in the same area.

f) Farmers' education

According to Table B2, this variable increased the probability of developing IC in dynamic environments. This finding is consistent with the result obtained by Knight *et al*. (2003). As explained in Section 2, these researchers found that education affects farmers' attitudes toward risk. As a consequence, it is possible that farmers who received formal agricultural educational training (i.e. obtained diplomas or a bachelor degree in agricultural science from colleges of universities) were more willing to innovate in the turbulent condition generated by the SRR because they were less risk averse.

g) Farm size

According to Table B2, this variable decreased the probability of developing IC in dynamic environments. This result is also unexpected. According to Boahene *et al*. (1999), large-scale farmers have more access to bank loans and this strongly increases their chance of innovation in response to exogenous shocks in comparison to small-scale farmers. However, since most of the ESBF in the sample faced capital constraints (i.e. difficulty to obtain loans either to satisfy short-term cash flow needs or to develop long-run investment activities) independently of the size of their farms, this argument does not apply to them. In addition, it is possible that the larger farms were more profitable growing the traditional crops and, therefore, faced less pressure to innovate than smaller farms. Unfortunately it was not possible to obtain data of farm profitability from the survey to support this argument. Nonetheless, research developed in different countries and in different agricultural activities has revealed the existence of a positive relationship between farm-profitability and farm-size (see, for instance, Kumbhakar, 1993; Heltberg, 1998; Gloy *et al*., 2002; and Salami *et al*., 2009).

6. Summary and Conclusions

Researchers have identified a number of drivers that help firms to develop innovative capacity in dynamic business environments associated with rapid technological change. The present research found that some of these drivers were not significant in explaining farmers' capacity to innovate in turbulent conditions caused by the Sugar Regime reform (SRR). In particular, the probit analysis conducted in the investigation revealed that it is not network with other farmers, suppliers and buyers itself what help farmers to develop this capacity. It is the intensity with which these individuals interact with different actors of the supply chain (i.e. networking in all directions and possible levels). It was also found that the group of farmers who reported that they faced increasing legislation (81.3% of the farmers in the sample) had more chance to innovate in the unstable business environment caused by SRR. Apparently, this is because these farmers had developed skills to overcome this barrier by means of innovation. As a result, they were better prepared to innovate in response to this exogenous shock. It is also possible that through the process of innovation, these farmers encountered new regulatory constraints.

The formation of tactical alliances to increase negotiation power also was related to the capacity to innovate in dynamic environments. This is because the formation of these types of alliances can help farmers to enter in new markets and to obtain from them the information that is needed to innovate. It appears that these alliances were formed by innovative farmers. Finally, farmers' formal education was related to the capacity of these individuals to develop innovative activities in the turbulent condition caused by the SRR. According to Knight *et al*. (2003), formal education affects individuals' attitudes towards risk. Following this argument, it is possible that this result indicates that education corresponded to a mediate variable between innovation and farmers' attitudes towards risk.

The probit analysis also revealed that capital constraints constituted an important inhibitor of innovation when farmers operated in the turbulent environment caused by the SRR. In particular, it was found that when farmers faced this limitation, the formation of tactical alliances to reduce market risk was useless to develop innovative activities because they were unable to affect investment decisions on innovation. The existence of capital constraints across farmers can explain why no ex-sugar beet farmer in the sample innovated in highly profitable crops: they were unable to invest in the specific and expensive machinery that is needed to produce these crops.

From a political point of view, policy makers could help the ESBF to innovate in response to future policy changes by encouraging the formation of tactical alliances to increase negotiation power; facilitating the interaction with different actors in social and commercial networks; promoting farmers' formal agricultural training; providing better access to capital for investment; and introducing training programmes designed to develop the skills needed to control farm's resources more efficiently. It is important to clarify, nonetheless, that generalisations from this research have to be made with caution because the sample used in the investigation was relatively small. It would be interesting, therefore, to extend this research including both larger samples and farmers operating in other industries.

About the authors

Daniel E. May

Daniel E. May (dmay@harper-adams.ac.uk) is a Researcher in Quantitative Economics at Harper Adams University College and is nearly of completing his PhD in Economics and Strategic Behaviour at Wolverhampton University. He holds an MPhil in Economics from Essex University, a MA in Economics from Catholic University of Chile and a BSc in Agricultural Economics from University of Chile. He has published different articles and has also worked as a referee for some Journals. Before moving to the UK, he used to work in Chile as a lecturer and as an adviser in the Central Bank, the Treasury Department, and the Ministry of Agriculture.

Graham J. Tate

Dr Graham Tate (Graham.Tate@wlv.ac.uk) is a senior lecturer in Rural Enterprise and Strategy at the University of Wolverhampton Business School. He has more than 25 years experience of consultancy, research and teaching in the fields of farm business management, rural enterprise and diversification, entrepreneurship and business management. His current research activity includes two studies of farmers' new enterprise decisions after sugar beet and the financial viability of bioenergy in the West Midlands. He holds a PhD from Reading, an MBA from Aston and a BSc (Hons) from Wye College.

Leslie Worrall

Professor Les Worrall (leslie.worrall@coventry.ac.uk) is Professor of Strategic Analysis at Coventry University Business School. He holds a PhD in information systems from the University of Liverpool. Professor Worrall has published extensively in organisational analysis, business transformation and regional economic development. He has conducted research for a number of major organisations such as PriceWaterhouseCoopers, Aviva, Adecco, the Confederation of British Industry, the Chartered Management Institute and the Australian Institute of Management.

Acknowledgements

The authors wish to thanks two anonymous reviewers for their useful and valuable observations.

REFERENCES

Ajzen, I. (1985). From intentions to actions: a theory of planned behaviour. In: J. Kuhl and J. Beckman (Eds.), Action-control: from cognition to behavior. Heldelberg: Springer, pp. 11–39.

Beedell, J. and Rehman, T. (2000) Using social-psychology models to understand farmers' conservation behaviour. *Journal of Rural Studies*, 16, pp. 117–127.

Bergevoet, R.H.M., Ondersteijn, C.J.M., Saatkamp, H.W., van Woerkum, C.M.J. and Huirne, R.B.M. (2004) Entrepreneurial behaviour of dutch dairy farmers under a milk quota system: goals, objectives and attitudes. *Agricultural Systems*, 80, pp. 1–21.

Boahene, K., Snijders, T.A.B. and Folmer, H. (1999) An integrated socioeconomic analysis of innovation adoption: the case of hybrid cocoa in Ghana. *Journal of Policy Modeling*, 21 (2), pp, 167–184.

Burgelman, R.A. (1996) A process model of strategic business exit. *Strategic Management Journal*, 17, pp. 193–214.

Conway, S. (1997) Informal networks of relationships in successful small firm innovation. In: Jones-Evans, D. and Klofsten, M. (eds), Technology, Innovation and Enterprise: the European Experience. London: Macmillan, pp. 236–273.

Davidson, R. and Mackinnon, J.G. (1993) *Estimation and Inference in Econometrics*. Oxford University Press.

DEFRA (Department for Environment Food and Rural Affairs) (2011) Statistical database at: http://www.defra.gov.uk/statistics/foodfarm/landuselivestock/junesurvey/junesurveyresults/ [Accessed 5 July 2011]

Delmas, M.A. (2002) Innovating against European rigidities: institutional environment and dynamic capabilities. *Journal of High Technology Management Research*, 13, pp. 19–43.

Dougherty, C. (2007) *Introduction to Econometrics*. Third edition, Oxford University Press.

Dwyer, J., Ward, N., Lowe, P., and Baldock, D. (2007) European rural development under the Common Agricultural Policy's 'Second Pillar': institutional conservatism and innovation. *Regional Studies*, 41(7), pp. 873–887.

Eisenhardt, K.M., and Martin, J.A. (2000) Dynamic capabilities: what are they? *Strategic Management Journal*, 21, pp. 1105–1121.

Eisenhardt, K.M., and Tabrizi, B.N. (1995) Accelerating adaptive processes: product innovation in the global computer industry. *Administrative Science Quarterly*, 40(1), pp. 84–110.

Gasson, R. (1973) Goals and values of farmers. *Journal of Agricultural Economics*, 24, pp. 521–537.

Gloy, B.A., Tauer, L.W. and Knoblauch, W. (2002) Profitability of grazing versus mechanical forage harvesting on New York dairy farms. *Journal of Dairy Science*, 85(9), pp. 2215–2222.

Harryson, S.J., Dudkowski, R. and Stern, R. (2008) Transformation networks in innovation alliances – the development of Volvo C70. *Journal of Management Studies*, 45 (4), pp. 745–773.

Hagedoorn, J. and Duysters, G. (2002) External sources of innovative capabilities: the preferences for strategic alliances or mergers and acquisitions. *Journal of Management Studies*, 39 (2), pp. 167–188.

Heltberg, R. (1998) Rural market imperfections and the farm size – productivity relationship: evidence from Pakistan. *World development*, 26 (10), pp. 1807–1826.

Knight, J., Weir, S. and Woldehanna, T. (2003) The role of education in facilitating risk-taking and innovation in agriculture. *Journal of Development Studies*, 39 (6), pp. 1–22.

Kobrich, C., Rehman, T. and Khan, M. (2003) Typification of farming systems for constructing representative farm models: two illustrations of the application of multi-variate analyses in Chile and Pakistan. *Agricultural Systems*, 76, pp.141–157.

Kumbhakar, S.C. (1993) Short-run returns to scale, farm-size and economic efficiency. *Review of Economics & Statistics*, 75(2), pp. 336–341.

Lawson, B., and Samson, D. (2001) Developing innovation capability in organisations: a dynamic capability approach. *International Journal of Innovation Management*, 5(3), pp. 377–400.

Macpherson, A., Jones, O. and Zhang, M. (2004) Evolution or revolution? Dynamic capabilities in a knowledge-dependant firm. *R&D Management*, 34, pp. 161–177.

May, D.E, Tate, G.J. and Worral, L. (2011) Explaining the formation of network innovations by small agricultural firms: the case of the ex-Sugar Beet Farmers of the UK. *International Journal of Economic Behaviour* (in press).

Metselaar, E.E. (1997) *Assessing the willingness to change: construction and validation of the DINAMO*. PhD Thesis, Vrije Universiteit.

Morgan, G. (1986) *Images of organisation*. Sage Publications, Inc.
Rural Business Unit of the University of Cambridge and The Royal Agricultural College. (2004) *Economic, Social and Environmental Implications of EU Sugar Regime Reform.* Department of Land Economy, University of Cambridge. Available online: http://archive.defra.gov.uk/evidence/economics/foodfarm/reports/documents/Sugar.pdf [Accessed 5 July 2011]
Salami, P., Keyhani, A. and Rafiee, S. (2009) The impact of farm size on energy use and profitability of red bean production in Iran: A case study in Kurdistan province. *Nature and Science*, 7 (9), pp. 95–104.
Solano, C., Leon, H., Perez, E. and Herrero, M. (2001) Characterising objective profiles of Costa Rican dairy farmers. *Agricultural Systems*, 67, pp. 153–179.
Stiles, J. (1995) Collaboration for competitive advantage: the changing world of alliances and partnerships. *Long Range Planning*, 28 (5), pp. 109–112.
Teece, D.J., Pisano, G., and Shuen, A. (1997) Dynamic capabilities and strategic management. *Strategic Management Journal*, 18(7), pp. 509–533.
Virkkala, S. (2007) Innovation and networking in peripheral areas –a case study of emergence and change in rural manufacturing. *European Planning Studies*, 15 (4), pp. 511–529.
Wang, C.L., and Ahmed, P.K. (2004) The development and validation of the organisational innovativeness construct using confirmatory factor analysis. *European Journal of Innovation Management*, 7(4), pp. 303–313.
Wang, C.L., and Ahmed, P.K. (2007) Dynamic capabilities: a review and research agenda. *International Journal of Management Reviews*, 9(1), pp. 31–51.
Willock, J., McGregor, M.M., Sutherland, A., Edwards-Jones, G., Morgan, O., Dent, B., Grieve, R., Gibson, G. and Austin, E. (1999) Farmers' attitudes, objectives, behaviours, and personality traits: the Edinburgh study of decision making on farms. *Journal of Vocational Behaviour*, 54, pp.5–36.
Zubair, M. and Garforth, C. (2006) Farm level tree planting in Pakistan: the role of farmers' perceptions and attitudes. *Agroforestry System*, 66, pp. 217–229.

Appendix: Questions and statements used in the questionnaire

A1. Questions related to collaborative alliances

Which of the following business strategies do you think were more suitable to make your farm a successful business enterprise after the closure of Allscott? For your answers, use the following scale:

Irrelevant (1)	Not very important (2)	Important (3)	Very important (4)	Essential (5)

a) Collaborative alliances to reduce market risk
b) Collaborative alliances to increase negotiation power

A2. Statements related to farmers' goals

Please, use the scale below to best represent your **goals**:

Strongly disagree (1)	Disagree (2)	Indifferent (3)	Agree (4)	Strongly agree (5)

G1) Achieve an income as high as possible
G2) Enjoy my work
G3) Provide for next generations
G4) Have sufficient time for leisure
G5) Maintain nature and environmental value
G6) Produce a good and safe product
G7) Gaining recognition and prestige as a farmer
G8) Belonging to the farming community
G9) Maintaining the family tradition
G10) Working with other members of the family
G11) Feeling pride of ownership
G12) Enjoyment of work tasks
G13) Preference for a healthy, outdoor, farming life
G14) I enjoy having a purpose and value hard work
G15) Have independence and freedom from supervision
G16) Have the control in a variety of situations

A3. Statements related to farmers' attitudes, perceived behavioural control and subjective norms

Please use the scale below to best represent your opinion about the following statements:

Strongly disagree (1)	Disagree (2)	Indifferent (3)	Agree (4)	Strongly agree (5)

Attitudes (A)

A1) Achieve low debts on my farm
A2) My goals and objectives are clear
A3) I try to be among the highest producing farms
A4) I regularly negotiate with suppliers and buyers
A5) I like to try new things on my farm
A6) Keeping my farm up to date is very important to me
A7) In decision-making I take the environment into consideration, even if it lowers profits
A8) Off-farm income is important for sustaining our farm
A9) When making an important decision I ask for a lot of advice
A10) I take challenges more often than other farmers
A11) I use my equity capital as a risk buffer
A12) I try to minimise contract work
A13) Farming is still fun and satisfying

Perceived behavioural control (P)

P1) I'm well informed on the relevant legislation for my farm
P2) I can further lower my production costs
P3) Before I take important decisions I thoroughly inform myself
P4) When I need a new loan, I always go to the same bank
P5) I can increase the sales-price of my production
P6) Administrative obligations consume a lot of time on my farm
P7) I don't make plans because they don't work out in reality

Subjective norm (N)

N1) The way other farmers think about my farm is important to me
N2) I consider government policy unpredictable
N3) Legislation spoils the pleasure in my work
N4) The increasing amount of regulation interferes with my plans for the future

CALL FOR PAPERS

International Journal of Agricultural Management (IJAM)

General

IJAM welcomes submission of articles of various types:

- Articles based on original research, submitted for peer-review (up to 6000 words);
- Reviews of 'state-of-the-art' of research in relevant arenas, again subject to peer-review (up to 6000 words);
- Reviews of 'state-of-the-art' in agricultural or related practice (up to 5000 words);
- Case Studies of innovative practice, including evaluation of results (up to 3000 words);
- 'Viewpoint' articles taking a particular standpoint on current issues, and encouraging response from readers (up to 1500 words);
- Professional updating pieces (e.g. in rural policy, market trends, managerial practice) (up to 3000 words);
- Book reviews (up to 1000 words).

Guidance for contributors can be found on the journal website at www.tinyurl.com/6cb3hmq

Themed issues

It is proposed to produce occasional special issues based on a particular theme relevant to agricultural management, the latter term including social, economic and environmental aspects of food production and rural development, but with a farm-level orientation. If you would be interested in being a Guest Editor for a themed issue of IJAM, please email the Editor at editor.ijam@gmail.com with an outline of your proposal. We would expect a Guest Editor to:

1. Identify potential authors who might be expected to write an article relevant to the theme, of the appropriate quality and rigour;
2. Invite those authors to contribute;
3. Identify reviewers with appropriate expertise for each paper;
4. Make judgements on inclusion of papers, in consultation with the IJAM editorial team.

The IJAM team would provide administrative support to minimise the workload on the Guest Editor. This might include, for instance, putting out a general call for contributions on the theme; communication with authors subsequent to submission, and with reviewers once identified.

Topic areas could include:

- business and commerce
- supply-chain management
- animal and crop husbandry
- farm diversification and pluriactivity
- governance, democracy, activism
- digital divides, alleviation of poverty
- internet-mediated co-operatives, joint ventures
- village and social enterprise
- crime
- health and rural services

Special Issue on Agricultural Marketing in a Globalized Economy

This issue will be edited by Dr. Sanzidur Rahman, a researcher in agricultural economics and development since the 1980s.

the term 'marketing' includes a wide range of issues and aspects related to market, such as:

- marketing channels
- marketing structures
- dimensions (e.g., wholesale, retail)
- futures markets
- spot markets
- export/import markets
- marketing efficiency
- price formation
- price discovery
- price transmission
- socio-economic as well as political issues/environment

Analytical procedures may encompass both quantitative and qualitative approaches depending on the requirement and justification provided for specific projects/papers.

Special Issue on internet and social media in agricultural management

This issue will be edited by Martyn Warren, a Board member of EFITA (The European Federation for Information Technology in Agriculture, Food and the Environment) and a researcher in this area since the 1990s.

The phrase 'internet and social media' is quite wide-ranging, including

- WWW, email, instant messaging
- Web 2.0
- social networking
- blogs
- mobile internet
- rural broadband
- interactive video games
- online television and radio
- voice-over-internet telephony
- virtual worlds
- interactive community radio
- converging technologies

Prospective authors are invited to submit an abstract to Dr Sanzidur Rahman or Martyn Warren via editor. ijam@gmail.com

The Cash Cows, Dogs, Stars and Problem Children of the South African Agricultural Sector

JOUBERT, J.C.N.[2], JOOSTE, A.[3] and LOTRIET, R.[3]

ABSTRACT

This paper investigates the development path of different agricultural sectors over the past 10 years in order to identify those subsectors that can contribute significantly towards reducing poverty and increasing national & household food security. The Boston Consulting Group (BCG) matrix was used to analyse growth patterns for different agricultural subsectors and classify them as cash cows, dogs, stars and question marks. The results show that the real average growth for the agricultural sector over the last ten years was 5.64 %. Of the 44 agricultural subsectors, 9 subsectors show a negative growth. The BCG matrix indicates one cash cow industry (sugar cane), eight dogs'(sisal, cotton, tobacco, tea, chicory, mohair, fry peas, dried fruit), fourteen stars (fowls slaughtered, maize, cattle & calves slaughtered, milk, vegetables, deciduous and other fruit, eggs, citrus fruit, wheat, potatoes, hay, viticulture, sheep and goats slaughtered, pigs slaughtered) and twenty one question marks. Institutional intervention by the public-private sectors are therefore necessary to unlock the potential of the problem children, maintain the momentum of the stars, extent the life of the cash cow and decide on the future of the dogs.

KEYWORDS: Development path; growth patterns; South Africa; agricultural industry; cash cow

1. Problem Statement

The South African agricultural sector started liberalising in 1995 and deregulated in 1997. Jooste & Van Zyl (1999:10) explained that previous policy was focused on food self-sufficiency and agricultural subsidies. The liberalisation entails the reform of the agricultural marketing system. This trend was further enhanced by the pressures from GATT negotiations for the abolition of quantitative import controls and the introduction of tariffs. Liberalization of price controls in the food sector was one of the important aspects of marketing deregulation. The agricultural sector traditionally received differential tax treatment from the Receiver of Revenue, but this also changed, with fiscal allocations to agriculture that relatively also declined over the past number of years.

In addition to dealing with the challenges of globalisation and the deregulation of domestic agricultural markets in the 1990s, the South African (SA) producers at farm level also had to adapt to a rapidly changing political environment after 1994. For example: land reform; broad-based black economic empowerment ('Agri-BBBEE'); new labour legislation; minimum wages; property taxes and skills levies have been instituted during the last couple of years.

The SA farmers also face some specific challenges to remain competitive which their equals in many other countries with more business-friendly political environments do not experience (Ortmann, 2005). Apart from increases in production costs, expenses related to electricity and labour will also increase rapidly over next few years. In this regard the BFAP (2010:viii) indicated that electricity's share of total production costs of maize under irrigation is projected to increase from 8% in 2009 to 20% by 2015, while the durability of water rights for irrigation farmers has become less certain. To aggravate this micro-economic level scenario even more, it is estimated that the HIV/AIDS prevalence rate amongst adults in South Africa was 20.1% with up to five million people estimated to be living with HIV/AIDS (Chaminuka *et al.*,2006). The smallholder agriculture sector, relying mainly on labour because of the low levels of mechanisation, has also not been spared by the pandemic. The government extension services has also shifted its focus from serving commercial agriculture to advising mainly these emerging producers. An estimated 90% of the SA agricultural and redistribution programmes are declared a failure (Radebe, 2011:2).

On an international policy level, SA also has most of the World Bank approved macro-economic policies in place to attract investment, but is does not qualify for

[1] This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

[2] Senior Researcher, MERC Division, National Agricultural Marketing Council

[3] Senior Manager, MERC Division, National Agricultural Marketing Council and Affiliate Professor in the Department of Agricultural Economics at the University of the Free State, South Africa.

[3] Professor at the Potchefstroom Business School, North-West University. Potchefstroom Campus, South Africa.

much of the poorest countries' financial assistance schemes, despite being still in many agricultural areas a predominantly developing country (FANRPAN, 2006). Projections relating to the global increases in population tendencies show that agricultural production need to increase by approximately 70% to meet the demand levels by 2050 (FAO,2010:ii). In the country on its own the demands are huge – SA's economy remains one of the most inequitable in the world (40% of national income went to the richest 10% of households), with fewer than 50% of all working-age population has income-generating jobs (international benchmark is almost 67% employment) (Mills, 2011:7). Although South Africa is self-sufficient in terms of a net export of primary agriculture, the sector needs to import a lot of basic foods for example poultry, beef, wheat, soya bean, oil cake, etc.

In the ambit of this the South African agricultural sector is one of the least supported sectors in the world as measured with the Producer Support Estimate by the Organisation for Economic Cooperation and Development. The result of the above is subsectors with diminishing growth rates. Van der Merwe and Otto has argued a number of years ago (1997) that the optimum allocation of agricultural resources; competitive advantages based on natural endowments and unsubsidised markets are important policy issues. Despite the fact that commercial farming has contributed significantly to the country's economic growth in the past, and that it shows the best employment ratio of 19 for every R1 million gross value added in the economy, employment by the sector reduced by 46% from September 2003 and number of commercial farming units reduced by 34% since 1996 (NWPG,2008).

Therefore, on a macro-economic level, many questions are being asked about the sustainability of the subsectors and what must be done to ensure production, self-sufficiency and food security.

2. Objectives

This paper investigates the development path of different agricultural sectors over the past 10 years in terms of average growth and market share. The paper also strategically categorise the South African agricultural subsectors as 'question marks', 'stars', 'cash cows' and 'dogs'.

3. Discussion

Agriculture, machinery and equipment, pharmaceuticals and other chemicals, were indicated as economic sectors in SA that have the highest strategic value, with agriculture as such identified to be one that are most suited to absorb the large pool of unskilled labour. South Africa's recent exports per capita are barely higher than in 1960's and the country's status as a natural resource exporter does not rationalize this performance. Similar countries have all performed much better. One of the important principles in competitive markets relates to comparative advantage which basically proposes that every country would benefit from specializing in what it was relatively best at producing and then engaging in trade for everything else (Moss, 2007:16–19). It led to Paul Samuelson remarking that "*for all its oversimplification, the theory of comparative advantage provides a most important glimpse of truth.*" A country that neglects this will pay a price in terms of living standards and growth.

The Boston Consulting Group (BCG) was responsible for the first analytical breakthrough in corporate strategy in matrix format (Collins & Montgomery (2005:20). The BCG-matrix describes the business position in the market and basically shows areas where a business excel or drag behind. The basic assumption is that businesses that are large enough to be organized in strategic business units face the challenge of allocating resources among these units. Within the context of agriculture, this could increase the capacity for the involved stakeholders to allocate resources more effectively and reduce risks like the improved management of water resources (FAO,2010: 18–22).

The BCG matrix has two important dimensions (determinants of profitability):

- The *growth rate*, which attempts to capture the potential resource usage of a business (industry). A growth rate measures the percentage change in the value of a variety of markets, companies, or operations (a proxy for industry attractiveness). It is also more accurate when a comparison is done between entities to use a growth rate (than the actual numerical value), because the size of economies can be fastly different (Farflex; 2010). Brigham and Ehrhardt (2005: 256) explain that the capital gain through a specific year is the value it gains in a specific year and can be calculated as follows:

  $$g = P_1 - P_0 / P_0$$

  Where: P_1 = Ending Price
  P_0 = Beginning Price

  The average growth rate for each subsector for the past 10 years was measured as follows:

  $$g = \left(\left(P_{2009} - P_{2008)} / P_{2008}\right) + \ldots\ldots\ldots + \left(P_n - P_n / P_n\right) + \ldots\ldots\ldots\ldots + \left(P_{2000} - P_{1999} / P_{1999}\right)\right) / n$$

  Where: P_{2009} = Deflated subsector value for 2009
  P_{2008} = Deflated subsector value for 2008
  P_{1999} = Deflated subsector value for 1999

  Market growth is illustrated on the vertical axis in figure 1 and illustrates real growth of the specific subsector.
- The second dimension is the *relative market share* **-** which is an indication of overall strength and hence the cash generation potential. The average market share for 44 South African subsectors are presented. The market share (a proxy for competitive advantage) of the sectors was calculated as a percentage of the total value of agricultural production for 2009.
- *Matrix compilation* **-** The matrix was compiled with four quadrants (grids) namely, question marks, stars, cash cows and dogs as illustrated in Figure 1.

[4] South African Rand

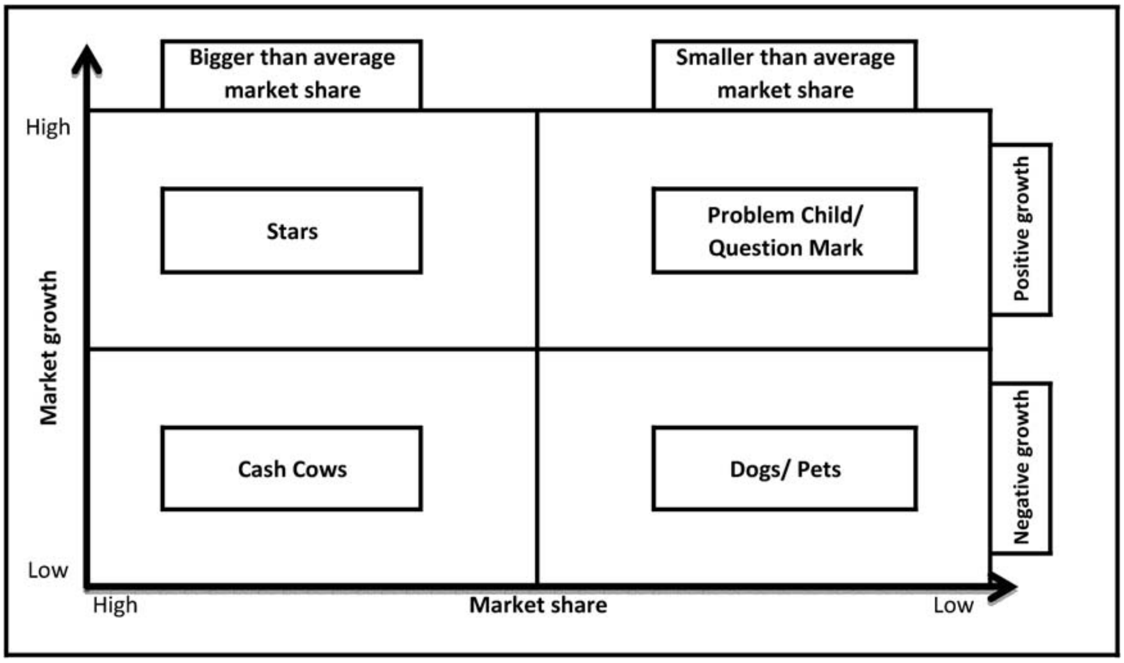

Figure 1. The Boston Consulting Group Matrix
Source: Own calculation based on literature from Thompson & Strickland, 1995

Thompson and Strickland (1995: 218) explain that the BCG methodology distinguishes between different matrix quadrants. Firstly, it is emphasised that a fast growing business with low relative market share would require a lot of cash to grow because of uncertainty about its future performance. Businesses in this quadrant were called *question marks*. The top left quadrant contained the *stars* – high growth-high market share businesses that were users of cash today because of their rapid growth, but whose dominant market position warranted investing in for the time when industry growth slowed and became the next cash cow. Conversely, a business with high relative market share in a slow-growing industry would be very profitable and would require little reinvestment. Since this implied the business would lose a lot of cash or use a lot of resources, business in this quadrant were called *cash cows*. *Dogs* are the low growth-low market share businesses to be found in the lower right quadrant, at a competitive disadvantage and with little hope of changing that position because of the slow industry growth. In principle the best strategy for this category of business was divestment or harvesting.

4. Results

The agricultural industry is basically divided into three main sectors namely: field crops, horticulture and animal production. Figure 2 shows that the volume of agricultural production for 2008/9 was 0.7% higher than the previous year. The volume of field crop production reflected a 2.4% decrease as a result of a decline in the production of summer grains (DAFF,2010:10). Horticultural production increased by approximately 1% with animal production showing an increase of nearly 3%, mainly because of increases in poultry products; fresh milk production, stock slaughtered and pastoral products.

The challenge for future agricultural production in South Africa is to increase the overall efficiency, resilience, adaptive capacity and mitigation potential of the sector through its various components. Collaborative disease control and increased provision of ecosystem services are examples of this. With increasingly complex supply chains it is becoming more important to increase value added benefits from commercialized activities such as the processing, packaging and transportation aspects to ensure enhanced product qualities and reduced environmental footprints (FAO,2010: i-5).

The average growth for the last 10 years and respective market share for the 2009 production season is illustrated in Table 1:

The results show that the real average growth for the agricultural sector over the last ten years was 5.64 %. Of the 44 agricultural subsectors, 9 of the 44 subsectors show negative growth (see Figure 2). The BCG matrix indicates that the sugar cane industry can be seen as a *cash cow* industry. The *stars* of the agricultural sector are the poultry, maize, beef, dairy, vegetables, deciduous fruit, citrus, wheat, potato, hay, viticulture, mutton and pork industries. The *problem children* of the agricultural sector are the lentil, karakul, lucerne seed, oats, nuts, wattle bark, rye, rooibos, other horticulture, other field crops, ostrich feather, barley, grain sorghum, dry beans, ground-

Table 1. Agricultural sector division, growth rate and market share

Agricultural Sectors	Average growth rate	Market Share
Field crops	6.65%	27.97%
Horticulture	4.58%	24.84%
Animal products	7.00%	47.19%

Source: Own calculation from data from DAFF (2010)

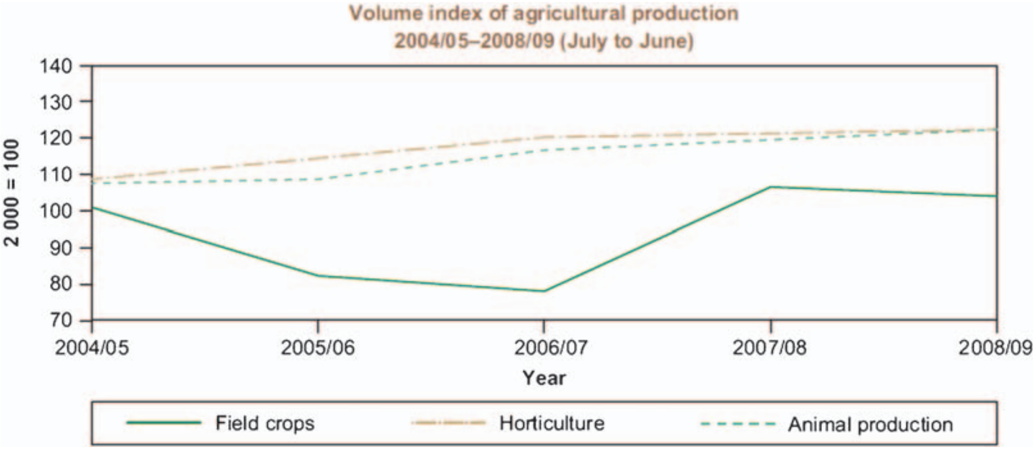

Figure 2. Volume of agricultural production (2004–2009)
Source: DAFF(2010:10)

nuts, flower bulbs, wool, soya bean, subtropical fruit, other livestock products and sunflower seed subsectors. The *dogs* or *pets* of the agricultural sector can be seen as the sisal, cotton, tobacco, tea, chicory root, mohair, dry peas and dried fruit subsectors – see Figure 3.

Although some of these subsectors do not have a big market share they are important in their contribution towards the value of agriculture. It is thus imperative to stimulate and protect these industries, some of which also have a very high labour multiplier and socio-impact.

Stars

	Sub Sector	Avg Growth	Market share
1	Fowls slaughtered	6.93%	17.18%
2	Maize	13.16%	12.51%
3	Cattle and calves slaughtered	10.24%	10.09%
4	Milk	5.48%	6.95%
5	Vegetables	8.28%	6.01%
6	Deciduous and other fruit	4.15%	5.93%
7	Eggs	7.56%	5.05%
8	Citrus fruit	8.86%	4.47%
9	Wheat	10.97%	3.81%
10	Potatoes	4.15%	2.98%
11	Hay	4.12%	2.93%
12	Viticulture	2.94%	2.53%
13	Sheep and goats slaughtered	5.74%	2.37%
14	Pigs slaughtered	11.02%	2.33%

Question Marks/ Problem Children

	Sub Sector	Avg Growth	Market share
1	Other livestock products	9.20%	1.94%
2	Sunflower seed	33.08%	1.82%
3	Subtropical fruit	2.43%	1.60%
4	Soya beans	23.97%	1.26%
5	Wool	6.04%	0.83%
6	Flowers and bulbs	0.53%	0.65%
7	Groundnuts	12.96%	0.55%
8	Dry beans	1.53%	0.41%
9	Grain sorghum	24.11%	0.36%
10	Barley	11.32%	0.34%
11	Ostrich feathers and products	3.52%	0.29%
12	Other field crops	12.08%	0.13%
13	Other horticultural products	21.64%	0.11%
14	Rooibos tea	14.86%	0.11%
15	Rye	111.97%	0.07%
16	Wattle bark	3.24%	0.06%
17	Nuts	3.65%	0.06%
18	Oats	18.10%	0.04%
19	Lucerne seed	80.98%	0.01%
20	Karakul pelts	10.77%	0.01%
21	Lentils	28.86%	0.00%

Real market growth > 0 %

Market share > 2.27%

Market share < 2.27%

Real market growth < 0 %

Cash Cows

	Sub Sector	Avg Growth	Market share
1	Sugar cane	-0.82%	3.38%

Pets/ Dogs

	Sub Sector	Avg Growth	Market share
1	Sisal	-37.96%	0.00%
2	Cotton	-10.92%	0.06%
3	Tobacco	-7.67%	0.20%
4	Tea	-4.17%	0.06%
5	Chicory root	-3.49%	0.01%
6	Mohair	-1.42%	0.16%
7	Dry peas	-0.85%	0.00%
8	Dried fruit	-0.54%	0.33%

Figure 3. BCG matrix for the South African agricultural sector (2009)
Source: Own calculation based on data from DAFF (2009)

However, large-scale investments are required to meet the projected costs of expanding the potential future growth path of agriculture, but, the financial resources for agriculture is indicating increasing gaps. Even the share of agriculture in official development assistance declined from 19% in 1980 to a current average of 6% (FAO,2010:24–25). It is a serious challenge for the state to deal with the problems of poverty and food insecurity (more than 20% have inadequate access to food) through the means of agricultural development (Mkokeli & Shoba,2011:1). The problem is the seemingly lack of consensus regarding the strategic role of SA agriculture in the future economic growth plans if the New Growth Path of the Economic Development Minister (to reduce unemployment to 15% in 10 years), the Planning Commission's Strategic Plan for SA; the IPAP2 in connection with the creation of export markets and the union's SA growth plans' programmes are considered (Radebe,2011:2).

5. Conclusions

It is evident that certain important subsectors struggle to perform and are likely to diminish even further if intervention does not take place. For example the effect of policy on the cotton industry resulted in a decreasing area planted from 90 000 hectares in 1995 to 7 000 hectares in 2009. On the other hand, the current surplus has enabled the maize industry to export a portion of its surplus of 4 million tonne. The government intervened here by finding markets for about 100 000 tonnes of maize in Saudi Arabia and India (Blom, 2011:38) - this after the Competition Commission initially prevented maize farmers from pooling the surplus for export purposes.

Classifying the position of the subsectors in the BCG matrix, must give way to decisions regarding what to do with them (Tutor2U, 2011) - subsectors can move from problem children to stars if the necessary support and action plans can be implemented to make them more competitive. A main concern regarding subsectors is competitiveness. Studies on competitiveness often err by only considering the output side of the agribusiness system (from farm to table) and thereby ignoring the possible impact the input sectors could have on the competitiveness of the agricultural industry. Relating to the matrix findings, and the balance of trade for agricultural products it challenges these subsectors to strategically position themselves according to the trend line and ultimately create and think value chain reaction (Esterhuizen et al: 2001) such as a 'double-positioning' strategy of food products.

The exhibition of different levels of vulnerability in the subsectors as indicated by the BCG matrix, show a real need for collaboration and differentiated policy responses that target these needs. The government should rather ensure an enabling environment for the sector through partnerships that focus on knowledge management and policy actions to perform competitively through private initiative.

This strategic positioning is not an isolated research project – it needs to serve as a basis for further research into the different subsectors to understand the drivers in the value chain to pro-actively react to ensure sustainability. An example in this regard is the fact that the fastest growth in the potato industry during 2003–2007 happened in the processed market expansion. There are many subsectors in the SA context that due to a lack of finances, resources and capacity are performing well below the potential yield that could be achieved. Some of the fundamental issues here are the distortion in some markets (Irish butter in SA retail is cheaper than the domestic product); stagnation in other subsectors like the fruit and vegetable industries (product development basically the same as 30 years ago) and adaption of the export initiative (Duvenhage,2011:1) and the adaptability to climate smart production.

The BCG matrix may serve as a starting point of discussing resource allocation among the various stakeholders. The agricultural sector has large multiplier effects in respect with forward and backward production linkages. Therefore research in this regard must focus on more than just the direct market impacts, but should also research the indirect impacts or the value added in the value chain processes as well because agricultural growth multipliers generally are three times as large as those for non-agricultural growth ((Hausmann & Klinger as cited *in* SACOB, 2007). The South African economy needs a much more aligned strategy in a largely underdeveloped agricultural potential, based on significant market opportunities and establishing an effective market information system.

About the authors

Christo Joubert

Christo Joubert (MBA, MSc (Real Estate), BSc Agric-Economics UP, BSc Agric-Economics UFS) started his career in 1997 at Outspan International as a business manager. He then joined Standard Bank and become specialized in agricultural finance, research and product development and grain marketing. After this he started up with colleagues a Grain Portfolio Management business. He joined Senwes in 2005 as a Risk manager and left the company two years later as a grain procurement officer. He continues his career at Absa as an Executive Relationship Manager. In 2009 he accepted a position as Senior Researcher at the Market and Economic Research Center of the National Agricultural Marketing Council (NAMC) in Pretoria. He does research in the ''Agro Food Chains'' focus area. In his private time he value agricultural properties. He is also a keen knife maker and hunter. He loves nature and is blessed with 3 beautiful daughters. Christo is joint author of one national and four international papers and three published articles in academic journals.

André Jooste

Prof André Jooste obtained his MSc (Agric)(Cum Laude) in Agricultural Economics at the University of Pretoria in 1996. He also worked at the University of Pretoria as lecturer, after which he joined Standard Bank of South Africa as Information Manager in the Agricultural Department. In 1998 he left the employment of the bank to accept a position as lecturer in the Department of Agricultural Economics at the

University of the Free State. He completed his PhD in 2001 and was promoted to Associate Professor in 2003. He was chairperson of the Department of Agricultural Economics at the University of the Free State from 2004 to 2006. On 1 January 2007 he joined the National Agricultural Marketing Council as Senior Manager in the Markets and Economic Research Centre.

He has extensive experience in conducting market, policy, rural and industry analysis. This includes, amongst others, implementation of management information systems, identification and use of applicable market research methodologies, compiling industry wide strategies, conducting surveys and value chain analysis. He also specialises in international trade issues and their implications from a country and firm point of view.

He has been involved in 33 scientific publications in academic and scientific journals. 17 Contributions have been made in books and technical reports. 68 papers have been presented at conferences, congresses, workshops and symposiums nationally, whilst 34 papers were presented internationally. 38 Popular scientific articles have been published. 59 Research and project reports on a variety of subjects have been completed, and more than 80 popular scientific papers have been presented at farmer's days.

Ronnie Lotriet

Ronnie Lotriet (Ronnie.Lotriet@nwu.ac.za) is Professor at the School for Economics, Risk Management and International Trade at Potchefstroom University. Programme Manager at the School for Economics. Author of more than 30 national and international articles and received numerous awards for training excellence. Prize winner for debut work & best paper award at a Management Conference. Attended the Convention for the commencement of the BEN-AFRICA (Business & ethics Network of Africa) Organisation. Currently the Programme Manager of the MBA, Potchefstroom Business School, North-West University and the Fundamental Management Programme leader as well. Hobbies include coaching rugby at a university as well as provincial level, and loves the outdoor life. Married with 2 children.

REFERENCES

BFAP see Bureau for Food and Agricultural Policy

Bureau for Food and Agricultural Policy (2010) *The South African Agricultural Baseline*. BFAP: Pretoria.

Blom, N. (2011) Business as usual. *Business Day Investors Monthly:* vol.2 (2):36–38. February 23–March 29.

Brigham, E. F. & Ehrhardt, M.C. (2005) *Financial Management Theory and Practice*. Ohio: R.R. Donnelley Willard.

Chaminuka, P., Anim, P., Debusho, L.K & Nqangweni, S. (2006) *The Impact of HIV & Aids on Agriculture and Food Security. The Case of Limpopo Province in South Africa.* (FANRPAN Working Document: Series Ref. Number: NAT SAA005. Prepared for FANRPAN by authors). [Web:]. http://www.fanrpan.org/documents/d00150/Agriculture_Aids_SA_2006.pdf. [Date of Access: 15/02/2011].

Collins, D. J. & Montgomery, C. A. (2005) *Corporate Strategy: A Resource-Based Approach*. New York McGraw-Hill/Irwin.

Department of Agriculture, Forestry and Fisheries *see* DAFF

DAFF (2009) *Abstract for Agricultural Statistics*. Pretoria: Department of Agriculture Forestry and Fishery.

DAFF (2010) *Strategic Plan For The Department of Agriculture, Forestry and Fisheries 2010/2011*. DAFF: Pretoria. ISBN: 978-1-86871-308-0.

Duvenhage, H. (2011) *Ipap2 gaan landbou weer tot kroonjuweelstatus verhef*. Sake24: 1. Februarie 2011.

Food and Agricultural Organization of the United Nations *see* FAO

FAO (2010) Climate Smart Agriculture. Italy: Rome. 41p. (Paper at the *Hague Conference on Agriculture, Food security and Climate Change*. 31 October to 5 November. 2010.)

Hausmann, R & Klinger, B. (2006) *South Africa's Export Predicament.* [Web:]. http://www.cid.harvard.edu/cidwp/pdf/129.pdf. [Date of Access: 15/02/2011].

CID Working Paper No. 129. 50 years of abysmal export performance:

Esterhuizen, D, Van Rooyen, C.J., Doyer, O.T. (2001) *How competitive is the South African Agricultural industry? Production, processing and inputs*. A report by the Agricultural Business Chamber, ABSA Chair in Agribusiness Management, University of Pretoria and the Agricultural Research Council. Pretoria. Agricultural Business Chamber.

Farflex (2010) *The Free Dictionary*. Growth Rate. Available from: http://financial-dictionary.thefreedictionary.com/CAGR/ (Accessed 3 July 2010).

Mkokeli, S & Shoba, S (2011) Zuma turns to state to generate more jobs. *Business Day*: 1. January. 10.

Mills, G. (2011) New, new growth path will only survive on political will. *Sunday Times Review*: 7. January. 30.

Moss, D.A. (2007) *A Concise Guide to Macro-Economics*. Harvard Business School Press:Massachusetts. 189p.

North-West Provincial Government *see* NWPG

NWPG (2008) *Environment Outlook*. [Web:] 2008. http://www.nwpg.gov.za/Agriculture/NW_ENVIRONMENTAL_OUTLOOK/chapter.asp?CHAPTER=3&PAGE=4&TITLE=Conclusion. [Date of Access: 15/02/2011].

Organisation for Economic Co-Operation and Development: see OECD

OECD (2006) *Review of Agricultural Policies: South Africa*. Paris: OECD.

Ortmann. G.F. (2005) Promoting the competitiveness of South African agriculture in a dynamic economic and political environment. *Agrekon,* 44(3). September.

Quickmba.com. (2010). BCG Growth-Share Matrix Available from: http://www.quickmba.com/strategy/matrix/bcg/ (Accessed 3 July 2010).

Radebe, H. (2010) State failing to assist emerging farmers. *Business Day*: 2. November. 17.

Radebe, H. (2011) Agricultural sector left in the lurch. *Business Day*: 2. January. 1.

SACOB (2007) Land Reform in South Africa & Selected issues. [Web:] http://www.authorstream.com/Presentation/Herminia-30163-SACOB-Land-Reform-South-Africa-Selected-Issues-Outline-role-agriculture-growth-poverty-reduc-in-as-Entertainment (ppt-powerpoint presentation). [Date of Access: 20/02/2011].

Thompson, A. A. & Strickland, A. J. (1995) *Crafting & Implementing Strategy. Text and readings.* United States of America. Richard D. Irwin, Inc. Oakland.

TUTOR2U (2011) *Product Portfolio Strategy*. [Web:]. http://tutor2u.net/business/strategy/bcg_box.htm. [Date of Access: 20/02/2011].

Van der Merwe, A. & Otto, R.J. (1997) International marketing developments and the effects on South African agriculture. *Agrekon* .36(4): 434–452.

CONFERENCE PAPER[1]

Rural household capacity building: Innovative approaches to ensure adoption of record keeping by farm households

IVY DRAFOR[2]

ABSTRACT

Externally designed strategies for improving the farm enterprise and reduce poverty among rural households may not produce desired results. For farm households to adopt economic approaches such as record keeping and management, innovative approaches that are participatory and which build on their indigenous knowledge are better. The value of farm level record keeping has been known for many decades now, yet many farmers in developing countries do not keep records. This paper presents the outcome of using innovative approaches that involved a rural community in a rural Ghanaian community. This research used consultation, village level meetings and participatory approaches to design user-friendly systems. This resulted in systems with which they can cope and which continued after the programme was over. There is the need to improve rural livelihoods by building on indigenous knowledge and using approaches that achieve greater productivity, efficiency, equity, profitability and sustainability. The findings show that rural households are knowledgeable and have the ability to decide on data collection formats that suit their needs.

KEYWORDS: High value markets; participatory approaches; Ghana; farmer decision-making; household economic management; indigenous knowledge

Introduction

Ensuring that rural households adopt approaches that enhance their income situation depends on the methods used. For rural households to adopt economic approaches such as record keeping requires innovative approaches that are participatory and which build on their indigenous knowledge. This has implications for achieving poverty reduction, which depends largely on what poor rural communities are able to do for themselves. Gillespie (2004) asserted that poor people are prime actors in the development process, not targets of externally designed poverty reduction efforts. The cornerstone of community-based development initiatives is the active involvement of a defined community in at least some aspects of project design and implementation (Mansuri and Rao, 2004). Presenting structured programmes to rural people does not produce sustainable outcomes because communities are aware of their desired developmental goals and embrace initiatives that reflect such goals. With high rural poverty in Ghana, there is the need to improve rural livelihoods by building on indigenous knowledge and using approaches that achieve greater productivity, efficiency, equity, profitability and sustainability (PEEPS).

The value of farm level record keeping has been established for several decades now. However, many farmers do not keep records, especially in developing countries. A variety of efforts have been made in the past to ensure that rural households keep records in Ghana, yet many do not do so. Capacity building programmes that enable farmers in making informed decisions need to focus on the availability of timely and adequate data – both externally provided and internally generated within the farm household. As James (2002) described it, if capacity building is a process, then learning must be at the heart of that process. Data on farmers' own economic activities helps them determine the profitability of the various enterprises, and make decisions to concentrate on those that result in maximum benefit for the household. Though rural people can do very little about the global production environment and adverse weather conditions, they can be responsible for making economic decisions and in managing their financial resources effectively.

Farm level record-keeping is mostly found among large-scale farmers in Ghana but rare among small-scale farmers. Many of the initiatives used to reach farmers with this economic technique failed because of low levels of adoption, high cost of supervision, and farmers' inability to cope with the systems, which were developed with limited community involvement.

[1] This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

[2] Methodist University College, Ghana

This paper presents the findings from an innovative initiative to ensure the adoption of record keeping approaches in a rural community in Ghana, which used participatory methods to build on their indigenous knowledge. It presents the process used to design user-friendly record keeping systems with the rural households, moving from what they knew to what was not well known, which ensured sustainability of the system. This initiative was designed as a supporting activity in a community in which the World Vision Ghana had been involved with the provision of portable water. It was realised that the effective management of economic resources was important for enhancing the livelihoods of the community members in a sustainable way. The paper shows that getting to rural communities with already prepared systems may not lead to sustainable adoption levels and documents reasons for success in approaches used. This project serves as an example for future developmental programmes and in promoting similar programmes in other locations.

Community Capacity Building

Many countries still struggle with getting farmers to keep records, yet record keeping has the potential of empowering rural households. Though these skills are not new, acquiring them is an added ability, and enables them to make informed and economically responsive decisions that can lead to reduction of poverty. The next few years will see much more detailed reporting of agricultural chemical use (Frisvold, 2000) especially with the increasing concerns about climate change and meeting the millennium development goal of ensuring environmental sustainability. Besides, record keeping at the farm level has become complex because more and more information is being required by importers to satisfy retailers (Fulponi, 2007). The most difficult task of Vietnam's efforts to improve small farmer access to export markets through attainment of group EUREPGAP certification was getting farmers adopt record-keeping practices (Thao, et al, 2010). In accessing the success and failure factors of several small farm initiatives, Fulponi (2007) identified record-keeping as a key element.

Efforts to extend the techniques to as many farmers as possible must be intensified at regional, district and local levels. Inability to keep records leads to the inability of small farmers to meet export requirements and to access local high value markets such as supermarkets and hotels. According to Crane (2010), a major management challenge is to collect, sort, and use accurate information for decision-making, while ignoring volumes of useless, time-consuming and erroneous information. He added that although information is power, record keeping is not particularly exciting and has few immediate tangible benefits.

Data collected at farm level can become a valuable tool for regulating input use, natural resource management, and ensuring product quality for meeting quality demands of high value markets (supermarkets and export markets). A system can be created in future to make data collected at the farm level available for wider use. First, it makes it possible to link farmers to input providers in new and dynamic ways. Second, it could increase the confidence of high value markets in the produce from the community as information about the production practices becomes available. Third, it gives opportunities for more targeted support, which can further develop the capacity of the participating households. Eventually, the systems of data collection can be improved and made uniform for effective planning at the household, community, district and national levels. A good monitoring system of chemical use by small-scale farmers can be another benefit.

Vollmers and Tyson (2004) are concerned about studies in accounting focusing on large companies and institutions and revealing few insights about the working life of farmers, villagers and the rural populace. Frisvold (2000) stated that farmers are coming under greater competitive pressure to keep much better track of where and when they use material inputs, making record-keeping become even more critical.

The Training Workshop

The interest and willingness of households was particularly important and this formed the basis for household selection. The households would be part of the design of the systems, ensure continuity of the programme, and help evaluate them for improvement and wider use. The activity was carried out in the Watro community in the Atebubu district of Ghana. World Vision Ghana and the Agricultural Extension Agents (AEAs) facilitated the village entry dynamics. They made the initial negotiations with the community to determine their interest and willingness and planned the community meetings based on dates suitable for everyone.

Participatory adult learning approaches were used at community meetings to first document their indigenous knowledge and traditional systems of keeping data before the 'new' systems were designed. The activities engaged both men and women. The participants used role plays to show the importance of information documentation and to enhance the learning process. The designed systems made minimal demands on literacy. The methodology seeks to understand the preferred approach from the perspective of the rural households themselves, resulting in increased commitment and ownership of the process.

Several more families joined the training and it was difficult to restrain them. They were willing to purchase their own cashbook. The record-keeping activity was carried out in families with each member participating either by providing the information or doing the recording. Watro was known as a progressive community in the district and plays prominent roles in their annual Yam festival celebration. At the time of the project, there were 144 households with an estimated 482 registered adults of eighteen years and older. Agriculture is the major economic activity in the community with most adults engaged in some form of farming. Non-farm activities were also present. Their major crops are yam, cassava and groundnuts, with vegetables and some tree crops found in the farming systems. Though the community is a remote community and difficult to access by road, it produces a lot of food for urban populations.

Recording Systems

The records to be kept were discussed thoroughly and how the data should be kept. Cashbooks were used for recording because they are cheap and available in nearby markets. The use of pocket notebooks was encouraged for keeping information on activities that occurred outside the house. It was discovered that rural households have the ability to translate their indigenous knowledge into practical systems that can be used on a sustainable basis.

A group assignment was given for participants to categorise the costs of farm enterprises and the results presented the following day. Presentations were made to the plenary and some groups presented their work in written form. Participants then agreed on the formats for recording information for crop enterprises. Various types of expenditure were to be recorded on one page and the various kinds of revenues, incomes and receipts were to be recorded on another page. Care was to be taken in intercropping situations in order to allocate the costs to the various crops. Information about assets and farm implements were to be recorded on a separate sheet because they are likely to be owned by the farmer for more than one year. Flexibility was encouraged so they could use systems that they find convenient and understandable. Some participants demonstrated the calculation of profit and loss to the whole group. Female participants were very active and freely expressed their views.

Moving From the Known to the Less Known

Mansuri and Rao (2004) had shown that the key objective of participation is the incorporation of local knowledge into the project's decision-making processes. Initial discussions with the households showed that most of them kept mental records. Some of the participants indicated that they have used symbols, wrote on calendars, transferred knowledge by mouth from one generation to another, recorded in notebooks and consulted educated family members and friends to assist. Further discussions and role plays helped reveal some limitations of keeping records mentally, which include forgetfulness and inability to capture small costs and revenues. They recognised the need for a better way that could be more comprehensive and serve as a reference document.

The research team then introduced the concept and importance of record-keeping. They were encouraged to see their farming as a business by planning, properly organising their activities, keeping records and adopting demand-driven production practices. Mixed views were expressed on what constitutes a business. Discussions among participants led to the conclusion that any activity undertaken to make a profit is a business and that includes farming. Everyone agreed that it is good to know that one is making a profit and the ability to measure the level of the profit was necessary.

The formats for recording information on assets, costs, and revenues were agreed upon after several deliberations. Some participants indicated that they were previously not recording items such as feeding costs for labour employed but now realise it was a large expense being overlooked. Traditionally the farmers used output as a measure of profit and treated all revenue as profit without subtracting expenditures. They claimed that the initiative led to increased transparency and therefore united families.

The use of Role Play

Three groups were formed and each group given a role play scenario to discuss and share lessons learned with the rest of the participants. The role plays were adapted from an FAO manual (FAO, 1994). The scenarios were later converted into short skits, which were performed at various stages of the meetings. These plays were highly enjoyed and extensively discussed, resulting in increasing understanding of critical issues regarding record-keeping and its benefits.

The scenario for the first group was about a woman who was actively engaged in trading, but did not record anything. When it was time for her to pay her child's school fees, she realised that although she traded, she did not have enough money to pay the education expenses. She became confused and did not know what to do. Lessons learnt from this scenario included the need to keep records of trading activities to know whether one was making profit or losses. Another lesson was the need to keep records of household expenditure as it will help in planning. Not keeping records left her wondering about what might have happened to her money. She could not plan and was therefore not ready for very important expenditure items. The woman was said to have family problems due to poor record keeping. In effect, they understood that record keeping is vital for household level planning.

The second group's scenario was the sale of a piece of furniture on credit without any records. A carpenter sold the furniture to a woman on credit for fifteen thousand cedis (Ghana's currency). Later when the woman came to pay, she brought thirteen thousand cedis, arguing that they had agreed on that amount. This resulted in a disagreement and a dispute between them. Lessons learned from this scenario included the need to keep records, to serve as evidence for business transactions and the need for traders to put price tags on their goods.

The third group's scenario involved a group that had decided to undertake baking activities together with the aim of generating income. Within this group, there were the bakers, those who sold the raw ingredients for baking and those who bought the raw materials. The group had a treasurer who did not keep records. Any money which was collected or brought was not recorded because the group had total trust in the treasurer. When the time came to render accounts, the group was surprised to find less money than they had expected and this generated a dispute within the group. Lessons learnt from this role play included the fact that no one can be totally trusted when it comes to money and it is important to record every transaction within any group. They showed the need to put order in any group so that people will act according to rules not by their own will.

They balloted for the position in performing the skits. The lessons learnt after each skit was the result of a general discussion and the importance of record keeping that was emphasised in the skit. Credit was raised as an issue and its importance was explained as well as situations that could require late payments, deferred payments, and borrowing and how such records should be kept. Family members were encouraged to support each other in keeping the records. Generally, it was concluded that records are needed in all economic activities. They help in planning and serve as evidence that can avoid disputes.

Strengths of the Approach to Record Keeping

This approach and the aspect of flexibility may not make the records identical for achieving aggregate data for use in regional and national level policy making. However, the benefit to the farmer who keeps the records using a system with which they can cope outweighs the potential benefits of wider use, at least in the short term.

The initiative has the potential for achieving collective empowerment, connecting individuals within a household with each person having a clear conception of their roles (Kirk and Shutte, 2004). Both parents and children are actively engaged in the recording process. According to Miller (2003), young people are competent citizens and have the capacity to engage in local issues. The use of participatory methods increases the engagement of young people and their active participation in the programme confirms this.

Field results show that record-keeping is necessary for planning both at individual and family levels, for trust building, for improvement in knowledge, and for creation of harmony in society as it can reduce disputes. Frisvold, (2000) noted that a key to using inputs more efficiently is information. He argued that improved information systems and the use of precision technologies will allow farmers be able to monitor their field conditions closely and use inputs more efficiently. Records help the rural farmers in estimating profit and loss of their economic activities and in recalling past ones. In handing over farming activities from one generation to another, records become particularly important. As such, it helps in generational capacity building.

Records are important for strengthening rural community based organisations and can result in effective lobbying and advocacy. Without farm level records, how could governments understand the nature of the small-scale farmer and the challenges faced by this group of people. Personal accounts provide a window into the working life of families who have to combine a variety of activities to ensure a descent livelihood (Vollmers and Tyson, 2004). It is worthwhile exploring options of extending record-keeping initiatives to many rural communities in Ghana and other developing countries.

Conclusions

The importance of farm records cannot be overemphasised. The benefits for the farmer, the researcher, NGOs, governments and donor agencies are many. But why are so many small-scale farmers not keeping records though the concept has been introduced to them? Using an approach that involves rural communities and builds on their indigenous knowledge can result in the adoption of economic concepts. Strategies that do not involve community members cannot ensure ownership of the process and its sustainability.

The initiative discussed in this paper was used to improve the welfare of the rural people and enable them to become better managers of their financial and natural resources. Policies intended to benefit the agricultural sector may not be relevant to the sector if they are not based on appropriate information from the field. The outcomes of the workshops used in this research show that rural households have the ability to decide on data collection formats that suit their needs and with which they can cope. Rural households are very knowledgeable and need to be part of development programmes designed for them. Gillespie (2004) puts it as ''poor communities have greater capacity than generally recognized''. The ability of rural households to keep and analyse simple financial information on their economic activities can lead to improved livelihoods.

About the author

Dr. Ivy Drafor (ivydrafor@yahoo.com) has a B.Sc and M.Sc. from the University of Guelph, and a PhD from University of Ghana in collaboration with Cornell University. She has been on full-time university faculty since 1995 and has carried out research on food security, gender and farming systems, water and sanitation for persons with disabilities, and community development initiatives. She is concerned about issues in rural development and the progress of the rural populations. She has led research initiatives, working with interdisciplinary and inter-institutional teams as a consultant for national and multinational organizations. Dr. Drafor is a 2008–2010 African Women in Agricultural Research and Development (AWARD) Fellow, which is under the Consultative Group for International Agricultural Research (CGIAR)'s Gender Diversity Programme. She has published a number of articles and made presentations at national and international conferences. She spent about six months at the University of Pretoria as a Post-doctoral fellow.

Acknowledgements

The author is thankful to the World Vision and NARMSAP for their great support and to the Hilton Family for financial support.

REFERENCES

Crane, Laurence M. (2010). ''Record-Keeping: Essential to Risk Management''. National Crop Insurance Services, Inc. Accessed, May 20, 2010. http://agmarketing.extension.psu.edu/ Business/PDFs/RecrdKeep.pdf

Gillespie Stuart (2004). ''Scaling Up Community-Driven Development: A Synthesis Of Experience.'' FCND DISCUSSION PAPER NO. 181. International Food Policy and Research Institute., Washington D.C.

FAO (1994). Simple Book-Keeping Business Skills: Facilitator's Guide. FAO – Rome.

Frisvold, George B. (2000). ''Data, Information, and Rural Environmental Policy: What Will the Next Ten Years Bring?'' *Review of Agricultural Economics*. Volume 22(1): 237–244

Fulponi, Linda (2007). ''Private Standard schemes and Developing Country Market Access: Findings from 4 case studies.'' Joint UNCTAD/WTO Informal Information Session on Private Standards. June 25, 2007.

James, R. (2002) People and Change: Exploring Capacitv Building In NGOs, INTRAC, Oxford.

Kirk, Philip and Anna Marie Shutte (2004). ''Community leadership development''. *Community Development Journal*. Vol 39 (3):234–251.

Mansuri, Ghazala and Vijayendra Rao (2004). ''Community-Based and Driven Development: A Critical Review''. World Bank Research Observer. Vol 19(1):1–39

Miller, Chris (2003). Editorial. Community Development Journal. Vol 38 (4):275–276.

Opare, Service (2007). ''Strengthening community-based organizations for the challenges of rural development''. *Community Development Journal*. Vol 42 (2)251–264

Thao, Nguyen Phuong, John E. Bowman, John Campbell, and Nguyen Minh Chau (2010). ''Good Agricultural Practices and EUREPGAP Certification for Vietnam's Small Farmer-Based Dragon Fruit Industry''

Vollmers, Gloria and Thomas Tyson (2004). ''A personal account book of Joseph E. Bell: a record of survival in nineteenth century rural America'' *Accounting History*. Vol 9 (2004): 89–109

CONFERENCE PAPER[1]

Demonstration farms and technology transfer: the case of the Lincoln University dairy farm

M.C. PANGBORN[2], K.B. WOODFORD[2] and P.L. NUTHALL[2]

ABSTRACT

In 2001, Lincoln University and six commercial, education and research partners established a 161 hectare dairy farm (milking platform) and formed the South Island Dairy Development Centre (SIDDC) to demonstrate 'best practice' for South Island dairy farmers. In 2008, to assess the impact of the Lincoln University Dairy Farm (LUDF), a survey was sent to 622 farmers located in the LUDF extension catchment. Responses totalled 146 (24% response rate). The mean age of respondents was 45 years with 77% having some form of tertiary education. Respondents had higher milksolids production per cow (419 kg) and per hectare (1441 kg) than the Canterbury averages (381kg and 1224kg respectively). Most respondents (86%) identified themselves as using moderate levels of supplementary feeding (Systems 2, 3, 4).

Nearly 70% of respondents attended at least one focus day (field day) over a three year period. Most attended to learn about grazing and animal management, to benchmark against the LUDF from a production and financial standpoint, and to learn about environmental management. Focus day attendees had larger operations and higher levels of productivity than those who never attended. Over 68% of respondents visited the farm website each year, with some visiting more than 30 times, but mainly to view benchmarking data rather than to learn about new technologies

Of the technologies promoted by the LUDF, 82% of farmers had adopted low grazing residuals and 74% had re-grassed paddocks based on monitoring. Lower numbers had adopted synchronisation of heifers to calve a week before the main herd (29%), aggressive hormone intervention for non-cycling (42%) and a nil induction policy (36%). Over 70% felt that the adoption of some of the LUDF technologies had made their farm management easier. Twenty three farmers were willing to place an economic value on the adoption of LUDF practices. These ranged from NZ$50,000[3] per year to NZ$1,000,000 per year.

It is concluded that a demonstration farm with clearly defined extension messages can be effective at achieving farmer adoption and that adoption is high for messages where farmers see clear economic advantages, and that farmers obtain information from a wide variety of sources.

KEYWORDS: Dairy demonstration farm, technology transfer, farmer adoption

Introduction

The number of dairy farms in the North and South Canterbury regions of New Zealand (NZ) grew from 247 to 689, between the 1988–89 season and the 2006–07 season; cow numbers grew from 81,014 to 467,061 during this period (LIC 1988/89 & 2006/07).

In 2001, Lincoln University converted a 185 hectare (ha) dry land sheep property to an irrigated dairy farm with a milking platform of 161 ha. At this same time the South Island Dairying Development Centre (SIDDC) was formed consisting of six commercial, education and research partners. Management of the Lincoln University Dairy Farm (LUDF) was delegated to SIDDC with the aim of fostering best practice to South Island dairy farmers. Since formation, a number of management techniques have been trialled and results reported at focus days (field days), in the media and via the www.siddc.org.nz website. Financial data and benchmarks have been provided for the use of the industry. The LUDF had hosted over 13,000 visitors through to the end of 2008. Focus days are typically attended by between 200 to 400 farmers and other agribusiness personnel.

The farm runs a high stocking rate system with over 4 cows/ha, producing between 1,700 to 1,800 kg of milk solids (ms) per hectare from a low input system. In the 2005/06 season, this resulted in the harvesting of

[1] This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

[2] Agricultural Management Group, Lincoln University.

[3] Approximate currency conversions at 13 July 2011: 1 NZ$ is equivalent to US$0.83 and £0.52.

approximately 16t dry matter (dm) of pasture per ha and an operating profit of NZ$2,240[4]/ha at a NZ$4/kg ms payout. This compared favourably with the industry's 'Dairy Base' benchmarks which showed an average operating profit of NZ$1,406 for the Marlborough/Canterbury areas (personal communication, van Bysterveldt and Christie 2006[5]).

The key objectives for the LUDF as listed on its website (SIDDC 2007) were:

1. To develop and demonstrate world-best practice in dairy farm systems and to transfer them to dairy farms throughout the South Island;
2. To operate as a joint research centre with DairyNZ[6], where the practical application of new technologies and on-farm forage production systems can be tested and developed;
3. To use the best environmental monitoring systems to achieve best management practices under irrigation, which ensure that the industry's 4% productivity gain target is achieved in a sustainable way and that the wider environment is protected;
4. To continue the environmental monitoring programme and demonstrate technologies that will ensure that the 3-year rolling average concentration on nitrate-N in drainage water from below the plant root zone remains below the critical value (16mg N/L) that is specified in Environment Canterbury's (ECan) proposed regional rule as requiring reduction (Rule WQL18);
5. To operate an efficient and well organised business unit.
6. To provide a commercial return on adjusted capital value to Lincoln University, and a defined benefit to each of the stakeholders;
7. To create and maintain an effective team environment at policy, management and operational levels;
8. To assist Lincoln University to attract top quality domestic and international students into the New Zealand dairy industry.

In June of 2008, a postal survey was conducted of dairy farmers in the LUDF's catchment area. The objective of the survey was to determine the demographics of farmers in the area and to gauge whether farmers had adopted the technologies demonstrated by the LUDF.

Methodology

The Livestock Improvement Corporation (LIC) provided a mailing list of dairy farmers in the prescribed areas. Nearly all farmers deal with the LIC in terms of herd testing, herd recording and/or artificial insemination of their herds. Initially 689 contacts were identified by the LIC; however this was reduced to 622 through the elimination of multiple ownership farms. A four page questionnaire was prepared by SIDDC and staff from the Agricultural Management Group at Lincoln University. The questionnaire was reviewed by Consulting Officers and Business Managers from DairyNZ and a select group of dairy farmers. The Human Ethics Committee of Lincoln University reviewed the proposal and approval was granted on June 16, 2008.

A total of 146 responses were received by August 1, 2008 (24%). The data was analysed by staff in the Agricultural Management Group of Lincoln University using the software SPPS 15. Reported correlations are significant at $p<.05$ unless denoted otherwise.

Results

Demographics

The majority of respondents identified themselves as Owner/Operators (73%), with 50/50 Sharemilkers constituting 17% (a system where the sharemilker owns the cows) and the balance farm managers. A large proportion (43 %) had attended University, with a further 24% receiving training after high school through Polytechnics or the Agriculture Industry Training Organization. The mean age was 45 years and 81% lived within 150 kilometres of the LUDF.

The farmers' milking platform ranged from 50 hectares to 1,400 hectares, with 239 hectares being the mean. Cows milked ranged from 130 to 5,000, with a mean of 611. The average cow as estimated by farmers weighed 480 kg, which would indicate that the majority of herds were tending towards Friesians. However, 38% of farmers believed that their cows weighed less than 400 kg which indicates that these herds have a Jersey base.

Production per cow averaged 419 kg ms and the farms produced 1,441 kg ms per ha. An average for the areas derived from LIC 2006–07 statistics, shows production of 381 kg ms per cow and 1,224 kg ms per ha.

In New Zealand it is common to classify farm intensity according to the levels of supplements imported to the property (Dairy NZ 2010, p. 5) during the milking season (not including feed or grazing for young stock). Most farmers (35%) felt they were running a system 3 farm (10% to 20% imported feed). As farm systems intensified from system 1 (no imported feed) to system 5 (25–55% imported feed), the farms milked more cows, produced more ms per cow and more ms/ha. As systems intensified, farmers were less likely to attend LUDF Focus Days to learn about grazing and animal management techniques.

The number of cows milked and hectares farmed were both significantly correlated with level of education and the number of cows milked and hectares farmed. Age and lower educational achievements were both negatively correlated with ms/ha. Ms/ha increased with herd size.

When asked to rate seven possible reasons for farming from 1 (very important) to 5 (not at all important), the highest rated were "cash profit" and "being their own boss" (Table 1).

Those farming for capital gain had a significant negative correlation with the aesthetic side of farming (lifestyle, quality stock, good place for a family).

The majority of respondents (68%) used the services of a professional consultant.

[4] XXXXXX
[5] Adrian van Bysterveldt was the DairyNZ Business Developer assigned to the LUDF and Richard Christie was the Business Manager of SIDDC
[6] DairyNZ is the industry good research and extension body in New Zealand

Table 1: Reasons for farming (percentage of respondents)

	1	2	3	4	5	Mean rating
Cash profit	64	27	7	2	0	1.47
Own boss	61	27	8	4	1	1.57
Lifestyle	43	35	17	3	2	1.85
Family	47	30	15	7	1	1.85
Quality stock	42	35	19	3	1	1.86
Working outside	39	30	23	6	3	2.03
Capital gain	36	29	31	2	3	2.08

1= highly important, 5 = not at all important

Awareness of the messages of the LUDF

For the purpose of the survey, staff associated with SIDDC identified a number of messages that they felt had been stressed by the LUDF in its extension activities. Farmers were asked to identify awareness of these messages by indicting 'yes or no' (Table 2).

Table 2: Percentage of farmers indicating awareness of LUDF extension messages

Low grazing residuals	89%
Pasture monitoring	80%
Nutrient and environmental management	64%
Irrigation monitoring	47%
Re-grassing of pastures based on monitoring	41%
Use of reproductive technologies (treating anoestrus cows, synchronizing heifers	34%
Once a day milking during calving	21%
Once a day calf feeding	9%

Farmer's interaction with the LUDF and other sources of information

An analysis of LUDF focus day attendance over three seasons (Table 3) showed that in each season over 30% of respondents did not attend any focus days. A very small percentage attended all four focus days in a season.

Of those participating in Focus Days, 80% indicated that they attended to learn about farming with low grazing residuals, 79% to learn how the LUDF is performing, 76% to compare their farms to the LUDF, 65% to learn about environmental management at the LUDF, 61% to learn about the latest animal management techniques, 58% for the financial information provided, 36% to meet other farmers and have a day off of the farm and 13% to meet agri-business personnel.

Table 4 analyzes information from those who had attended the focus days at least once over the three years versus those who had not attended the focus days. Dairy farmers attending had larger farms, milked more cows and had higher levels of production.

Not used	32%
1–10 times	42%
11–20 times	8%
20–30 times	4%
more than 30 times	15%

SIDDC operates a website which provides information on the operation of the LUDF, including the weekly farm walks, data collected and financial performance. Farmers indicated that their usage of the website during a year was as follows:

Although there was a positive correlation to attendance at field days and use of the website, those visiting the website did not do so to learn about the LUDF messages, but rather to monitor how the farm was performing.

Respondents were asked to rate seven sources of information for their contribution to the farmers learning about new technology and innovations using a scale from 1 (very important) to 5 (not at all important) (Table 5). All sources were rated highly except for sales representatives.

Have farmers adopted the messages?

Low grazing residuals as practiced by the LUDF have been adopted by 82% of respondents, although 15% of

Table 3: Attendance at LUDF Focus Days (percentage attending number of days)

year	0	1 day	2 days	3 days	4 days	Mean
2005–06	32	23	20	18	6	1.4
2006–07	35	19	24	20	2	1.4
2007–08	37	32	19	8	4	1.1

Table 4: Demographic and production levels of farmers attending and not attending LUDF Focus Days

	Ha farmed	Cow numbers	Ms/cow	Ms/ha
Non-attenders (n=29)	211	686	401	1,370
Attenders (n=113)	247	856	422	1,454
Difference	+36 ha P<.20	+170 cows P<.08	+21 kg ms/cow P<.03	+84 ms/ha P<.17

Table 5: Farmers rating of sources of information (percentages).

Source	Responses (n)	Percentage for each rating level					Mean Rating
		1	2	3	4	5	
Demo. farms	135	33	40	20	4	4	2.09
DairyNZ	136	32	44	17	1	7	2.10
Other farmers	134	31	36	26	6	1	2.10
Media	135	31	31	26	7	5	2.25
Consultants	138	28	38	17	9	9	2.36
Conferences	131	22	33	31	10	5	2.44
Sales reps.	131	5	16	24	20	36	3.69

1= highly important, 5= not at all important

the survey respondents said that they had always followed this technique. Ten respondents did not follow the practice as they felt that their cows would not be fully fed.

Re-grassing based on the measurement of poor performing paddocks had been adopted by 74% of respondents; however 25% of respondents included as adopters reported that they had always re-grassed. It appeared from the answers provided, that the question may have been mis-read as "Do you re-grass", rather than "Do you re-grass based on the measurement of poor performing paddocks.

The policy of synchronizing heifers to calve one week before the herd had only been adopted by 29%. Those who had adopted the process did so to get heifer calving finished early and to give heifers more time to cycle. The main reason for not adopting was that heifers are grazed off the property and it was considered too difficult to operate a synchronisation programme, although a number reported that they did "not believe in the practice". There were positive correlations between synchronizing heifers to calve early, those who use the website and those who use consultants.

In regards to the use of hormone technology to treat non-cycling cows, 42% follow the LUDF aggressive intervention system while 58% did not. Of those following the system, nearly 50% of farmers reported that they did so to maximize cycling, conception rates and/or condense calving. Of those not following the practice, 10% of farmers said it was too expensive, 27% did not believe in the practice, 14% felt that they achieved good reproductive results through "breeding and feeding", 14% used other methods such as once-a-day (OAD) milking, teaser bulls, etc. and 6% said that they do not have a reproductive problem in their herd.

The LUDF nil induction policy had been adopted by 36%, with the remainder continuing to use inductions as a tool. Of those adopting nil induction, 39% did so because they were philosophically opposed for animal welfare reasons. Those inducing said that they used the practice to "tidy up" the calving interval, grow herd numbers and reduce cow wastage. A number of sharemilkers pointed out that they needed to induce, as sharemilkers consider cows their wealth.

Twenty three farmers were willing to put an economic value on the adoption of the LUDF practices. These farmers felt that they had increased income from between NZ$50,000 and NZ$1,000,000 through the adoption of the various technologies.

When asked whether the adoption of LUDF technologies had made farming easier or harder, 70% felt that it had made management easier with most of the comments supporting low grazing residuals and pasture monitoring. A number of those who said it made management more difficult also commented that it was worth the effort.

Discussion and Conclusions

Given the overall response rate of 24% to the mail out, some caution is appropriate in drawing conclusions relating to the total population of Canterbury dairy farmers. However, it is clear that those who did respond can be characterised as, in general, well educated high performing farmers who have a strong focus on cash returns and who access information from diverse sources. Amongst those information sources, the LUDF, Dairy NZ events and 'other farmers' all rated highly. Focus days and the use of the SIDDC website are complementary information sources with 68% using each. Whereas the focus days are used primarily for appraisal of appropriate technologies, the website is used primarily for ongoing benchmarking of performance, particularly relating to pasture management. Farmers are discriminating in their adoption of technology, with adoption being high for technologies that are seen as giving clear economic payoffs. Farmers who responded to the survey have larger farms, higher production per cow and higher production per hectare that industry averages for Canterbury and of those who responded; farmers who attend at least some focus days have larger farms, higher milk production per cow and higher production per hectare than non-attendees.

About the authors

The authors are based at Lincoln University, Agricultural Management Group, Lincoln University, Lincoln 7647. Marv Pangborn (marvin.pangborn@lincoln.ac.nz) is a dairy farmer and part-time lecturer in Farm Management at Lincoln University. Keith Woodford is Professor of Farm Management and Agribusiness at Lincoln University. Peter Nuthall is a part time Research Fellow and former Associate Professor within the Agricultural Management Group at Lincoln University

Acknowledgements

The following provided valuable input into this survey: R. Christie, M. Lyne, A. Steed, A. van Bysterveld.

Project funding was provided by the South Island Dairy Development Centre.

REFERENCES

DairyNZ. (2010). Facts and Figures—for New Zealand farmers. Retrieved from www.dairynz.co.nz/file/fileid/31361 Accessible only from New Zealand.

LIC. (1989). *Dairy Statistics 1988–89*. Livestock Improvement Corporation, Hamilton, N.Z.

LIC. (2007). *Dairy Statistics 2006–2007*. Livestock Improvement Corporation, Hamilton, N.Z.

South Island Dairying Development Centre (SIDDC) (2007). *Lincoln University Dairy Farm Key Objectives.* www.siddc.org.nz/lincolnuniversitydairyfarm/ludf.html [accessed August 2, 2008]

CONFERENCE PAPER[1]

Complementing tradition, managing change: using communication technology to connect an industry; the case of AGRIWEBINAR™

HEATHER WATSON[2]

ABSTRACT

It is a significant challenge to be successful farming in Canada today. In an ever-changing and increasingly competitive global environment, the Canadian agricultural industry faces the impacts of international competition and trade negotiations, evolving regulations, climate change, shifting consumer demographics and trends, rapidly evolving technology, competition for qualified human resources, and environmental concerns, to name but a few challenges.

Much of the solution to deal with these intensifying realities lies in applying proven business approaches and methodologies, coupled with emerging innovative business thinking. Indeed, producers require the appropriate resources and tools to capture opportunity – to anticipate, respond to, and plan for change.

However, it is not enough to have the facts and figures; rather, appropriate delivery mechanisms for these resources become equally essential to making the information transferrable and more importantly, applicable. Effective communication of proven business practices with tangible benefits will motivate the sector and empower managers to reach for new heights.

This paper focuses on the ever-increasing importance of farm business management – communicating best practices to secure a sustainable and profitable future for Canadian farmers and agriculture at large, using online technology as a means to increase reach and impact, whilst complementing traditional means of information dissemination. The paper seeks to prove delivery is essential to and can greatly enhance content. Specifically, the Agriwebinar™ system exemplifies the importance and benefits of using communication technology to disseminate and encourage farm business management best practices. Agriwebinar™ provides an electronic platform to conduct online seminars on diverse topics to an international audience, and is achieving great success. It is a communication platform that can be used and adopted by other countries for information dissemination and industry collaboration.

KEYWORDS: Farm; management; webinar; education; Canada; online

1. Introduction

The success of any farm enterprise is directly related to the business management skills of the farm manager – this is the *raison d'être* of the Canadian Farm Business Management Council (hereafter referred to as CFBMC or 'Council'). Numerous domestic and international factors influence the profitability, sustainability and success of farmers and other agricultural businesses. Efforts to improve business management practices are critical for the ongoing sustainability and profitability of the agricultural sector.

The Canadian Farm Business Management Council was established in 1992 to coordinate, develop and disseminate farm business management resources and tools to Canadian farmers. CFBMC initiatives provide farm managers with the tools and inspiration to confront change with confidence and seize opportunity. CFBMC helps farmers assess risk, market potential, develop plans, manage human resources, and understand the forces shaping the world around them.

CFBMC's key to success is not in providing farm business management resources and tools alone, but rather, having effective communication mechanisms to source and deliver the information. The Council is dedicated to using emerging technologies to continuously enhance delivery of products and services to assist existing and reach new target client groups. *Agriwebinar*™ is one such mechanism responding to the learning needs and preferences of Canadian farmers in an increasingly information-technology-based culture. *Agriwebinar*™ as an easy-to-use webinar platform

[1] This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

[2] Canadian Farm Business Management Council

to improve access to leading edge farm management information for Canadian farmers and the agricultural industry at large.

2. The Medium is the Message[3] – Keeping Pace with a Culture

A recent survey by Farm Credit Canada (2009) found that fifty percent of farmers plan to expand or diversify in the coming five years. Likewise, Canada's 2007 National Renewal Survey (Agriculture & Agri-Food Canada, 2007) identified an upward trend in producer participation in farming-related training and in the development of business and related plans such as: financial assessment, production, marketing, environmental, food safety, and human resources. Canadian farmers' passion for their profession remains strong, and so does the need to provide those farmers with the tools and information they need to achieve their goals. While only twenty (20) percent of Canadian producers have a written business plan, of these farmers, seventy-one (71) percent have used these plans to secure financing. Thus, we can demonstrate a direct financial benefit to creating and following formal business plans. Perhaps the problem is not the information, but rather, the delivery thereof.

The question becomes not *what* information is needed, but rather, *how* do we communicate the information to maximize reach and impact towards instilling a culture of farm business management in Canadian producers?

Merriam-Webster defines *management* as "judicious use of means to accomplish an end." (Merriam-Webster Online Dictionary (2010). It is becoming increasingly important for organizations like CFBMC to embrace practices that permit and restore a connection with producers. The management of information – what is being disseminated, and how. Information management is exemplified by *Agriwebinar*™. Facing a new reality of information overload, it becomes essential for organizations to invest in opportunities that meet the changing needs and preferences of target clients – accessible, cost-effective learning.

It is often said that necessity is the mother of invention. Hectic work and life schedules, along with economic pressures, signify an opportunity to create an alternative mechanism for training and information dissemination. Communication technology, as evidenced by the Agriwebinar system, provides a means to reach a broad audience in a way that aligns with current learning trends and increasing demand for accessible, convenient, timely, relevant, reliable, trusted and interactive information transfer and learning opportunities.

While encouraging farmers to stay informed to manage change, Council too must seek to provide resources and information that respond to the changing learning needs and preferences of farmers.

[3] McLuhan, Marshall. *Understanding Media: The Extensions of Man*. New York: McGraw Hill, 1964.

3. Agriwebinar™

Agriwebinar™ is a unique and easy-to-use online presentation platform delivered by the Canadian Farm Business Management Council. *Agriwebinar*™ uses state-of-the-art online communication technology to provide farmers and other agricultural stakeholders with access to topical and leading-edge farm business management information and expertise. As an online learning tool, *Agriwebinar*™ mitigates the time, geographic and financial constraints, while also providing an opportunity to complement and communicate between face-to-face meetings such as workshops, conferences and seminars. *Agriwebinar*™ can be accessed by an individual or groups from the comfort of their home or business. Webinars are an effective communication tool to connect with audiences in a way that is convenient and far-reaching - the same information is being communicated coast to coast, in both Official languages.

Agriwebinar™ serves as a broadcasting and communication mechanism for a number of presentations and events, including:

- Workshops
- Conferences
- Training
- Corporate communications
- News bulletins and timely information
- Focus groups

The content is not only extended, but also and arguably more importantly, enhanced by its presentation in a new format that responds to current and future learning trends in an increasingly fast-paced learning environment motivated by information technology.

Virtual learning through online technologies is a critical enabler to accelerate the pace of information transfer into agricultural practice and commercialization, and ultimately stimulate growth and prosperity for the agricultural industry. *Agriwebinar*™ uses information and communication technologies in such a way as to present farm business management in interesting, applicable, and accessible way.

Key Features of Agriwebinar™

- Education & Training
- Accessibility
- Knowledge Transfer / Communication Technology
- Timely, Leading Edge

4. Education & Training – Lifelong Learning and Restoring Extension

For over a decade, there has been a significant lack of formal extension services to the agricultural community in Canada. Extension services provide education and training outside of formal educational programs offered by accredited institutions. Extension serves an important role in lifelong learning to continue to meet the demands of an increasingly complex and competitive society through ongoing educational opportunities.

A University of Illinois survey recognized extension services in farm business management benefit all producers, large or small. However, extension services must adapt to the changing demands for services (Irwin, Schnitkey *et al*., 2004). *AgriwebinarTM* provides a mechanism to bring together the expertise of academia, consultants, government, non-government, and producers, to share best practices, emerging trends and new opportunities. As an easily-accessible educational platform, *AgriwebinarTM* provides learning opportunities that respond to and meet the need for easy-access, affordable learning.

It is often said by producers themselves that they respond best to "show and tell" learning. Demonstrating tangible payback from adopting farm business management best practices will continue to drive uptake and create a culture of business management in Canadian agriculture, strengthening the capacity of the sector as a whole. In keeping with this mentality, the webinars focus on practical learning, promoting success stories, and increasing access to and awareness of the suite of tools available for farmers to integrate their learning into business activities.

CFBMC also uses the Agriwebinar system to build partnerships for delivery to provide specialized content to a diverse audience – expanding the reach, impact and extension of the educational programming. *Agriwebinar*™ also facilitates collaboration and coordination amongst industry stakeholders who are exposed to what is happening across the country (and globe) in their areas of interest.

5. Accessibility & Availability – There are No Limits

Using electronic media, *Agriwebinar*™ provides greater access – putting key information into the hands of producers and agricultural stakeholders, without limits. *Agriwebinar*™ provides an educational platform that users can adapt to their life stages, work schedules and learning needs and preferences.

Agriwebinar™ truly is exemplary in making pertinent information accessible to anyone. There is no limit to the number of attendees, presenters, or length of the presentation. Content captured through presentation archives adds permanence to traditionally one-time events, increasing reach and impact long after the live event takes place. *Agriwebinar*™ complements, while enhancing traditional face-to-face learning. As an online platform, the cost to organizations to deliver information is substantially less than face-to-face learning events, and these savings are passed onto participants. The Agriwebinar platform can be used for both public and private access events.

Live and recorded webinars use a combination of:

- PowerPoint slides
- Video and/or audio
- Networking text chat
- Private questions to the presenter
- Resource files and links

This multimedia approach appeals to the diverse learning preferences and practices of participants, while also allowing the information to be manipulated and repurposed for greater reach and impact. For example, audio can be singled out and provided to users in the form of podcasts to listen to the presentations without requiring access to the internet or a computer. This format also allows for users with slower rural internet connection speeds to access content. The information not only becomes more accessible, but to a wider, more diverse audience. As an online platform, International presenters are not uncommon, and this is an area of great potential.

6. Knowledge Transfer / Communication Technology – Connectivity, Cooperation, Collaboration

Knowledge and information transfer is essential to fostering a culture of farm business management, entrepreneurism and innovation towards improved sustainability and profitability for Canada's farmers. The 2002 Odyssey Report (Odyssey Group 2010) cites the importance of having a mechanism to transfer knowledge and information: "…to take advantage of innovation and leading-edge technology and remain competitive globally, we must have a mechanism to transfer this information from the academic and research community into practical advice at the farm level." Such transfer narrows the gap between research and practice; top performers and average or below-average achievers.

Effective knowledge transfer is achieved by employing more accessible, understandable, and applicable formats that use emerging communication technologies to create multimedia-rich learning experiences to address the unique learning needs, preferences and practices of the client (farmers and industry stakeholders). Information must be transferred in such a way that it can be applied at a practical level.

Education, training and knowledge transfer have traditionally been confined to face-to-face events – workshops, seminars and conferences. These means are not cost-effective, are often restricted to one-time events, and information is transitory and reaches a narrow audience. As a web-based tool, *Agriwebinar*™ complements and builds upon existing technology transfer mechanisms for more timely and effective knowledge and information transfer. Partnerships and industry relations realized through this platform are reducing duplication of efforts, while providing collaboration and connectivity in the agricultural sector.

AgriwebinarTM shares expertise from not only government, academia, and consultants, but also successful, entrepreneurial and inspirational farmers.

"The over-reliance on scientific knowledge and the neglect of farmers' tacit (informal) knowledge in agricultural extension practice has long been identified as an impediment to increased agricultural productivity…Since tacit and explicit forms of knowledge complement each other, it is imperative for agricultural extension experts to pay more attention in harnessing the tacit knowledge of farmers and complement that with their explicit knowledge." (Boateng 2004).

Agriwebinar™ gives innovators and entrepreneurs of all occupations and positions a platform to share &

inspire. Knowledge is uniquely harnessed from the farm-level to researchers, academics, policy makers, etc., thereby fulfilling the need for comprehensive knowledge transfer.

Furthermore, traditional knowledge and information transfer mechanisms are restricted to one-way communication whereby information is presented to an audience in the form of a paper, seminar, etc. for consumption. *Agriwebinar™* provides users with a way to interact with the content and presenter. Participants can interact with one another and the presenter through text chat and question windows. Presenters can also upload files for download by users, giving users access to content outside of and supplementary to the presentation at hand.

Not only is knowledge transfer essential, but also the translation of information into formats that allow and encourage uptake and implementation of the information. The Agriwebinar platform uses a combination of video, audio, text and interactivity to present a complete learning experience that appeals to a diverse audience and recognizes the unique learning needs and preferences of the target audience. The multimedia-based learning format of *Agriwebinar™* makes the information more attractive, interactive, comprehensive and therefore more accessible and understandable.

7. Timely, Leading Edge – Quick Response Mechanics

In an increasingly complex and demanding industry, producers and industry stakeholders must stay informed. *Agriwebinar™* provides timely access to the knowledge, information and resources required to manage change and embrace innovation and entrepreneurism.

Planning a webinar takes virtually no time at all, as the system is set up to be user-friendly for all parties. If so inclined, one could host an Agriwebinar within hours of expressing the desire to do so. Training and technical assistance is available for presenters and users at any time. Likewise, *Agriwebinar*™ mobilizes industry and partners with a means to get information out in a timely, accessible way to stakeholders and members.

To ensure effective response to sector needs, *Agriwebinar*™ content is 100% client driven. An annual user survey provides feedback on system improvements, as well as speaker and topic suggestions. Thus, the platform and content undergo improvements on an annual basis to continue to serve the industry and its changing needs.

8. *Agriwebinar™* Series – The Results

The *Agriwebinar*™ program began in 2006 and is now in its 5th season. The regular season typically runs November – April as this coincides with the off-season for farmers in Canada. Topics covered throughout the season include agricultural economics, business planning, succession, new entrants, marketing, sustainable agriculture, human resource management, value-added agriculture, local food, organic agriculture, and more.

CFBMC continues to host this series of online seminars every year due to its increasing popularity, positive feedback and demand by the agribusiness sector including government, non-government, producer groups, producers, advisors and other key industry stakeholders.

Speakers and topics are selected from the results of a client survey conducted previous to each new season of *Agriwebinar™*, thus content is 100% client-driven.

CFBMC's Agriwebinar Series

From November to April, CFBMC hosts a webinar every Monday at Noon Eastern Standard Time. Each webinar is an hour in length. These webinars are publicly accessible at no cost for live and archived presentations. The Agriwebinars are presented in both of Canada's Official languages – French and English.

Viewers from all over Canada and the world have signed up to the *Agriwebinar*™ system. Currently, over nine thousand (9000) individuals including producers, educators, advisors and other agricultural stakeholders are subscribed to *Agriwebinar*™. Forty-four percent (44%) of subscribers are farmers and farm managers.

Performance is measured by tracking user statistics for live and archived presentations, as well as through an annual survey. CFBMC staff can log into the administrative system at any time to see exactly how many users were on for each session, how long each user viewed the presentation and who was participating.

Since its inception in 2006, *Agriwebinar™* has enjoyed exponential growth in its subscribers. Steady growth in the number of viewers accessing archived webinars, indicates a demand for increased access to information to fit around farm and family commitments.

2009–10 Highlights and User Statistics

Although there is no limit to the number of attendees for any given webinar, the 2009–10 Agriwebinar series averaged eighty-seven (87) attendees per live session. This represents a twenty (20) percent increase in live viewership, compared to the 2008-9 season. *Agriwebinar*™ also welcomed 2,789 new subscribers to the system and 22,304 visits to the official website: www.agriwebinar.com, via 522 cities in Canada alone. On average, the *Agriwebinar™* archive was accessed over

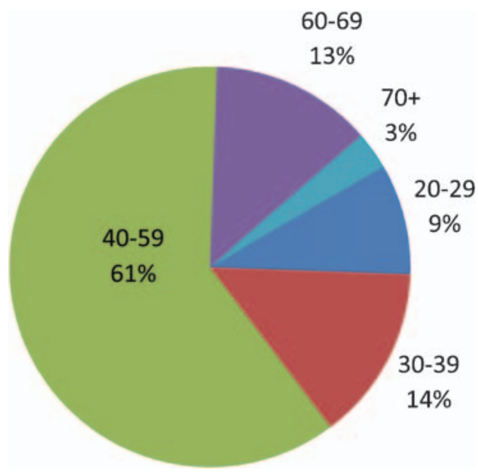

Figure 1: Agriwebinar participants by age, 2009–10

750 times per month, clocking close to one hundred (100) hours of viewing.

While users include government, associations, and academia, this year sixty-eight (68) percent of *Agriwebinar*™ subscribers were farmers or professionals providing a direct service to producers (such as consultants or advisors). The majority of participants are between the ages of forty and fifty-nine (61%), however an impressive 23% are under thirty years of age.

It is critical that *Agriwebinar*™ reach young and beginning farmers – to instill a culture of lifelong learning and farm business management to carry throughout their farming careers and ensure an entrepreneurial and innovative future for Canadian agriculture.

Agriwebinar™ is achieving immediate, intermediate and long-term results. Users testimonials indicate that the Agriwebinars are increasing the understanding of farm business management and the importance thereof, the application of farm business management best practices to farming operations and ultimately, helping Canadian farmers realize their business goals towards greater farm business prosperity and profitability.

The 2009–10 user survey revealed sixty-six (66) percent of respondents felt *Agriwebinar*™ had helped them better manage their business, and seventy-four (74) percent have recommended *Agriwebinar*™ to others, highlighting the valuable work that *Agriwebinar*™ does in bringing relevant and helpful information to the agricultural community.

Following, are some comments from participants:

> *The information is easily accessible. The presenters have experience and information not always readily available to me. I can use their experience and information to make more informed management decisions.*
> *The farm succession webinar helped our two generations start a positive and productive dialogue that will help to ensure the farm's future viability. Before that, we were stuck.*

Increasingly, *Agriwebinar*™ is being used to broadcast and record conferences and other face-to-face events to increase reach to participants during and after the event. In 2009–10, the Canadian Farm Business Management Council hosted their regular series of twelve (12) webinars, while also broadcasting two conferences: *Managing Excellence in Agriculture* and the *International Farm Succession Conference*, archiving the presentations for future reference, increased reach, and impact.

Figure 2 shows topic popularity, as chosen by participants in the 2009–10 user survey.

9. Partnering to Extend & Effect

The Canadian Farm Business Management Council works with partners and third-party hosts to increase the reach and impact of *Agriwebinar*™.

The regular Agriwebinar season focuses on broad topics of national appeal. Working with partners and third-parties gives Council the opportunity to enhance and expand its content; branching out into specific topics relative to the needs of target audiences. Council can mobilize quickly to partner for delivery. This allows the Council to use *Agriwebinar*™ to more effectively respond to sector needs and deliver information and updates in a timely, far-reaching, and cost-effective manner.

In 2009–10, partners brought an additional forty (40) webinars through the system via a combination of private and public events. Working collaboratively with other industry groups, *Agriwebinar*™ provides a significant opportunity to reach more producers in a way that substantiates the content for participants brought in from all partner groups. The content becomes trusted, reliable and far-reaching. The diverse viewership brought to the Agriwebinar platform also raises the profile and brand of the Council, *Agriwebinar*™ and affiliate programs and resources.

Partners and third-parties have the opportunity to use the Agriwebinar platform in partnership with the Council to expand public access offerings, or alternatively, host private events. While it is within Council mandate to offer its regular series to producers without

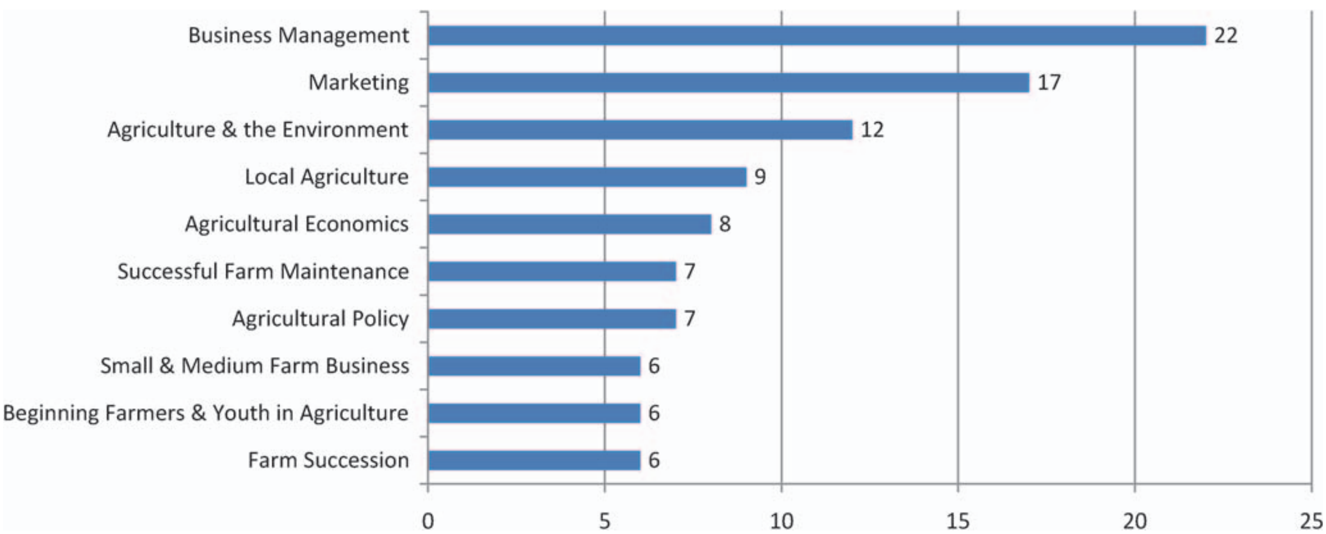

Figure 2: Top ten topic choices, 2010–2011 (by percent of total responses)

charging user fees (*au gratis)*, partners and third-party collaborators can use *Agriwebinar*™ as a revenue-generating or cost-recovery stream from participant fees.

10. *Agriwebinar™* and the International Stage

Agriwebinar™ was created as an educational tool to get timely, relevant information and knowledge to Canada's farmers and other industry stakeholders. As an online platform, *Agriwebinar™* is, by default, international.

In 2009–10, users registered to the system from Africa, Europe, New Zealand and the United States.

On an International stage, *Agriwebinar™* can be used in three ways:

1. Immediate - Exposure – anyone can subscribe to and participate in Agriwebinars from anywhere in the world
2. Intermediate - Partnership – with CFBMC to provide international perspective presentations
3. Long-Term - Adopt a Similar Program – replicate for your country

Using *Agriwebinar*™ immediately brings information and knowledge transfer into the 21st century and helps portray organizations as leading-edge, using the latest communication technology. No technical knowledge or special equipment is needed to use *Agriwebinar*™, as it was designed to be easy-to-use by presenters and participants.

11. Conclusions

The Canadian Farm Business Management Council is uniquely positioned to play a leading role in fostering the collaboration needed to effectively reach Canadian farm managers with the information and resources they need to make sound business decisions; connecting agricultural stakeholders across provinces, production sectors, demographics and language groups.

Recognized as a credible, unbiased and nationally-mandated body, CFBMC continues to expand its partnership network; new synergies and opportunities are being realized to deliver real benefits to Canadian farm managers and other stakeholders in the agri-food continuum. Increasingly, industry groups are seeking partnership with CFBMC to network resources and drive farm business management across Canada.

For close to two decades, CFBMC has demonstrated a steady positive impact on the industry and we are committed to continue applying our resources in an effective manner to drive our mandate.

Agriwebinar™ is helping CFBMC achieve real results. Agriwebinars provide Canadian farm managers with the tools and inspiration to confront change with confidence and seize opportunity. Agriwebinars helps farmers assess risk, market potential, plan (marketing, business, succession, new venture), manage human resources, and understand the forces shaping the world around them.

Communication technology, as evidenced by the Agriwebinar system, provides a means to reach a broad audience in a way that aligns with current learning trends and increasing demand for accessible, convenient, timely, relevant, reliable, trusted and interactive information transfer and learning opportunities.

CFBMC looks forward, with confidence, enthusiasm and optimism, to continue to meet the demands of an increasingly complex industry with advanced learning tools to continue to create a culture of farm business management and lifelong learning for Canada's agricultural stakeholders.

About the author

Heather Watson (heather.watson@cfbmc.com) is General Manager of the Canadian Farm Business Management Council (CFBMC), the only national organization in Canada devoted to the development and dissemination of advanced farm business management information to Canada's farmers. Heather obtained her Bachelor's from the University of Guelph in Ontario, Canada, and her Master's from the University of Warwick in Coventry, England.

Heather is passionate about education and committed to enhancing efforts to encourage better business management practices for a sustainable and truly remarkable agriculture industry in Canada. Heather grew up in South-western Ontario and now lives in Arnprior, just outside of Ottawa, Ontario.

Visit www.farmcentre.com to find out more about the Canadian Farm Business Management Council and subscribe to stay informed of farm business management initiatives in Canada.

Acknowledgements

The Canadian Farm Business Management Council is funded in part by Agriculture and Agri-Food Canada and the Government of Canada, industry partners and members.

REFERENCES

Agriculture & Agri-Food Canada (2007) *2007 National Renewal Survey*, April 2008.

Boateng, W. (2004) Knowledge management working tool for agricultural extension: the case of Ghana. *Knowledge Management for Development Journal* 2 (3), 19–29. http://journal.km4dev.org/index.php/km4dj/index [Accessed 5 July 2011].

Farm Credit Canada (2009) *Optimism in Canadian Agriculture*. www.fccvision.ca. [Accessed 5 July 2011].

Irwin, S., Schnitkey, G., Good, D. *et al*. (2004) *The FARMDOC Project: This Is Still Your Father's Extension Program*. Department of Agricultural and Consumer Economics, University of Illinois. 2004.

McLuhan, M. (1964) *Understanding Media: The Extensions of Man*. New York: McGraw Hill.

Merriam-Webster Online Dictionary (2010) Merriam-Webster Online. www.merriam-webster.com/dictionary/management. [Accessed 14 September 2010].

Odyssey Group (2010) *Odyssey Report*. Canada: ON

Financial performance configurations

MICHAEL LANGEMEIER[2]

ABSTRACT

The purpose of this paper is to examine the financial performance of a sample of crop/beef cow farms using the operating profit margin ratio and farm growth as relevant measures. Farms were divided into four performance categories: low profit/low growth; low profit/high growth; high profit/low growth; and high profit/high growth.

Approximately 36 percent of the farms had above average operating profit margin ratios. Of this group, approximately 54 percent had a below average growth rate in the beef cow herd and the remaining 46 percent had an above average growth rate in the beef cow herd. Characteristics of these two groups were similar. However, interestingly, the farms with the above average growth rate in the beef cow herd, also had a higher growth rate in crop hectares from 2002 to 2009.

KEYWORDS: Operating Profit Margin Ratio; Farm Growth

1. Introduction

Net farm income in the United States has been relatively high during the last three years. For example, using data from the Kansas Farm Management Association (KFMA), the average net farm income during 2007, 2008, and 2009 was $115,312 (£72,000)[3]; $124,617 (£77,000); and $104,781 (£65,000) respectively (Herbel and Langemeier, 2010). In contrast, the average net farm income from 2000 to 2006 was only $43,867 (£27,000).

It is also important to note that crop farms have been relatively more profitable over the last few years than crop/livestock and livestock farms. In particular, average net farm income for beef cow and crop/beef cow farms that participated in the KFMA program were below the five-year average in 2008 and 2009 while average net farm income for non-irrigated and irrigated crop farms were substantially above average.

In addition to varying among farm types, performance varies substantially among individual farms and ranches with similar enterprises (Langemeier, 2010a). Because of this, benchmarking performance with similar farms is essential.

The purpose of this paper is to examine performance differences among crop/beef cow farms. Performance was measured using the operating profit margin ratio as well as farm growth.

2. Methods

Steffens, Davidsson, and Fitzsimmons (2009) emphasize the importance to firms of simultaneously discovering and exploiting advantages. Discovering advantages is related to firm growth while exploiting advantages is related to profitability. The agricultural economics literature typically has addressed firm growth and profitability separately (e.g., Villatora and Langemeier, 2006; Yeager and Langemeier, 2009).

This study examines both firm growth and profitability. Firm growth was measured by computing the growth in the beef cow herd on each farm. Firm growth is particularly important for family farms that are bringing another generation into the operation. The operating profit margin, a commonly used measure of financial performance, was used as the profitability measure. This ratio was computed for each farm and year by adding accrual interest expense and subtracting unpaid family and operator labor from net farm income and dividing the result by value of farm production (Langemeier, 2009). The annual operating profit margins for each farm were then used to compute the average operating profit margin ratio for each farm.

The two performance measures described above, the operating profit margin ratio and the growth in the beef cow herd, were used to categorize farms into the following groups: low profit/low growth; low profit/high growth; high profit/low growth; and high profit/high growth. In addition to comparing the profit margins and the growth rate of beef cow herd among these groups; value of farm production, net farm income, total hectares, crop hectares, number of beef cows, number of beef feeders, percent of labor devoted to crops, growth rate in crop hectares, asset turnover ratio, and economic total expense ratio were compared across performance groups. The percent of labor devoted to crops was computed using crop and livestock labor standards as well as information on crop hectares and the head of livestock managed. The asset turnover

[1] This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

[2] Department of Agricultural Economics, Kansas State University, USA

[3] Approximate conversions using a rate of around $1.6 per £1, July 2011.

ratio was computed by dividing value of farm production by average total assets. The economic total expense ratio was computed by adding the opportunity cost on owned assets to total expenses and unpaid family and operator labor, and dividing the result by value of farm production. If the economic total expense ratio is below 1.00, the farm is covering all accrual and opportunity costs, and is earning an economic profit.

3. Data

Data for 321 crop/beef cow farms in the Kansas Farm Management Association (KFMA) with continuous data from 2002 to 2009 were used in this study. These 321 farms represent approximately 22 percent of the farms with whole-farm analysis data in 2009 (Herbel and Langemeier, 2010). To be included in this study, a farm had to have beef cows, and usable income, expense, and balance sheet data. Income and expense were expressed on an accrual basis. Value of farm production included crop income, livestock income, income from government payments and crop insurance proceeds, and miscellaneous income sources such as patronage dividends and custom work income. Livestock income was expressed on a value-added basis. Specifically, accrual livestock purchases were subtracted from accrual livestock sales to arrive at accrual livestock income.

Table 1 presents the summary statistics for the 321 farms. Value of farm production averaged $304,108 (£189,000). Average total hectares included feed grain (corn and grain sorghum), oilseed (soybeans and sunflowers), wheat, and hay and forage hectares as well as hectares in pasture or rangeland. The average total hectares and total crop hectares were 844 and 440, respectively. It is important to note that hay and forage hectares are included in crop hectares. Most of the farms had a least some hectares in feed grains, oilseeds, or wheat. In fact, only 6.5 percent of the farms did not have these crops. This illustrates how diversified the sample farms are.

The average number of beef cows was 105, which was approximately twice as large as the average 2007 Census farm with beef cows in Kansas (Langemeier, 2010c). The number of beef feeders, which included raised steers and heifers, was 199. The average growth rates in the beef cow herd and total crop hectares were 0.69 percent and 2.16 percent, respectively. The average profit margin was 0.1419 or 14.19 percent while the average asset turnover ratio was 0.2914. The average economic total expense ratio was 1.1131 indicating that on average the farms were not covering all opportunity costs.

4. Results

Table 2 presents the summary statistics for the profit and beef cow herd growth farm groups or categories. Economies of size are very prevalent in Kansas agriculture (Langemeier, 2010b). These economies of size are clearly prevalent in Table 2. Specifically, the farms with low profit margins tend to be considerably smaller than the farms with high profit margins. Because of the strong economies of scale exhibited by the sample farms, the discussion below will focus on comparisons between the two low profit categories and the two high profit categories.

The only variables that are significantly different between the low profit farms with a low growth rate and a high growth rate are the growth rate of the beef cow herd, the asset turnover ratio, and the economic total expense ratio. Though information on strategic planning and life cycle stages is not available, the low growth group may be represented by individuals that are slowly retiring or exiting production agriculture. The high growth group may be trying to garner economies of scale by increasing their crop hectares and cow herd size.

When comparing the high profit farm groups, the only variable that was statistically different between the two groups was the growth rate in the cow herd.

Though similar in farm characteristics; for example crop hectares, size of the cow herd, and percent of labor devoted to crops are very similar; the two groups of farms obviously responded quite different to the

Table 1. Summary Statistics for Crop/Beef Cow Farms in Kansas, 2002–2009.

Variable		Average	Standard Deviation
Value of Farm Production	US $	304,108	318,459
	GB £*	189,000	198,000
Net Farm Income	US $	72,326	90,970
	GB £*	45,000	56,000
Total Hectares		844	600
Total Crop Hectares		440	376
Feed Grain Hectares		118	147
Oilseed Hectares		130	163
Wheat Hectares		135	163
Number of Beef Cows		105	86
Number of Beef Feeders		199	698
Percent of Labor Devoted to Crops		0.6543	0.2226
Growth Rate of Crop Hectares		0.0216	0.0758
Growth Rate of Beef Cow Herd		0.0069	0.0730
Operating Profit Margin Ratio		0.1419	0.2484
Asset Turnover Ratio		0.2914	0.1780
Economic Total Expense Ratio		1.1131	0.4646

*Approximate conversions using a rate of around $1.6 per £1, July 2011.
Source: Kansas Farm Management Association Databank, 2009.

Table 2. Summary Statistics for Profit and Beef Cow Herd Growth Categories.

Variable		Low OPR Low GR	Low OPR High GR	High OPR Low GR	High OPR High GR
Number of Farms		106	101	61	53
Value of Farm Production	US $	207,790[a]	224,035[a]	448,223[b]	483,471[b]
	GB £*	129,000	139,000	278,000	300,000
Net Farm Income	US $	36,100[a]	33,935[a]	138,268[b]	142,045[b]
	GB £*	22,400	21,000	86,000	88,000
Total Hectares		714[a]	700[a]	1,061[b]	1,129[b]
Total Crop Hectares		323[a]	332[a]	629[b]	662[b]
Feed Grain Hectares		77[a]	77[a]	184[b]	203[b]
Oilseed Hectares		74[a]	90[a]	224[b]	211[b]
Wheat Hectares		108[a]	104[a]	180[b]	197[b]
Number of Beef Cows		100[a]	94[a]	123[a]	114[a]
Number of Beef Feeders		111[a]	172[a]	235[a]	383[a]
Percent of Labor Devoted to Crops		0.6002[a]	0.6159[a]	0.7447[b]	0.7318[b]
Growth Rate of Crop Hectares		0.0088[a]	0.0295[ab]	0.0185[ab]	0.0359[b]
Growth Rate of Beef Cow Herd		−0.0421[a]	0.0605[b]	−0.0404[a]	0.0571[b]
Operating Profit Margin Ratio		0.0242[a]	0.0316[a]	0.2493[b]	0.2259[b]
Asset Turnover Ratio		0.2425[a]	0.2942[b]	0.2911[b]	0.3498[b]
Economic Total Expense Ratio		1.2903[a]	1.2228[b]	0.9979[c]	0.9867[c]

Notes:
OPR = operating profit margin ratio and GR = growth rate in beef cow herd.
Unlike superscripts within a row indicate that the values are significantly different.
*Approximate conversions using a rate of around $1.6 per £1, July 2011.

relatively low beef enterprise net returns experienced in recent years. The low growth farms are reducing the size of their cow herd while increasing crop hectares. In contrast, the high growth farms are increasing their size in terms of both crop hectares and livestock numbers. The dichotomy between the two groups of farms is probably at least partially due to the increased volatility of crop and livestock prices experienced in recent years. It is important to note that, historically, many large farms in Kansas have been quite diversified. The high profit/high growth farms seem to be taking this route as they increase their size.

5. Summary and Conclusions

This paper examined the financial performance of a sample of crop/beef cow farms using the operating profit margin ratio and farm growth as relevant measures. Farms were divided into four categories: low profit/low growth, low profit/high growth, high profit/low growth, and high profit/high growth.

Approximately 36 percent of the farms had above average profit margins and approximately 48 percent of the farms had above average growth rates in the beef cow herd. The low profit/low growth farms had the lowest growth in crop hectares. The characteristics and financial performance of the high profit farms with low and high growth rates were very similar.

How can the difference in the growth rates of beef cow herds between the high profit farms with low and high growth rates be reconciled? Though specific information related to future plans is not available, it appears that these groups have different views concerning the future profitability of both the cow herd and production agriculture in general. In addition to expanding the cow herd, the high profit/high growth group also had the largest growth rate in total hectares.

About the author

Michael Langemeier (mlange@agecon.ksu.edu) is a professor of Agricultural Economics at Kansas State University. Michael received his Ph.D. from Purdue University in 1990. Extension and research interests include benchmarking of technical and financial performance, strategic positioning, and economies of size. Michael teaches courses in Farm Management, Managerial Economics, and Production Economics.

REFERENCES

Herbel, K. and M. Langemeier. (2010) *KFMA Executive Summary: 2009 Profitlink Analysis*. Department of Agricultural Economics, Kansas State University, May.

Langemeier, M. (2009) *Financial Ratios Used in Financial Management*. Department of Agricultural Economics, Kansas State University, MF-270, December.

Langemeier, M. (2010a) Financial Performance and Farm Type. *KFMA Newsletter*, Department of Agricultural Economics, Kansas State University, May.

Langemeier, M. (2010b) Financial Performance and Farm Size. *KFMA Newsletter*, Department of Agricultural Economics, Kansas State University, June.

Langemeier, M. (2010c) *Comparison of 2007 Census and KFMA Farms*. Department of Agricultural Economics, Kansas State University, Staff Paper No. 11-02, August.

Steffens, P., P. Davidsson, and J. Fitzsimmons. (2009) Performance Configurations over Time: Implications for Growth- and Profit-Oriented Strategies. *Entrepreneurial Theory and Practice*. Volume 33, January, pages 125–148.

Villatora, M. and M. Langemeier. (2006) Factors Impacting Farm Growth. *Journal of the American Society of Farm Managers and Rural Appraisers*. Volume 69, pages 74–80.

Yeager, E. and M. Langemeier. (2009) Measuring Sustained Competitive Advantage for a Sample of Kansas Farms. *Journal of the American Society of Farm Managers and Rural Appraisers*. Volume 72, pages 112–123.

PROFESSIONAL UPDATING

Economics of film antitranspirant application: a new approach to protecting wheat crops from drought-induced yield loss

PETER KETTLEWELL[1]

ABSTRACT

Drought is a major cause of economic loss to the world's wheat growers; estimated at up to US$20 billion (£12.5 bn) in 2000. Film antitranspirants are polymers applied to foliage to reduce water loss and have recently been shown to increase droughted wheat yield. This increase is linearly related to the drought severity (soil moisture deficit [SMD]) at the time of application. This paper demonstrates how this linear relationship can be used to calculate an economic threshold SMD, above which an economic yield response should be obtained, from spray cost and expected grain price. This will enable agronomists and growers to make a clear decision on the cost-effectiveness of spraying to protect from drought damage. Sensitivity analysis shows that using the correct spray decision threshold SMD is especially important when the wheat grain price is expected to be low.

KEYWORDS: Spray decision-making; spray threshold; water stress; polymers; grain price

1. Introduction

World production of food needs to increase to supply the forecast nine billion population by 2050 (Godfray *et al*., 2010), but drought is a serious impediment to increasing food production. There is little information on the economic impact of drought on food production, but comparing yield of rainfed and irrigated crops should give an approximate quantitative estimate of drought effects. Recent data on the yield of separate rainfed and irrigated crops are not readily available, but Molden (2007) gives irrigated and rainfed data for the major cereal crops for the year 2000. For wheat, one of the world's main food crops, rainfed crops gave 2.4 t/ha yield and irrigated crops gave 3.4 t/ha. The total wheat area in 2000 was 215 Mha (FAOSTAT, 2011), and if it is assumed that all wheat had given the same yield as the irrigated wheat, then wheat production would have been 731 Mt instead of the recorded 586 Mt (FAOSTAT, 2011). World wheat grain price from the Home Grown Cereals Authority data archive (HGCA, 2011) for the calendar year 2000 was US$138/t (£87/t)[2], thus it can be estimated that drought may have caused up to (731-586) × 138 = US $20 billion (£12.5 bn) loss to wheat growers in 2000.

The above value will be an overestimate of drought effects for several reasons. In addition to water, irrigated crops will tend to be given more yield-enhancing inputs, such as fertilizer, than rainfed crops so that not all the difference between yield of rainfed and irrigated crops is due to drought. Also the price of wheat would be likely to fall as production increases. Nevertheless, this estimate gives a crude quantitative indication of the upper limit of the economic impact of drought on wheat in this particular year.

Availability of water for irrigation is declining as a result of climate change-related reductions in rainfall and increasing competition from industrial and domestic use (Morison *et al*., 2008). Therefore alternative technologies, applicable to rainfed crops, are needed to reduce drought-induced yield loss. One approach is to breed drought resistant varieties, but this is proving a difficult task due to the complexity of drought resistance (Cattavelli *et al*., 2008).

A new agronomic approach for ameliorating drought effects on wheat is to use sprays of film antitranspirant polymers, which reduce water loss from leaves (Kettlewell *et al*., 2010). This approach has given up to a 42% yield increase (Kettlewell & Holloway, 2010) if applied at the most drought-sensitive stage of develop-

[1] Harper Adams University College, UK

[2] Currency conversions approximate, as at 11 July 2011.

ment, just before the heads emerge (Saini & Westgate, 2000). Yield loss from drought is related to the severity of the drought, and thus for wheat growers to make cost-effective use of this new approach a method of assessing drought severity and the likely yield increase from a film antitranspirant spray is needed. The aim of this paper is to show how an economic threshold drought severity can be calculated to assist decision-making on spraying a film antitranspirant on wheat, and to illustrate the sensitivity of this threshold to grain and to film antitranspirant prices.

2. Threshold calculation

Kettlewell *et al.* (2010) have shown in the UK that the yield response of droughted wheat to a spray of film antitranspirant is linearly related to both the development stage and to the drought severity (expressed as the SMD) at the time of spray application. The multiple regression equation of yield response against both numerical development stage and SMD given in Kettlewell, Heath and Haigh (2010) can be used to calculate the fitted line for estimating the likely yield response for a given SMD. This relationship is illustrated in Fig 1 assuming that spraying occurs at the development stage which Kettlewell *et al.* (2010) found to give the greatest yield response (Zadoks Growth Stage 37 [ZGS 37], flag leaf appearance [Zadoks *et al.*, 1974]). If strong wind or other reasons delay timely spraying, then the multiple regression equation given in Kettlewell *et al.* (2010) can be used to calculate the yield response – SMD relationship for a later development stage.

A calculation of the minimum yield response needed to cover the cost of spraying film antitranspirants can be made using expected grain price, film antitranspirant price and spray application cost. Using the price of the film antitranspirant as £20 ($32) per litre (B. Lewis, personal communication) gives a cost per hectare for the product, at 2.5 l/ha applied (Kettlewell *et al.*, 2010) of £50 ($80) per hectare. An average spraying cost of £10 ($16) per ha (Nix, 2010), gives a total application cost of £60 ($96) per ha. For a wheat grain price of £200 ($319) per tonne, a minimum yield response to film antitranspirant of 60/200 = 0.3 t/ha is therefore necessary to cover the cost.

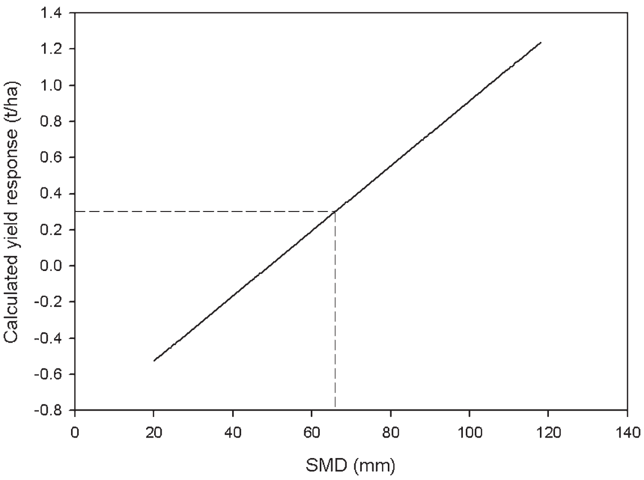

Figure 1. Yield response of wheat grown on a loamy sand soil to film antitranspirant application at ZGS 37 in relation to SMD at the time of application.
Note: Equation of the solid line is: yield response=(0.018 SMD) −0.874. Broken line shows the economic threshold SMD assuming a wheat grain price of £200 ($319) per tonne and an antitranspirant price of £20 ($32) per litre.

Using this yield response in Fig.1 shows that the economic threshold SMD is 64 mm for the soil type from which the multiple regression data was acquired. Spraying at an SMD above this threshold would thus be necessary to make a profit. The threshold SMD will vary with the available water capacity (AWC) of the soil, and for more general use the threshold SMD can be expressed as the proportion of available soil water. Since the AWC of the soil used to generate the relationship shown in Fig. 1 was approximately 180 mm, the economic threshold can be stated as one third of the available water on this soil type for a wheat grain price of £200 ($319) per tonne and a film antitranspirant price of £20 ($32) per litre.

It is possible that the cost of spraying the antitranspirant could be reduced by tank-mixing the antitranspirant with a fungicide, since wheat crops are routinely sprayed with a fungicide at around ZGS 39 in the intensive production systems used in Western Europe. Furthermore, there is evidence that the materials used as film antitranspirants can reduce fungal diseases (Walters, 2009), so that it might be possible to reduce fungicide cost by using a lower fungicide application rate whilst maintaining disease control.

3. Sensitivity analysis

In producing general guidelines for wheat growers, it is necessary to know the likely variation in the economic threshold SMD. The film antitranspirant used in the studies of Kettlewell *et al.* (2010) has recently increased markedly in price (B. Lewis, personal communication) and the spray threshold SMD was calculated for a range of potential antitranspirant prices at a constant grain price of £200 ($319) per tonne using a rearrangement of the equation given for Fig. 1. Similarly, wheat grain prices in the UK have varied dramatically in the last decade and the above calculation of spray threshold SMD was conducted for a range of expected grain prices at a constant antitranspirant price of £20 ($32) per litre. These calculations show that changes in spray threshold SMD in response to film antitranspirant price are relatively small (Fig. 2), and that for the soil type in the example given, using a threshold SMD of one-third of AWC would not be greatly in error for a wide range of prices. The threshold SMD is however, especially sensitive to expected wheat grain price when the latter is low (Fig. 3). Thus growers and agronomists should pay particular attention to calculating the threshold SMD when expected grain prices are low.

4. Conclusions

The data presented here show that it is possible to aid the decision whether to spray a film antitranspirant on wheat for ameliorating drought by calculating an economic threshold SMD. The threshold SMD will vary with expected grain price and with antitranspirant

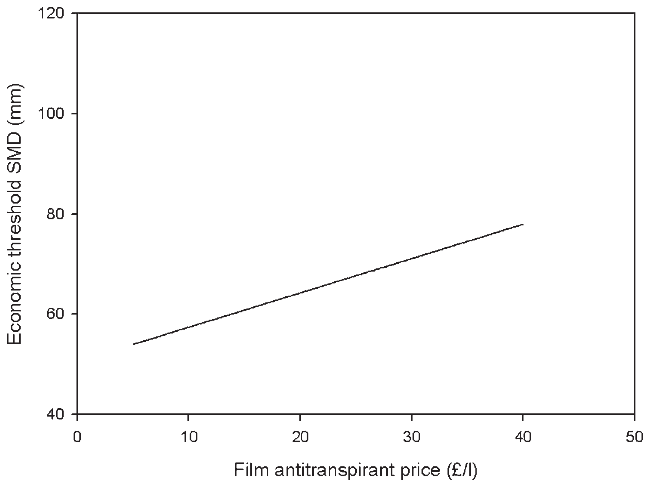

Figure 2. Relationship of the economic threshold SMD for spraying film antitranspirant on wheat with the film antitranspirant price (at a wheat grain price of £200 ($319) per tonne and a spraying cost of £10 ($16) per ha).
Note: Equation of the line: SMD=(((antitranspirant price*2.5+10)/200)+0.874)/0.018

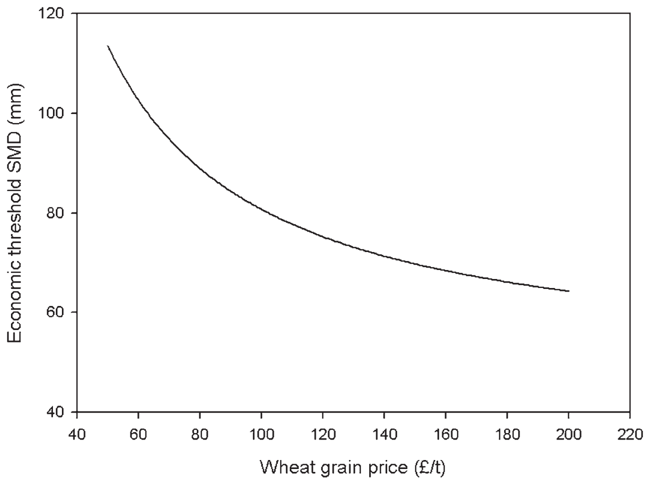

Figure 3. Relationship of the economic threshold SMD for spraying film antitranspirant with the wheat grain price (at a film antitranspirant price of £20 ($32) per litre.and a spraying cost of £10 ($16) per ha).
Note: Equation of the line: : SMD= ((60/grain price)+0.874)/0.018

price, but it is especially important to take account of low expected grain price. Further field experiments on soils differing in AWC and in different cropping systems and environments are needed to establish the general applicability of these conclusions and the possible variation in the equation used to derive the threshold.

About the author

Peter Kettlewell (pskettlewell@harper-adams.ac.uk) is Professor of Crop Physiology and Research Co-ordinator at Harper Adams University College, Newport, Shropshire, UK.

REFERENCES

Cattivelli, L., Rizza, F., Badeck, F.W., Mazzucotelli, E., Mastrangelo, A.M., Francia, E., Marè, C., Tondelli, A., Stanca, A.M. (2008). Drought tolerance improvement in crop plants: An integrated view from breeding to genomics. *Field Crops Research* **105**:1–14.

FAOSTAT (2011). http://faostat.fao.org/ (Accessed 3 June 2011).

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. Camilla Toulmin, C. (2010). Food Security: The Challenge of Feeding 9 Billion People. *Science* **327**:812–818.

HGCA (2011). Market Data Centre. http://data.hgca.com/ (Accessed 3 June 2011).

Kettlewell, P.S., Heath, W.L., Haigh, I.M. (2010). Yield enhancement of droughted wheat by film antitranspirant application: rationale and evidence. *Agricultural Sciences* **1**:143–147. Available at: http://www.scirp.org/journal/PaperDownload.aspx?paperID=3106

Kettlewell, P.S., Holloway, J.R. (2010). Connecting developmental and process physiology to improve yield of droughted wheat with a film antitranspirant. *Aspects of Applied Biology* **105**:23–24.

Nix, J. (2010). *Farm Management Pocketbook, 41st edition*. Agro Business Consultants Ltd., Melton Mowbray, UK.

Morison, J.I.L., Baker, N.R., Mullineaux, P.M., Davies, W.J. (2008). Improving water use in crop production. *Philosophical Transactions of the Royal Society B* **363**:639–658.

Molden, D. (2007). *Water for Food Water for Life*. Earthscan, London.

Saini, H. S., Westgate, M. E. (2000). Reproductive development in grain crops during drought. *Advances in Agronomy* **68:** 59–96.

Walters, D.R. (2009). Control of Plant Disease by Disguising the Leaf Surface. In: *Disease Control in Crops: Biological and Environmentally Friendly Approaches*, pp. 237–245. Ed. D Walters. Wiley-Blackwell, Oxford, UK.

Zadoks, J.C., Chang, T.T., Konzak, C.F. (1974). A decimal code for the growth stages of cereals. *Weed Research* **14**:415–421.

BOOK REVIEW

Tax Planning for Farm and Land Diversification (3rd Edition)

Julie Butler (Editor)

Published April 2011 by Bloomsbury Professional, Haywards Heath, UK. Soft back. ISBN: 978 1 84592 485 0. Price: £95. Length: 576 pages.

This text provides comprehensive coverage of the national taxation treatment of diversified farm activities in the UK. To get the most out of it, readers will find it helpful if they already have a basic understanding of the main principles of Income Tax, Capital Gains Tax, Inheritance Tax and VAT. Over thirty types of diversified activities are covered ranging from the more traditional such as adding value to produce or converting redundant farm buildings through to more recent developments such as wind farms or renting sites for mobile phone masts.

The farming/diversification boundary is explored in detail. It was interesting to note that studs and breeding racehorses are considered to be farming while a farmer using land and building for DIY horse livery has crossed the boundary and is regarded as diversified.

Other chapters look at specific aspects of tax planning on farms such as protecting the farmhouse, farm assets and stock from tax, or planning for death, divorce or unforced sales. Advice is given on protecting the core farming business and there are tips on pitfalls to avoid when diversified activities are entered into. There is quite extensive coverage of the interaction of Agricultural Property Relief and Business Property Relief from Inheritance Tax with analysis of all the recent cases in this area including *Antrobus 1 & 2, Arnander (McKenna), Farmer* and *Balfour*.

This is definitely a book for dipping into, for looking up advice on specific questions such as 'Will the sale of furnished holiday lets on a farm qualify for Entrepreneur's Relief?' Sadly, as tax is so complex, there will not be a single answer; further questions will need to be asked about the number of days the property is available to let and is actually let, and whether it was sold before or after 6th April 2011, but this book will set out the various permutations and advise accordingly.

The book does have one major omission in that while it purports to give comprehensive tax planning advice for farm and land diversification there is no chapter on local taxation. Diversification has a significant local tax impact as farmers lose the agricultural exemption from business rates when they, for example, set up a farm visitor attraction or start other non-farming enterprises. So please publishers, a chapter on local taxation for the next edition!

While it is certainly not a book for reading cover to cover (but what tax book is?) and it is likely to confuse those who do not have a basic grasp of tax terminology, overall I would recommend this text for those looking for detailed tax advice on the implications of farm and land diversification.

Susan Ragbourne[1]

[1] Senior Lecturer in Rural Land Management, Harper Adams University College, Shropsire, UK.

EDITORIAL

Welcome to the second issue of the new International Journal of Agricultural Management. We are getting well into our stride now, and I am very pleased to be able to bring you a varied and fascinating selection of articles.

Setting the scene for us, Sir John Beddington's essay on the future of food and farming takes a broad sweep, alerting us to developments in the global economy, society and environment which will have a profound impact on the wellbeing of the agricultural industry (as well as raising profound moral issues). Coupled with this, Carl Atkin brings us up to date on the latest proposals for reform of the European Common Agricultural policy and their implications. It is quite sobering to test the likely outcome of this policy development against Sir John's assessment of the actions needed to avert ecological and humanitarian crisis.

Our refereed papers address three key concerns in Western rural enterprise. Brian Jacobsen considers the opportunities and costs arising from slurry separation, particularly important in his native Denmark, but with resonance wherever intensive livestock production is prevalent. Graham Tate and Aurelian Mbzibain take a look at the ways in which bioenergy enterprises could boost the rural economy in the United Kingdom, and Eric Micheels and Hamish Gow take a close look at the relationships between 'value discipline', market orientation and firm performance using a study of the Illinois beef sector in the United States.

We continue our showcasing of papers from the International Farm Management Association's Congress in New Zealand in June 2011. Those with concerns about irrigation and water use (likely to be a rapidly growing band if Sir John is right) will enjoy the paper by Caroline Hedley and colleagues, and will want to follow their research as it unfolds in the future. At the other end of the technological scale, Philip Nyangweso and colleagues give a fascinating insight into farm cost structures and decision-making in a very disadvantage district of Kenya. Whether you are from a rich or poor country, there is much to learn here. The real value of training is always a hot topic, especially in small workforces where the opportunity cost of a day spent in training can be particularly high. Jeremy Neild and Dennis Radford use an approach developed in other industries to assess the benefit/cost ratio of training in various types of agriculture, based on a study in New Zealand. It would be interesting to see a parallel approach being taken in other parts of the world, to generate some comparative data.

As I write, the Eurozone creaks and groans, threatening to bring down the world's financial system in its own collapse. Whereas at one time I might have been looking back over this Editorial and wondering how many of the papers would still be valid in ten years' time, I now find myself wondering whether they will still hold good in ten weeks. A cheery thought – but then adversity breeds opportunity, for journals as well as for farmers...

Martyn Warren

The future of food and farming

SIR JOHN BEDDINGTON[1]

ABSTRACT

The UK Government Chief Scientist takes stock of the enormous challenges facing governments and citizens in balancing the competing pressures and demands on the global food system, not least in providing an adequate and sustainable nutrition for a rapidly-expanding population against the background of climate change. There are grounds for optimism in scientific and technical innovation, and in a growing consensus that global poverty is unacceptable and has to be ended. But the decisions ahead are difficult, and bold action is required to achieve the sustainable and fair food system the world so desperately needs.

This article is based on the 'Bishop Bill Lecture' given at Duchy College, Stoke Climsland, Cornwall, UK on 23 June 2011, and we are grateful for the assistance of the Rural Business School at Duchy College in bringing it to publication.

KEYWORDS: global food production; population; sustainability; agriculture; policy

For the latter part of the twentieth century, in the Western world, we have come to take the availability and affordability of food for granted. Indeed, in most developed countries, rather than worrying about the poorest people starving, obesity has become the modern food-related epidemic. But despite this apparent abundance of food, worldwide hunger still remains widespread and many aspects of the food system are unsustainable. Over the next 20–40 years, the food system will face significant further challenges as world population grows and critical resources such as water, energy and land become increasingly scarce, at the same time as we address and adapt to climate change. Deciding how to balance the competing pressures and demands on the global food system will be a major task for policy makers. The two year Government Office for Science Foresight project explored the increasing pressures on the global food system between now and 2050, bringing together evidence and expertise from a wide range of disciplines across the natural and social sciences and involving several hundred experts and stakeholders from around the world, to identify choices and to assess what might enable or inhibit future change. Their findings, published in the report 'The Future of Food and Farming: Challenges and Choices for Global Sustainability' launched on the 25 January 2011, highlight the decisions that policy makers need to take today, and in the years ahead, to ensure that a global population rising to nine billion or more can be fed sustainably and equitably.

One of the biggest factors driving our need to change will, in the short to medium term, be population growth. Based on the United Nations Population Divisions projections, today's population of about 7 billion is likely to rise to around eight billion by 2030 and to over nine billion by 2050 (United Nations 2009).

Most of the population increases will occur in low-income countries – Africa's population is projected to double from one billion to two billion by 2050 for instance (United Nations 2009). These population increases will also combine with other transformational changes, as rising numbers of people move from rural areas to cities that will need to be serviced with food, water and energy. Already a billion are hungry, 0.9 billion lacking access to clean water, and 1.4 billion without efficient electricity. Up to 192 million more people will be living in urban coastal floodplains in Africa and Asia by 2060, through natural population growth or rural-urban migration (Foresight, 2011d). Half the world's population now live in urban rather than rural areas, a figure that is projected to rise to 60% by 2030. It is estimated that there will be 26 cities with more than 10 million inhabitants in 2025, up from 19 today. Five of these new 'megacities' will be in Asia. The pace and scale of urbanisation will affect global food consumption. As many people are likely to be wealthier the demand for a more varied high quality diet, including increased dairy and meat consumption, will have major implications for the competition between resources (water, land and energy etc.) for food production and sustainability.

These increasing demands on our food system will add pressures on a system that is already failing in two major ways, both of which demand decisive action. Firstly, the global food system fails to feed the current world population appropriately. Nearly 1 billion people are hungry, and another billion are thought to suffer from 'hidden hunger', in which important micronutrients (such as vitamins and minerals) are missing from

[1] The Government Chief Scientific Adviser, United Kingdom.

their diet. In contrast, a billion people over-consume substantially, spawning a new public health epidemic involving chronic conditions such as type 2 diabetes and cardiovascular disease.

Secondly, many aspects of food production are currently unsustainable and the need to reduce greenhouse gas emissions and to adapt to climate change will become imperative over the coming decades. There are already widespread problems with land degradation as a result of soil loss from erosion, loss of soil fertility, salinisation and other pressures. Other challenges include: rates of water extraction from aquifers for irrigation are exceeding rates of replenishment in many places; over-fishing is a widespread concern; and there is heavy reliance of fossil fuel-derived energy for producing nitrogen fertilisers and pesticides. In addition, food production systems frequently emit significant quantities of greenhouse gases and release other pollutants that accumulate in the environment. Without change, the global food system will continue to degrade the environment and compromise the world's capacity to produce food in the future.

Any one of these factors would present substantial challenges for food security, but together they constitute a major threat. Our food system needs to change more radically in the coming decades than it did during the Industrial and the Green Revolutions. Many poor farmers orientate their livelihoods towards meeting their basic needs, particularly food, and with insufficient income, have little money to invest in increasing the productivity or sustainability of their production systems (IAASTD 2008). Substantial innovation will be needed, not only to increase production to the scale required, but to achieve this sustainably in a world where there is growing competition for resources, particularly land, water and energy. Sustainable intensification means simultaneously raising yields, increasing the efficiency with which inputs are used and reducing the negative environmental effects of food production. It requires economic and social changes to recognise the multiple outputs required of land managers, farmers and other food producers, and a redirection of research to address a more complex set of goals than just increasing yield.

This means there is a strong case for reversing the low priority that has been given to research on agriculture, fisheries and the food system in most countries – not just in biotechnology, including GM, but in more neglected subjects such as agricultural ecology, soil preservation and agronomy. For example, preserving multiple varieties, land races, rare breeds and closely related wild relatives of domesticated species will be important to keep a genetic bank of variation that can be used to select novel traits in the future; advances in soil science and related fields offer the prospect of understanding better how crop production is constrained and how we can improve the way we manage soils to preserve their ecosystem functions, improve output, reduce pollutant run-off and cut greenhouse gas emissions. Revolutionary advances such as developing perennial grain crops, introducing nitrogen fixation into non-legume crops and reengineering photosynthetic pathways for different plants were also all identified as important areas for study, but translating new science and knowledge into applications in the field takes time and is not certain. As some of these new technologies will take up to 40 years to make a contribution in the field, we need to make the investment now if we are to be ready to meet future needs.

A good example of a specific problem where more research can help is the challenge presented for the livestock sector with increasing demand for dairy and meat products. A significant amount of meat is obtained from 'grain-fed' (primarily wheat, barley, maize and soya) livestock (particularly poultry and pigs), and diets high in this type of food have a large resource footprint. The highest proportion of grain-fed meat is found in US diets, where the per capita requirement of grain is four times that of a vegetarian diet. However, there is great variation in the impact of different meat production systems, and the largest growth (particularly in Asia) is predicted in pigs and poultry, where resource efficiency can be relatively high. There are also exceptions to the generalisation that only the relatively wealthy have high meat-based diets. Many poor pastoral communities have diets based on livestock but sell high-value livestock products to buy lower-cost staple foods, and addressing their needs is critical to the reduction of hunger. Overall, the global cattle population has been predicted to increase by around 70%, from 1.5 billion in 2000 to about 2.6 billion by 2050, and the global goat and sheep population by nearly 60%, from 1.7 billion to about 2.7 billion over the same period. While acknowledging that these predictions are inherently uncertain, increases in the consumption of meat at this scale will have major implications for resource competition and sustainability. Research to find ways of reducing greenhouse gas emissions (and other negative externalities on the environment) from livestock production is a priority, while ensuring that livestock growth opportunities do not marginalize smallholder producers and other poor people who depend on livestock for their livelihoods (IAASTD 2008), along with a better understanding of what drives such dietary changes and how to discourage over-consumption and further growth.

The yield gap is normally considered to be the difference between actual yields achieved and the maximum possible yield given local soil and climatic conditions. Increasing food production using existing technologies is sometimes referred to as 'closing the yield gap'. Yield here usually refers to output per hectare, which assumes that land is the scarcest factor. However, farming systems vary greatly in terms of land availability, which means that maximising output per hectare may not always be the rational economic strategy. Equally, even where land is scarce, closing the yield gap may not be desirable if, for example, pushing yield to the maximum produces other unwanted outcomes, such as eutrophication of surface water (Pretty *et al* 2003), greater emissions of greenhouse gases or declines in wildlife (Foresight 2011a). Equally, it may not be financially worthwhile to increase production if competing supplies are available at lower prices. Achieving maximum yield from farmland, fisheries, livestock or aquaculture is constrained both by the genetic potential of the plants and animals involved and by management of the biophysical environment in which they grow or are reared. In a world of perfect information, producers would choose how much to invest in added inputs or intensification of management, given the expected returns and the revenues they can hope to receive from alternative use of these resources. In practice, all farmers live in a world of imperfect information, in which there are significant costs to acquiring information and they are subject to considerable uncertainty as regards rainfall, pest attacks, crop prices and ill health. This is especially the case for those in low-income countries, where there are also few options to insure against risk, not helped by poorly developed infrastructure, whether in roads, storage and markets, or in input and services. Conflict and political turmoil will also discourage farmers from making long-term investments in raising farm productivity. These factors keep yields low (Foresight 2011b).

The majority of the world's poorest people live on small farms and there are many existing technologies and interventions that would bring substantial gains to smallholder agriculture in sub-Saharan Africa, and elsewhere. Applying existing knowledge and technology has been estimated to increase average yields two to three fold in many parts of Africa, and two fold in the Russian Federation. Similarly, global productivity in aquaculture typically could, with limited changes to inputs, be raised by around 40% (Bostock *et al* 2010). Revitalising education or 'extension' services to increase the skills and knowledge base of food producers (often women) is critical to achieving sustainable increases in productivity in both low-income and high income countries (Pretty 2003), helping to increase producers' knowledge about best practice and to expand the social capital within and between institutions and communities in the food supply chain. Strengthening farmer associations is a vital means to addressing the range of challenges faced by farmers, whether for issues of the environment, market access or innovation. In Uganda, women have organised into groups to process and sell cassava. In Nigeria, aquaculture entrepreneurs have emerged to focus on raising and selling fish, while others concentrate on producing and selling feed. In Kenya, the extension system encourages farmers to form common interest groups for business activities (Foresight 2011c). Access to modern information communication technology (ICT), often as simple as mobile phones, in rural communities could also offer substantial potential for the dissemination of knowledge and good practice. National prioritization of the needs of resource-poor farmers may be more important in the future as scientific and agricultural technology spillovers from developed countries that are adapted by developing countries may be less available (Alston 2006). Farmers in high-income countries are demanding high-technology inputs that are often not as relevant for subsistence agriculture (such as precision farming technology or other capital-intensive methods). As well as differences in value-adding processes to serve consumer demands, differences in farm production technologies are emerging to serve the evolving agribusiness demands for farm products with specific attributes for particular food, feed, energy, medical, or industrial applications (Pardey *et al* 2006).

At the same time as putting food production back on the agenda however, it's important that we recognise that it can't be looked at in separation from the issues of water availability, energy supply and climate change. Greenhouse gas emissions from the food system constitute 12–14% of all emissions and are likely to increase substantially in the decades ahead. Livestock and nitrogenous fertiliser are major sources of emissions of the greenhouse gases methane and nitrous oxide. Agriculture uses 4% of global fossil fuels, of which about 50% is required for producing fertilizers. Agriculture already consumes 70% of the total global water withdrawn from the rivers and aquifers available to humankind (FAO 2006). There is a clear case for making agriculture and food production a central issue in future negotiations on global emission reduction, not least at the forthcoming COP17 discussions to take place in Durban in December 2011. The features unique to this sector will however need to be taken into account, in particular the possible effects on efforts to reduce world hunger and ethical issues concerning which geographical and economic groups should bear the costs of mitigation.

But as well as thinking about how we can help agriculture adapt to climate change, we should also be considering how agriculture can be used to mitigate climate change. Increasingly thoughts are turning to how, in the future, terrestrial and aquatic ecosystems used in food production will need to be managed to achieve multiple goals. The current World Bank/ FAO initiative highlights the need for 'Climate-Smart' agriculture, which promotes agricultural production systems that either reduces the level of green house gas production per unit product, or actually sequesters carbon dioxide in the production system. Improving current cropping and livestock systems to develop these new sustainable farming systems, will require using better technologies which produce less GHG emissions, and building on local and traditional knowledge. For example, the Nhambita community carbon project in Mozambique has offset 24,117 tons of carbon dioxide equivalent by helping farmers to adopt better agroforestry techniques (FAO 2010). Long term carbon capture on farmland through agroforestry may also provide other benefits such as reducing soil erosion and producing renewable fuels and animal feed. Similarly in Peru, there have been a number of initiatives to help increase milk production in poor rural areas through improved pasture management and breeding programmes. These initiatives have helped increase milk production by 25% per cow. This means that farmers are able to keep smaller, more efficient herds, which increases their incomes and reduces greenhouse gas emissions too (FAO 2010). Similarly, gains could also be achieved through appropriate management of aquatic and aquaculture habitats and the value of mangroves, seagrass beds and saltmarshes for sequestration needs to be recognised more fully and measures taken for their protection and restoration.

In the UK, there are also some real opportunities to improve food production in a low carbon way. The recently launched multi-partner Global Food Security programme promoting better co-ordination and coherence across public funded agri-food research is exploring multi-disciplinary approaches combining economic, environmental and social evidence to consider how to improve input-use efficiency (nitrogen, and water) and reduce the amount of food waste within the food system, while minimising adverse effects on the environment. The Technology Strategy Board (TSB) in collaboration with Defra, BBSRC and Scottish Government is investing nearly £16 million in 29 projects that will help to secure the sustainable supply of protein such as meat, fish and animal feed. The Greenhouse Gas Action Plan (GHGAP) sets out how the agriculture industry in England will tackle climate change by reducing greenhouse gas emissions by three million tonnes of CO2 equivalent per year from 2018–2022. These initiatives on various aspects of climate-smart agriculture will help us not only understand the full consequences of the very complex and context specific impacts on greenhouse gas budgets of different practices, but also help us to develop the potential of agriculture in reducing atmospheric carbon dioxide.

Agriculture also has a vital role to play in maintaining biodiversity. The food system relies on a variety of services that are provided without cost by nature (ecosystem services) but the way we produce food may negatively affect the environment and therefore harm the same ecosystem services it relies upon, or affect those that benefit other sectors. Indeed food production takes up more land and has a greater impact on marine and freshwater ecosystems than any other human activity – this can only increase as demands for food increase over the next 40 years. Until recently policies in conservation and in food security were largely developed in isolation. However, given their interdependence, there are both economic and non-economic arguments for why biodiversity should be considered in decision-making regarding our food system. This will however create some difficult tradeoffs including: How intensively can we farm the land while still looking after wildlife? Who pays the cost of protecting bio-diversity? This last question is particularly difficult as some of the most threatened and diverse habitats on earth exist in very low-income countries, where many rural poor depend on local bio-diversity for their livelihoods. There are strong ethical arguments against imposing the costs of protecting biodiversity on those least able to pay them and the Foresight report recommends that this is a key area where international policy needs to act, ensuring that countries receive benefits in return for safeguarding or providing global ecosystem goods. At the same time however, it is clear that we need to firm up the evidence behind what constitutes wildlife friendly farming and how it potentially benefits bio-diversity. While there is a very large literature on wildlife friendly farming and the numerous ways in which biodiversity can be encouraged on productive land, there is still debate about the effectiveness of schemes aiming to encourage this approach. There needs to be a more analytical and evidence based approach to establish what works best.

The global food system will face enormous challenges between now and 2050 – indeed as great as any it has confronted in the past. Food production and the food system must assume a much higher priority in political agendas across the world and we must be prepared for change on an unprecedented scale. But although the challenges are enormous, the Foresight report does point to real grounds for optimism. Innovation in the natural and social sciences continue to offer new solutions and understanding; and there is growing consensus that global poverty is unacceptable and has to be ended. But the decisions ahead are difficult. They will require bold actions by politicians, business leaders and researchers, as well as engagement and support by individual citizens everywhere if we are to achieve the sustainable and fair food system the world so desperately needs.

About the author

Sir John Beddington CMG FRS was appointed as Government Chief Scientific Adviser (GCSA) on 1 January 2008. Since being in post, the GCSA has led on providing scientific advice to Government during the 2009 swine flu outbreak and the 2010 volcanic ash incident. The GCSA has also been responsible for increasing the scientific capacity across Whitehall by encouraging all major departments of state to recruit a Chief Scientific Adviser.

Throughout 2008 and 2009 Sir John raised the concept of the "*Perfect Storm*" of food, energy and water security in the context of climate change, gaining considerable media attention and raising this as a priority in the UK and internationally.

Prior to his appointment as GCSA, he was Professor of Applied Population Biology and headed the main departments of environmental science and technology at Imperial College. His main research interests are the application of biological and economic analysis to problems of Natural Resource Management.

Sir John has previously been advisor to a number of UK Government departments including the Foreign and Commonwealth Office, the Department for Environment, Food and Rural Affairs, the Ministry of Defence and the Cabinet Office. He has also advised several Governments and international bodies including the Australian, New Zealand and US Governments, the European Commission, the United Nations Environment Programme and Food and Agriculture Organisation.

He was, for six years, a member of the Natural Environment Research Council. In June 1997 he was awarded the Heidelberg Award for Environmental Excellence, in 2001 he became a Fellow of the Royal Society. In 2004 he was awarded the Companion of the Order of St Michael and St George by Her Majesty the Queen and in June 2010 was awarded a knighthood in the Queen's Birthday Honours.

REFERENCES

Alston, J.M., Pardey, P.P., and Piggott, R.R. (2006). Synthesis of themes and policy issues. p. 361–372. In P.P. Pardey (ed) *Agricultural R&D in the developing world: Too little, too late?* IFPRI, Washington DC.

Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., Little, D., Ross, L., Handisyde, N., Gatward, I., and Corner, R. (2010). Aquaculture: global status and trends. *Phil. Trans. R. Soc. B.* 2010 365: 2897–2912.

FAO (2006). AQUASTAT Database *in* Molden, D. (ed.) (2007. *Water for Food, Water for Life: Comprehensive Assesment of Water Management in Agriculture,* London and Colombo,Sri Lanka: Earthscan and IWMI.

FAO (2010). *Climate-Smart'' Agriculture Policies, Practices and Financing for Food Security, Adaptation and Mitigation*.

Food and Agriculture Organisation of the United Nations, Rome.
Foresight (2011a). *Global Food and Farming Futures: Synthesis Reports - C2: External Pressures on the Food system, C12: The Food System in a Low Emissions World and C13: Maintaining Biodiversity and Eco-system Services*. London: Government Office for Science. Department for Business, Skills and Innovation.
Foresight, (2011b). *Global Food and Farming Futures. Synthesis Report C5: Producing more food sustainably, using existing knowledge and technologies*. London: Government Office for Science. Department for Business, Skills and Innovation.
Foresight, (2011c). *Global Food and Farming Futures. Synthesis Report C9: Sustainable Intensification in African Agriculture*. London: Government Office for Science. Department for Business, Skills and Innovation.
Foresight (2011d). *Migration and Global Environmental Change: Future Challenges and Opportunities*. London: Government Office for Science. Department for Business, Skills and Innovation.
International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD), (2008). *Agriculture at a Crossroads*. Eds: McIntyre, B.D., Herren, H.R., Wakhungu, J. and Watson, R.T.
Pardey, P G., Alston, J.M., and Piggott, R.R. (ed) (2006). *Agricultural R&D in the developing world: too little, too late?* IFPRI, Washington DC.
Pretty, J. (2003). Social capital and the collective management of resources. *Science*, 302, 1912–1914.
Pretty, J., Mason, C., Nedwell, D. and Hine, R. (2003). Environmental costs of freshwater eutrophication in England and Wales. *Environmental Science and Technology*, 37, 201–208.
United Nations (2009). *World Population Prospects. The 2008 Revision. Highlights*.

PROFESSIONAL UPDATING

New CAP, Old Hat? Some thoughts on the EU's Common Agricultural Policy 2014–2020

CARL ATKIN[1]

ABSTRACT

After a brief review of recent attempts to reform the Common Agricultural Policy of the European Union, the essential elements of the Commission's proposals for the reshaping of the policy from 2014 are reviewed and their implications considered. Given that this is just the first salvo in the campaign, the author concludes that we can expect a great deal of heated debate and substantial horse-trading before the final settlement is reached.

KEYWORDS: Common Agricultural Policy (CAP); Mid-Term Review; European Union; subsidy; cross compliance

1. Context

Those who are veterans to the European policy arena will have thought 12 October 2011 to be one of the most uneventful CAP reform release days of recent decades. There are two reasons for this. Firstly, in today's internet age, leaked copies of the Regulations appeared many months ago and so there was very little that was 'new' in the official announcement made last month. Secondly, there were very few substantive changes proposed to the basic architecture of the current policy, and it might unkindly be described as 'underwhelmingly unambitious'.

For those not familiar with CAP, we are now really well into what might be called 'Phase 3' of CAP – a period that began in 2005 with farm support now almost all decoupled from production decisions across the 27-member bloc. Assigned to distant memories are the famous butter mountains and wine lakes which became so politically embarrassing to the Commission during the 1980s under what might best be called 'Phase 1 – Market Support' of the CAP which ran from its inception in 1958 until the MacSharry Reforms of 1992.

The colourful Irishman who gave his name to that major reform of the early 1990s is also now a fading memory except to those well-versed in agricultural policy history. Ray MacSharry began the long slow process of dismantling the old market support mechanisms in the CAP and 'partially decoupling' the payments by linking them to crop areas and livestock numbers rather than to market prices in 'Phase 2' of the CAP which ran from 1993 to 2004 and saw farmers supported through a complicated structure of crop-based area payments and headage payments linked to livestock stocking densities. During this period, agri-environment and rural development policies and payments were fully integrated into the CAP architecture as 'Pillar 2', with mainstream agricultural support being designated 'Pillar 1.'

The introduction of the Single Payment Scheme (SPS) in 2005 following the Mid-Term Reform (MTR) of 2003 was arguably the most radical reform of CAP since it was founded. Almost all previous support payments and market support payments were bundled up into this new 'single payment' and paid irrespective of agricultural production activity. Since 2005 farmers simply have had to adhere to baseline environmental management standards, known as cross compliance, to receive the support payment. The MTR started with the arable, livestock and dairy regimes but has over the years been extended to cover tobacco, olive oil, hops and cotton (2004); sugar (2005) and fruit and vegetables (2008). The SPS is now the single most important policy instrument of the CAP.

2. Introduction to the 2013 Reforms

The 2013 CAP reforms have been promoted by the current funding and legislative arrangements for the Single Payment Scheme expiring in 2012. Although the 2003 Reforms were subject to a 'Health Check' or mini-reform in 2008, the basic architecture of the scheme has remained unchanged across the EU for the last six years.

There are the usual pressures bearing down on the reform process, notably the cost of the direct payments

[1] Head of Research and Consultancy, KinnAgri Limited. Carl.Atkin@Kinnagri.com

and the public justification for them – the SPS is, in effect, a complicated mish-mash of income support, compensation for previous supported price reductions and baseline environmental management payments through cross compliance. For many countries which adopted a 'historical' model of implementation of the SPS, the reference years of 2000–2002 now look increasingly anachronistic and there is pressure to harmonise large differences in payments that have been created by this historical quirk. The second pressure is the need to harmonise the SPS system with its simplified cousin (the Single Area Payment Scheme, or SAPS) which was offered to the New Member States who joined the EU in 2004 and 2007; these countries generally have substantially lower payments per hectare than the old EU-15.

As a reminder there are *four separate new regulations* proposed as part of the 2013 reforms although the aspect which continues to attract most is of course the future design of any new direct payments. This is partly because the budget for direct payments is the most important element of EU agricultural policy, accounting for 72% of EU CAP expenditure in the 2012 budget, and partly because of their continuing important role in underpinning farm income in the EU.

3. Key Elements of the Proposed New Regulations

In a nutshell, the key elements of the proposed new Regulations are:

i. The replacement of the existing SPS in the old EU-15 (plus Malta and Slovenia) and the SAPS in the 10 New Member States of 2004 and 2007 with a new **Basic Payment Scheme (BPS)**, based on up to 70% of the 'national ceiling' available for Pillar 1 payments. Entitlements to the new scheme will be allocated based on applications made on 15 May 2014, but the rules on the management of the newly allocated entitlements and the national reserve largely follow the current rules of the SPS. (In practical terms the current payment entitlements to SPS cease to exist on 31 December 2013). For those countries which have previously implemented SAPS, the creation of 'entitlements' separate to land will be a new concept. All Member States will be obliged to move towards a ***uniform payment per hectare*** at national or regional level by the start of 2019 – a potential major change for those countries currently using the 'historical' model of SPS implementation. There will be various provisions to deal with oddities created during the transition period – such as a National Reserve and Hardship provisions, very similar to those offered as part of the 2003 reforms.

ii. A new '**Greening Payment**' based on up to 30% of the annual ceiling for farmers who follow 'enhanced cross compliance' measures beneficial for the climate and the environment. If farmers wish to receive the BPS then ***participation in this scheme will be compulsory***. This came as a surprise to many commentators who had assumed in the early stages of the proposals that the 'greening' measures would be optional but this is not the case. The measures proposed in Articles 28 to 31 of the Regulation are:

- maintaining permanent pasture;
- crop diversification (a farmer must cultivate ***at least 3 crops on his arable land*** none accounting for more than 70% of the land, and the third at least 5% of the arable area); and
- maintaining an 'ecological focus area' of ***at least 7% of farmland*** (excluding permanent grassland) – i.e. field margins, hedges, trees, fallow land, landscape features, biotopes, buffer strips, afforested area.

This clearly creates all sorts of practical problems for those businesses which are 'block cropped' as part of larger farming rotations and it is not clear how any ecological focus area required under greening will fit with 'broad and shallow' stewardship schemes currently operating under Pillar 2, such as Entry Level Stewardship in the UK.

iii. **Other payments:** There will be a voluntary additional payment (up to 5% of the national ceiling) for farmers in disadvantaged areas; a mandatory additional payment to new entrants enrolled in the basic payment scheme (up to 2% of the national ceiling) and a simplified scheme for small farmers (up to 10% of the annual national ceiling). Provision is made for a voluntary coupled support scheme for specific types of marginal farming which are particularly important for economic and/or social reasons (up to 5% of annual national ceiling with the possibility to go beyond this in particular cases). There are also some transitional arrangements for Romania and Bulgaria allowing them to continue with Complementary National Direct Payments (CNDPs) in 2014 and 2015.

iv. **Cross compliance**: The award of all payments will continue to be linked to the baseline requirements relating to environment, animal welfare and plant and animal health standards known as 'cross compliance.' However, as an exercise in simplification, it is proposed that the number of Statutory Management Rules (SMRs) will be reduced from 18 to 13 and rules on Good Agricultural & Environmental Condition (GAEC) will be reduced from 15 to 8. It is worth noting that some of these elements will also be new obligations to existing SAPS claimants which do not have such rigorous cross compliance obligations as the current SPS. It is also proposed that the Water Framework Directive and the Sustainable Use of Pesticides Directive will be incorporated into cross-compliance rules.

v. **'Capping'**: This is potentially the most contentious point and is set out in Article 11 of the regulation. This proposes that the amount of support that any individual farm can receive from the Basic Payment Scheme will be limited to €300,000 per year[2], and the payment will be reduced by 70% for the part from €250,000–300,000; by 40% for the part from €200,000–250,000, and by 20% for the part from

[2] In mid-October 2011, €1 was approximately equivalent to $1.4 and £0.87

€150,000–200,000. Greening Payments will be excluded. However, in order to take employment into account, the holding can deduct the costs of salaries in the previous year (including taxes and social security contributions) before these reductions are applied. It is not believed this would include contract labour and so this interpretation could be a substantial disadvantage to those in share farming, contract farming or joint venture operations. This point is clearly highly contentious and likely to be the subject of significant debate and challenge during the on-going negotiations, and it would be very difficult to implement and police. I expect that these provisions will be watered down during the course of the negotiations.

vi. **'Active farmers'**: In order to iron out a number of legal loopholes, the Commission is tightening the definition of active farmers in these regulations – Article 9 of the regulation. Aimed at excluding payments to applicants who have no real or tangible agricultural activity (perhaps including some sports clubs, stud farms, airports and golf courses) the proposed definition states that payments would not be granted to applicants whose CAP direct payments are less than 5% of total receipts from all non-agricultural activities, or if their agricultural areas are mainly areas naturally kept in a state suitable for grazing or cultivation and they do not carry out the minimum activity required, as defined by Member States. In order to avoid small part-time farmers being caught by this, there is a derogation for farmers who receive less than €5,000 in direct payments the previous year.

vii. **Eligible hectares** – The rules foresee setting 2014 as a new reference year for land area, but there will be a link to beneficiaries of the direct payments system in 2011 in order to avoid speculation. Article 21 of the draft regulation sets out the details, but this is potentially a serious issue for land sales and tenancies being transferred after 2011 and there are many potential problems in this area. For example in the case of the sale or lease of a holding or part of it, by a contract signed before the 15 May 2014, currently the transfer of the right to receive payment entitlements is only to ***one*** farmer (provided that the latter complies with the conditions laid down in Article 9). What if a claimant needs to transfer the right to more than one other, where for example a number of tenancies have been given up since 2011? Additional issues on the horizon include where the status of the 2011 claimant changes, which is likely in a number of circumstances.

4. Payment Values

One of the key points of contention, especially for those countries who joined the EU in 2004 and 2007, is whether the question of 'equality' between the 'old' and 'new' Member States has been addressed. Commission figures show that the average direct payment per hectare of potentially eligible area (PEA) for the year 2013 is €94.70 in Latvia and €457.50 in the Netherlands, whereas the EU-27 average is €269.10. Here the Commission's direct payments regulation opts for a pragmatic approach. It proposes a very limited redistribution initially of funds, envisaging that for countries currently receiving less than 90% of the EU average payment per eligible hectare, one-third of the gap between their current figure and 90% of the EU-27 average is closed. This limited effect is confirmed in the impact assessment, which calculates that the redistribution would amount to just €738 million out of a total budget of €42.8 billion.

However, in the medium-term, and by December 31 2028 at the latest, the proposals suggest that all allocated payment entitlements in the Union should have a uniform value, implying that the payment per eligible hectare in Latvia should be the same as in the Netherlands. This ambitious objective was presumably inserted under pressure from the new member states in exchange for the more limited redistribution initially. Indeed, taken at face value, it appears to rule out different regional unit values within a member state, even though this is expressly permitted in the current regulation.

5. The Process from Now Until 2014

The Commission proposals for new CAP regulations published last month are only the first step in the legislative procedure. The proposal now enters the co-decision process between the Council of Ministers and the European Parliament. In the first reading, the Parliament will adopt its position by a simple majority and the Council will adopt its position by a qualified majority. If the Council adopts the Parliament's position, then the regulations are adopted.

It is more likely that the positions taken by the two parties will differ, in which case the process moves to a second reading in both the Parliament and the Council. Within a three month period, the Parliament can either approve the Council's common position (in which case the regulations are adopted) or propose amendments to the Council's position which are then put to the Council and the Commission for their opinion. The Council then has a further three months in which to accept the Parliament's amendments by qualified majority (or by unanimity where the Commission has given a negative opinion). If the Parliament's amendments are approved, then the regulations become law. Otherwise, a Conciliation Committee is convened within a six week period and the process continues.

It is hoped that the final decisions could be taken under the Irish Presidency of the Council in the first half of 2013 – but in reality there may be slippage and a further roll-on of the existing regimes for 2014 with a start date of 1 January 2015. What is clear is that over the next two years we can expect a lot of heated debate and substantial horse-trading before the final settlement is reached.

About the author

Carl Atkin is Head of Research and Consultancy at KinnAgri Limited, an international agribusiness management and consultancy business which is part of the Investment AB Kinnevik Group. He is joint Deputy Editor *of IJAM (with Professor John Gardner, Massey University, New Zealand). His business consultancy interests extend across the whole agribusiness value chain including life science companies and food processors as well as numerous private and corporate farming businesses. He currently spends a lot of time working in Central and Eastern Europe on agribusiness investment projects but maintains an active interest in CAP reform, having in the past given advice to both DEFRA and HM Treasury on agricultural policy issues and appeared before the House of Commons Environment, Food and Rural Affairs select committee to discuss the 2003 CAP reform issues. Carl has a first class Honours Degree in Agriculture and Farm Business Management from Newcastle University (2000) and a Postgraduate Masters in Business Administration (2007). He is a Council Member of the UK Institute of Agricultural Management (MIAgrM) and a Member of the International Farm Management Association (IFMA), the Agricultural Economics Society (AES) and the Agricultural Law Association (ALA). Email: carl.atkin@kinnagri.com*

Costs of slurry separation technologies and alternative use of the solid fraction for biogas production or burning – a Danish perspective

BRIAN JACOBSEN[1]

ABSTRACT
The purpose of this paper is to analyse different separation concepts in order to evaluate the overall costs based on a systems approach from stable to field. When livestock are produced in livestock intensive areas the distribution of manure without creating a surplus of nutrients is often a problem. Separation of the slurry into a liquid nitrogen rich fraction and a more solid phosphorus rich fraction, which is exported away from the farm, may alleviate this problem. Separation offers an alternative to transporting the slurry further away, renting more land or buying more land. The need for P-balance is stricter in Denmark than before, but developments in feeding, changes in regulation and the reduction of livestock numbers have made separation less favourable. This article compares dominant separation technologies in Denmark, such as decanter and flocculation, as well as source separation, in order to establish the overall costs. Key parameters are livestock density, transport distance, price of additional land and cost of separation. The conclusion is that unless land prices or prices on slurry agreements are very high, traditional handling of animal manure has the lowest costs. Decanter separation can be the cheapest if area is limited and co-operation with neighbours is possible as large volumes reduce separation costs per tonne. Flocculation is the best if much P has to be removed from the farm in the solid fraction. Separation will in the future in many cases be combined with biogas production as the solid fraction gives a much higher gas production per tonne than slurry.

KEYWORDS: Slurry separation; costs; economics; separation technologies; solid fraction; biogas

1. Introduction

In a number of regions in Europe, the amount of animal manure is high compared to the agricultural land where it can be applied, leading to applications of nitrogen and phosphorus which exceed the crops requirements. These regions cover the Western part of Denmark, The Netherlands (especially the Southeast), Belgium, as well as parts of France and Spain (Brower, 1999). In order to comply with the Nitrate directive (Commission, 1991) and the Water Framework directive (Commission, 2000) lower nutrient application is likely. In the reports to the commission several EU countries note that processing or separation of manure is used in livestock intensive areas (Commission, 2010).

The largest part of slurry is water and it is natural to consider separation of slurry into fractions where the water fraction stays on the farm. This separation can potentially reduce the transportation costs and perhaps storage costs (Burton, 1997 and Jacobsen *et al*., 2002b). In case higher overall utilisation of nutrients in the fractions could be achieved, this would lead to lower purchase of mineral fertiliser. Separation will especially help to decrease the phosphorus load if the phosphorus rich fractions are exported away from the livestock intensive farms (Jacobsen *et al*., 2002b). On the other hand, the use of separation techniques might not reduce the smell from pig production or lower the frequency of animal diseases from slurry as the process does not reduce the number of harmful bacteria (pathogens) (Burton, 2007). The solid fraction from the separation is well suited for biogas plants as the methane production increases with the dry matter content (Møller *et al*., 2004; Møller *et al*., 2007). The alternative is to burn the solid fraction. The area used for applying the manure might be reduced when the environmental regulation related to the Water Framework Directive and the Habitat Directive is implemented (Commission, 1992) is applied and separation is in this case a way to maintain the current animal production at the present location with lower environmental impact.

From an economic perspective, any additional cost related to the processing of slurry has to be recovered in one way or another. This can be through lower transportation costs or higher value of the end product. In other words, the total farm sector benefits have to

[1] Institute of Food and Resource Economics, University of Copenhagen, Rolighedsvej 25, 1958 Frederiksberg C, Denmark. brian@foi.dk

exceed the costs of separation for it to be worthwhile. However, the benefit of using new technologies might include a transfer of income from the animal producer to the arable farmer. Danish arable farmers, who are reluctant to receive slurry from neighbouring farms, do so only if most of the transportation and the application costs are paid by the animal farmer. In some very livestock intensive areas, the receiving arable farmer also receives a per hectare payment from the animal farmer.

The purpose of this paper is to analyse different separation concepts in order to evaluate the overall costs based on a systems approach from stable to field. The paper explains how regulatory changes (livestock density and burning) have changed the uptake of separation technologies. The paper then describes how separation might be combined with biogas production. Furthermore, the paper also looks at whether separation techniques can produce fractions which, on their own, can fulfil the nutrient requirements of the crops.

The paper starts with a short description of the development of the use of separation technologies in Denmark, which is one of the countries in Europe with the highest use of separation technologies. It then goes on to look at the rationale for using separation technologies and the legal restrictions. The paper then describes the costs and revenue related to using the three alternative technologies (decanter, flocculation, source separation) from stable to field on a large pig farm producing 18,000 finishing pigs a year. The effects on changes in land price and transport distance of the ranking of alternatives is discussed in the final section. In the appendix (table A1 to A4), the values for the scenarios are described in more detail.

The paper analyses separation techniques including both the environmental and economic dimension, looking at the entire chain from stable to the field, with a focus on nitrogen usages and phosphorus and the alternative use of the solid fraction.

2. Separation techniques and regulation in Denmark

In a Danish context, the separation technologies have been divided into ‘‘high technology separation’’ where the outcome is several fractions, of which one is almost pure water, and ‘‘low technology separation’’ which produced two fractions. The high technology separation techniques have been in the developing stages for a number of years, but the approach has been too costly and technically not reliable so the companies have closed down (e.g. Funki Manura and Green Farm Energy). This has left the market to simple, but well tested technologies such as the decanter technology (Jacobsen *et al.*, 2002b, Jacobsen and Hjorth-Gregersen, 2003).

In 2007, 944,000 tonnes of slurry was separated on 51 separation units in Denmark (Landscenteret og KU, 2007). This is equivalent to 3% of the total amount of slurry produced nationwide. The yearly production of manure in Denmark in 2007 was 34 million tonnes of which 27 million tonnes was slurry (liquid), 4.2 million tonnes was deep bedding with much straw) (solid), 0.7 million tonnes was urine (liquid) and 0.7 million tonnes was farm yard manure (solid) (Videncenter, 2008). The solid types of manure have a dry matter content of over 20%.

At all separation units, the slurry is divided into a solid fraction and a liquid fraction. Half of the units were based on slurry from pig production, whereas the other half were based on slurry or degassed material from biogas plants where the raw slurry also might come from a pig farm. Often the liquid fraction is distributed on the local farm, whereas 44% of the solid fraction is exported to other farmers and 31% to the biogas plant (Landscenter and KU, 2007). Only 3% of the solid fraction was burned and the rest is unknown. Most separation units were implemented between 2006–2007, partly because of a 40% investment subsidy in that period (Landscenter and KU, 2007). The Danish Farmers Advisory centre (Frandsen, 2010) estimates that of the units working today, 40% are screw press, 40% band filter and most of the rest decanter centrifuge.

This development fits in very well with the conclusion in a previous report from the Institute of Food and Resource Economics, which concluded that the high technologies plants were too expensive (Jacobsen *et al.*, 2002b). The report showed that the handling of fractions requires new application technologies and a focus on reducing the nitrogen loss at storage. Finally, the report points out that the alternative land price and the income from farming has to be large for even the low technology options to be a profitable alternative to longer transport or renting more land. The decanter separation units might in some cases be worthwhile as the total costs were lower than traditional handling, but the report pointed out that the lack of a market for the solid fraction was a major problem.

Since the high fertiliser prices in 2008–2009 have caused more arable farmers to be interested in receiving the solid fraction than before, as is also the case with biogas plants as the alternatives have become more expensive (Jacobsen, 2011b). The change has also lead to exchange of manure agreements over the internet, but alternative use of the solid fraction in gardens etc. is still very limited (Jørgensen and Jensen, 2010). Another key factor in the uptake of separation besides the technology and the economics, is the regulation of livestock farms and the need to transport slurry further away.

Area required for animal farms in Denmark

The Danish legislation allows only a maximum of 1.4 livestock units (pigs) and 1.7 livestock units (dairy) per hectare (standard conditions) (Anonymous, 2011). One livestock unit is 100 kg N measured from storage, which includes N-emissions at the storage, but not during application. One livestock unit was previously equal to one dairy cow, but is today equivalent to 0.75 dairy cows or 36 finishing pigs as the developments in feeding over the years has been taken into account. For dairy cows the nitrogen efficiency measures as the ratio between input and output has increased over time. In the United Kingdom 0.87 dairy cow produces 100 kg N (Defra, 2010).

According to the Danish regulation, the agricultural area needed for distribution of slurry needs to be owned, rented or guaranteed by 5 year slurry contracts. A given percentage of this distribution area has to be owned by

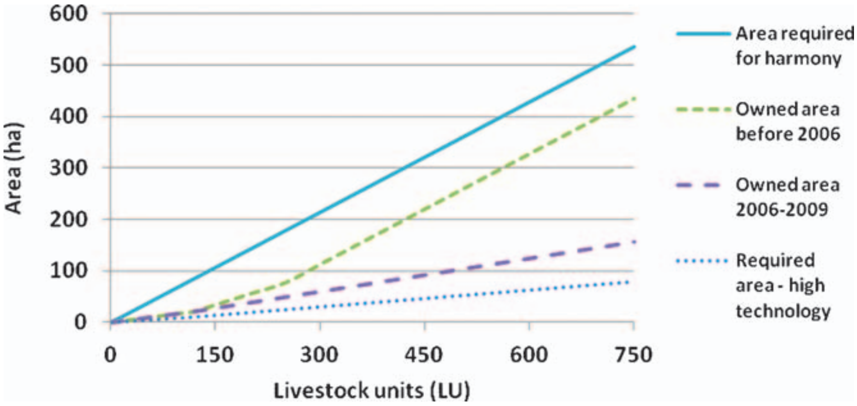

Figure 1: Area required for harmony on a pig farm according to Danish legislation
Source: Own calculations

the farmer, and this percentage increases with farm size. In Figure 1, the top line shows the area required to have harmony between area and livestock production on a pig farm. The top dotted line shows how much of the area required for harmony had to be owned by the farmer before 2006. The area requirement has been relaxed since and was, in April 2010, removed (Anonyms, 2010) so that farmers no longer need to own the area needed for the distribution of their slurry.

The regulation regarding distribution area has helped to avoid a large excess of phosphorus as has been seen in other livestock intensive countries e.g. in the Netherlands where the surplus was 31 kg P per ha in 1998 (Oenema and Berentsen, 2005). As a comparison, the Danish surplus was 11 kg P per ha in 2000 (Jacobsen *et al*., 2004), which is at the same level as the UK, which had a P-surplus of 10 kg P per ha in 2000 (Defra, 2011). In all three countries, the P-surplus in 2010 is lower than it was 10 years ago.

In 2002, an incentive to promote separation was included, as the area requirement was reduced by 25 and 50% for the use of high and low separation technology respectively, but this has later been abolished. The conclusion is that the incentive to support separation in the period 2002–2009 probably did help to increase the number of separation systems implemented as the land prices at the same time were increasing. Furthermore, the relatively low income in pig production in 2008–2010 has also worked against increasing the number of separation units. The total numbers of pigs has decreased by 10% from 14.0 million in the fourth quarter in 2007 to 12.5 million in the third quarter in 2010 (Statistics Denmark, 2010). Also, the total number of livestock in Denmark has decreased by 400,000 livestock units to 2.1 million livestock units in 2009, which is a decrease of 18%. Part of this reduction has happened because of the problems with getting approvals for new animal farms through the new electronic approval system introduced by the Danish Environmental Protection Agency (Husdyrgodkendelse, 2011 and Jacobsen, 2011a).

The lower livestock density has reduced the need for separation technologies as land is easier to come by, which together with the financial crises has reduced land prices. On the other hand, farmers and biogas companies are more willing to buy or receive separation products (solid fraction) than five years ago as they have realized the value of the products in the years with high fertiliser prices. However, the price for the fractions is still low, sometimes zero, even though the nutrient value per tonne is relatively high. This indicates that the barrier for arable farmers to receive slurry is relative high, perhaps based on negative experience and perceptions of the inconveniences.

Burning the solid fraction

An alternative to selling the solid fraction is to burn this fraction, but in 2008 this was only adopted in relation to 1–3 separation plants (Birkmose and Zinck, 2008). A Danish analysis of the costs shows that there can be a little gain from burning the solid fraction if the produced heat can be fully used and the burning facility is a large scale operation (e.g. 62,000 tonne per year) (FVM, 2005; Schou *et al*., 2006; Hjorth-Gregersen and Christensen, 2005). In this case, the heat is sold at €28.8[2] per MWh (or €7.4 per GJ). In the case where the burning is carried out in combination with a biogas plant, it is even more profitable.

The solid fraction can only be burnt in an approved facility. Typically the large burning facilities already fulfil strict rules and have the advantage that they can take large quantities. To allow burning of fractions at the farm separation plants the Danish Environmental Protection Agency would have had to classify the solid fraction as something other than waste (e.g. bio material like straw as advocated by the Farmers' Association (Miljøstyrelsen, 2009c and Birkmose and Zinck, 2008; Hansen *et al*., 2009). The conclusion is that, in a Danish context, the burning of the solid fraction is only possible at centralised plants. Apart from traditional burning, gasification is another option. The difference is that the substance is heated without oxygen and syngas is produced, which is a gas containing CO and hydrogen. Another issue is to what extent the technology used allows for recycling of P. Phosphorus is a limited resource and technologies which result in P-ash which cannot be fully used by plants is less sustainable. Analyses do indicate that the P in ash from burnt solid animal manure can be used by plants, but there are some uncertainty regarding the levels (Petersen and Sørensen, 2008; FVM, 2005).

[2] In mid-October 2011, €1 was approximately equivalent to $1.4 and £0.87

Separation and biogas

Biogas plants today try to use the solid fraction from separation in the production of biogas. Today 6–7% of the slurry is treated in a biogas plant, but the Danish Government intentions are to increase this to 50% based on the Governments Green Growth Plan (Government, 2009). This is part of the strategy to reduce Green House Gas Emissions (Dubgaard *et al*., 2010).

Biogas plants are less profitable than before as plants now have to pay for e.g. fish oil and other gas busting ingredients (see Nielsen *et al*., 2002; Maarbjerg bioenergy, 2005 and Morsø Bioenergy, 2009). The previous guaranteed price in the 2003 agreement was €0.08 per kWh for 10 years and then €0.05 per kWh for 10 years.

The price of €0.10 per kWh in 2010 includes a subsidy of €0.06 per kWh, which is paid by all Danish users of electricity. This higher price of €0.10 per kWh in 2010 for "green electricity" has not been able to ensure profitability in new biogas plants although this subsidy in index linked and as such increase over time. The subsidy in Germany is between €0.15 per kWh for large plants (5 MW) and €0.25 per kWh for small plants (150 kW) (Fuchs *et al*., 2011). The smallest biogas plants get the highest subsidy and it is relatively high even though the heat is often not used. It is, therefore, no surprise that the growth in biogas production at the farm size plants is much higher in Germany than in Denmark at the moment (Fuchs *et al*., 2011).

The advantage of using a biogas plant is the more balanced content of N and P and also that the utilisation of N in digested slurry is higher (lower ammonia emissions), it is free from germs and the smell is reduced. For biogas to expand in Denmark, feeding biogas to the current natural gas grid is an important option. The cost of using natural gas is around €0.36 per m3 methane. Production of biogas based on slurry costs is around €0.54 per m3 methane, increasing to €0.67 per m3 methane when it is upgraded to natural gas level (extracting CO2) (Jensen, 2009). In the case where the current subsidy for green electricity and heating is given to green methane production, the costs would come down to €0.36 per m3 methane, which is similar to the natural gas price (Jacobsen *et al*., 2010). With even conditions between biogas for heating locally and delivery to the natural gas grid, biogas companies would be interested in using this option. Today the biogas companies are restricted as they only have one buyer of the gas, namely the local combined heat and electricity plant. It will also allow the produced energy to be used better in the summer, where the need for heating is low. The introduction of technologies which can reduce the costs of upgrading biogas would further promote this change (Hashøj biogas, 2011).

Reducing P-surplus

Reducing phosphorus surplus is another important reason behind the use of separation, as the Danish environmental target in the Aquatic Plan III is to reduce the P-surplus of 30,200 tonne P in 2001/2002 by 50% by 2015. Feeding practices are changing so that an average pig farm with 1.4 LU/ha today applies 25–30 kg P, where the crops require 20–25 kg P per. ha. In 2002, the feeding norms resulted in an application of 37–44 kg P per ha based on 1.4 livestock units per ha and traditional feeding (Miljøstyrelsen, 2009a). The P-surplus in Denmark in 2009 has been estimated to 7–8 kg P per hectare (DJF, 2009). This development has, in other words, reduced the need to use separation as a way to reduce P application at the farm level. However, some farms might be required to reduce application even below the crop requirements as their P-levels in the soils are very high and the risk for P-levels are high indicating a high risk for P-leaching as the soil is saturated (Jensen, 2010).

3. Analysis of costs

For the purpose of this analysis, traditional handling of slurry is compared with separation in the stable, decanter separation and flocculation (se figure 2). With all the separation techniques, the end product is a liquid fraction and a solid fraction. The nutrient content will vary with the technology (see table 1). The separation can be carried out at the farm or at a centralised location (e.g. biogas plant), but in this analysis, it is assumed to be carried out at the farm level either through a fixed or mobile separator. The analysis looks at the entire chain from stable to field and includes the costs for storage, separation, transport and additional purchase of mineral fertiliser to fulfil the nutrient requirement of the crops. Based on the description above, a number of relevant scenarios for the use of separation techniques have been set up. They are (see appendix A for more detail):

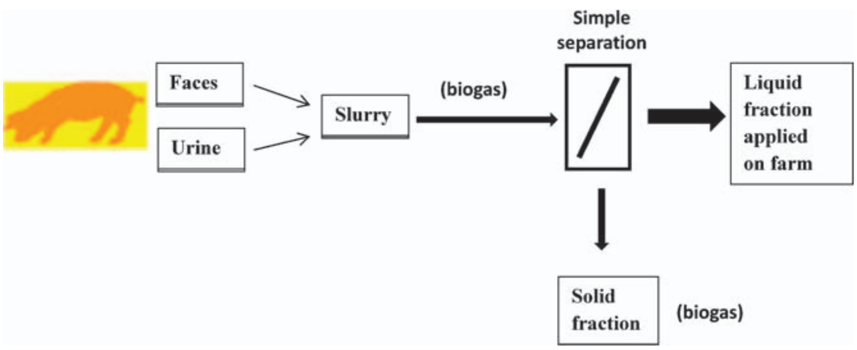

Figure 2: Slurry separation.
Source: after Møller and Sommer, 2002

Table 1: Content of the liquid fraction (% of the total content in slurry)

	Decanter (1	Flocculation (2	Source separation and screw press (3
Amount (tonnes)	91	80–90	45
Total N	73	60–70	47
NH4-N	85	85–95	
Total P	(25) 40	1–50	57
Total K	90	80	42
Dry matter	30	8–36	79
Utilisation of N i fraction	85	85	80
Effective N:P index		6–7	

Sources:
1) Landscenteret (2009)
2) Al-2 (2010)
3) Kai, 2010.
Note: Loss of N in the stable is 11% and loss in storage is 2% for slurry and liquid fraction.

Scenario 1: Traditional stable, storage and local distribution of slurry (203 and 357 ha);
Scenario 2: Traditional stable, separation (decanter) (stationary or mobile), farm use liquid fraction, transport and application of solid fraction (30 km), (203 ha);
Scenario 3: Traditional stable, separation (flocculation), farm use liquid fraction and transport and application of solid fraction (30 km), (203 ha);
Scenario 4: Separation in stable and screw press, farm use liquid fraction and transport and application of solid fraction (30 km), (203 ha).

The case farm is a pig farm which would like to expand from 250 LU to 500 LU enabling him to produce 18,000 finishing pigs a year. The crop rotation is barley, oilseed rape, wheat (1 year) and wheat (2 year). The N application follows the Danish N-norms, which is a legal requirement for clay soil (Danish Plante Direktorate, 2009). The average N application is 155 kg N per ha.

Loss of N in the stable is 11% and loss in storage is 2% for slurry and liquid fraction, but 28% for the solid fraction (with cover). (Hansen *et al*, 2008; Miljøstyrelsen, 2009b; Miljøstyrelsen, 2010). The utilisation of N in the field is based on trials (Petersen and Sørensen, P, 2008; Sørensen, 2006 and Birkmose *et al.*, 2003; Jacobsen *et al.*, 2002b). The amount of nitrogen applied on the field is the same for all systems.

The storage cost is an average based on Jacobsen *et al.* (2002a). The storage cost is €2.3 per tonne slurry, whereas the average cost when they are divided into two fractions is €2.5 per tonne (Jacobsen *et al.*, 2002b). A larger slurry storage (3,500 m3) is normally cheaper per tonne (€1.7 per tonne per year) compared with the small storages (1,500 m3), which have an annual cost of €2.4 per tonne (Jacobsen *et al.*, 2002a).

The value of the slurry applied on the field is around €5.1 per tonne based on the content of N, P, and K and a utilisation of N of 75%, of which 65% is the first year effect. In e.g. England the requirements regarding utilisation are lower (Defra, 2011). This is partly because only the first year effect is included. The share of applied total N applied for pig slurry is assumed to be 25–45% when applied in Winter, 55% based on band spreading (using a hose) in Spring and 60% when using injection in Spring. These values show that application in Winter is not to be recommended and that the expected utilisation levels are lower in England than in Denmark. With higher recommended N-applications per ha, this leads to much higher application of slurry per ha in England than in Denmark (Webb *et al.*, 2006).

The question is to what extent the cost of using more advanced technologies are paid by higher efficiency in application. The answer is that the cost of new technology is only partly paid for in terms of higher N-efficiency. Another issue relates to the application distance. The effective value of slurry is €5.1 per tonne or €127.5 per ha when applying 25 tonnes per ha. The transport costs are €4 per tonne when transported a distance of 30 km. On top come application costs which are €1.7 per tonne for slurry or €42.5 per ha, whereas the application costs using mineral fertiliser are only €20 per ha in Denmark. So the organic manure has a relatively large value, but the transport and application costs are often higher.

Injection in winter crops is still a challenge in a Danish context as the incorporation technology used might harm the plants and lower the yield. The use of band spreading has been standard practice for many years, but Injection technologies (little i) are used more and more and will in the years to come be obligatory on Spring crops and grass. Today, Danish farmers are used to having slurry storage of almost 12 months and try to use approaches which try to achieve a very high utilisation of N in slurry. With N-norms for each crop and required utilisation, it is important to reach the expected utilisation as this cannot be compensated for by buying more mineral fertiliser. In recent years, acidification of slurry with Sulphur acid has been promoted to reduce ammonia emission from livestock farms (Infarm, 2011) and increase the N-uptake by the plants.

The application costs are lower for slurry with hose (band spread) than the application of the solid fraction and the liquid fraction when injected into the soil. It is assumed that the spreading of animal manure costs around €1.7 per tonne when using a hose. The prices are based on contractor prices (Jacobsen *et al.*, 2002a). The application costs are higher in the eastern part than

Table 2: Scenario 1a: Baseline – Traditional handling (203 ha, limited P surplus)

	Tonnes	Nitrogen purchase (Kg N)	Costs (€ per tonne)	Total costs (€ per year)
Amount from stable	8,280			
Amount from storage	8,460		2.3	19,304
Application on field	8,460		1.7	15,103
Mineral fertiliser (N)		11,197		7,783
Transport of slurry	3,649		0.1	490
Sold slurry	3,649		5.1	- 18,419
Total costs			**2.8**	**24,262**
Costs per pig produced			**1.3**	

Note: The slurry for the area which exceeds 203 ha (154 ha) is transported 1 km and sold at full value.
Source: Own calculations

in the western part of Denmark as the competition among contractors is higher (Jacobsen *et al.*, 2002a).

The aim is to ensure that there is no P-surplus on the farm. The farm area before the expansion is 203 ha. The minimum area for harmony is 357 ha, but in that case there will be a little P-surplus. With 403 ha all the slurry can be applied on the fields without any P-surplus. The question is whether to buy or rent another 200 ha, transport 4.230 tonne of slurry or invest in separation technology and export the solid fraction. The fertiliser purchase is based on the price of N, P and K of 0.67, €1.2 and €0.3 per kg (Videncenteret, 2010). The utilisation of animal manure is described in the appendix A. When the area is larger than 203 ha, it is assumed that this land is rented and the farmer gets full value for the slurry applied to this area, but the costs of mineral fertiliser needed for this area are not included.

When renting land in livestock intensive areas, the price is higher than in areas without livestock as the opportunity to apply slurry has a value. Danish Statistics have estimated that the additional rent paid in livestock intensive areas is €262 per livestock unit over 1.0 (Danish Statistics, 2010b). With a very high livestock intensity of e.g. 1.5 LU per ha, this would result in an additional rent of €131 per hectare per year. For a farm with 200 ha, this additional cost of having a farm in a livestock intensive area would be €26,200 per year or an additional cost of €3.2 per tonne slurry on the case farm.

Decanter option

With respect to decanter centrifuge, the cost per tonne is smaller when large quantities are processed. The findings show that the cost on a farm with 500 LU is €2.1 per tonne for a stationery unit or €18,400 per year (including investment and maintenance). This is lower than the price of €2.6 per tonne found by Møller and Sommer (2000). The mobile unit costs €35,900 per year with a capacity of 50,000 tonnes per year which gives a total cost of €0.7 per tonne. However, such a capacity requires co-operation and that is sometimes difficult to get to work although there are economic incentives. This would require that the separator works 3,000 hours a year or 9 hours a day, which should be possible (see also Sørensen and Møller, 2006).

The cost of application of the solid fraction on a field 30 km away is included (no sales value). If it is only transported to a biogas plant (and not incorporated), the yearly costs would be reduced by €2,400.

Flocculation

The flocculation approach used here is based on addition of polymers to the slurry. This makes the substance coagulate. Flocculation is caused by polyelectrolytes. A polymer is a large molecule composed of repeating structural units. Approximately 0.2–0.3 litre of polymer is added per tonne slurry. The outcome of the flocculation can be varied more than with a decanter and the amount of P in the liquid fraction can be varied from 1 to 50% of total P (Hjorth *et al.*, 2010). With a production of 8,500 tonne per year, the company AL-2 suggest that their model 2.1 (see table 4) will cover the requirements (AL-2, 2010). The machine takes 3 tonnes per hour and has then to run 3,000 hours a year or 8 hours a day. However, most farmers will probably select the larger model called 3.6M as the additional costs are limited (see table 3). When used to full capacity, the 3.6M would have unit costs of only €1.6–€2.4 per tonne depending on whether it is fixed without screw press or it is a mobile unit (see table 3). Again economics of size is important for the costs per tonne which is treated.

The variable costs are polymer, water and electricity (0.7 kWh per tonne) and a service agreement on the equipment. The variable costs are €1.07–€1.34 per tonne. When using more or less polymer, the nutrient content of the end product can be controlled. The largest model can be mobile and this type has sold a lot, but the idea of several farmers sharing has not always worked. In other cases, it has been owned by the biogas company. The company (AL2) has delivered about 30 of this type to farmers in Denmark.

The actual N-utilisation is 85%, but it can be higher. The solid N can be utilised at 45–50%. With respect to P, the flocculation technique can deliver a wider range than the other technologies. For the nutrient balance to be covered 100%, the share between effective N:P has to be around 155 N : 22 P or 7:1. Another index is the separation index which shows how much of the selected nutrient is removed in the solid fraction (Hjorth *et al.*, 2010).

For this case farm, the costs of separation and screw press will be around €3.4 per tonne. Again, splitting the use between two farms and increasing the volume would reduce the costs to €2.4 per tonne, but it is not always possible.

With the mobile solution, the total costs are reduced to €8.06 per tonnes or €3.76 per finishing pig. The analysis indicates that flocculation is the most flexible,

Table 3: Costs related to flocculation of slurry (€)

Model name	Model 2.1	Model 2.1 + press Screw	Model 3.6	Model 3.6 + press Screw	Model 3.6 Mobile
Amount	8,280	8,280	8,280	8,280	8,280
Press screw	No	Yes	No	Yes	Mobile
Investment in base	63,760	63,760	68,460	68,460	
Invest in screw press		30,200		30,200	
Container/ building	16,780	16,780	16,780	16,780	174,500
Total investment	**80,540**	**110,740**	**85,240**	**115,440**	**174,500**
Yearly costs					
Building etc. (10 år, 4%)	9,932	13,691	10,926	14,631	21,516
Variable costs	8,859	8,859	11,141	11,141	11,141
Labour (20.1 €/hrs)	3,624	3,624	1,221	1,221	4,027
Total costs (€/ year)	**22,416**	**26,174**	**23,356**	**26,993**	**36,685**
Costs (€/tons) 8.280 tonnes per year	**2.7**	**3.2**	**2.8**	**3.2**	**4.4**
Costs (€/tons) 15,000 tonnes per year	**-----**	**-----**	**1.6**	**1.7**	**2.4**

Note: In other analyses, the labour requirement is smaller than stated above. This, with other adjustments, reduces the costs for the mobile unit to 26.845 € per year or 3.4 € per tonne in case of 8,280 tonne and model 3.6.
Source: AL-2 (2010) and own calculations.

Table 4: Key parameters and costs of the different technologies

Name	Scenario 1a Baseline -full value	Scenario 1b Baseline-transport	Scenario 2b Mobile-decanter	Scenario 3 Flocculation	Scenario 4 Source separation
Area (ha)	203	203	203	203	203
Transport distance (km)	1	30	30	30	30
P-surplus (kg P/ha)	3	0	0	0	0
Excess K	No	No	Yes	Yes	No
Eff. N:P in liquid fraction	4,0	4,0	8,4	7,7	5,8
Eff. Kg N/tonne	5.6	5.6	10.5 / 4.8*	14.8 / 4.1*	5.2 / 4.9*
Kg P/tonne	1,1	1,1	6,5 / 0,5*	6,5 / 0,5*	1,7 / 0,7*
Value slurry / solid fraction (€/tonne)	5.1	5.1	12.1	13.8	4.8
Economics (1000 €) :					
Storage costs	19.3	19.3	20.0	20.0	20.0
Separation costs	0	0	16.6	20.0	20.0
Application of slurry / liquid fraction	16.0	15.2	19.1	19.1	13.2
Application of solid fraction	0	0	1.7	1.7	6.7
Transport of solid /slurry	0	17.2	3.4	3.4	12.6
Mineral fertiliser	7.8	10.1	1.9	3.5	7.7
Value of slurry / solid fraction	18.4	0	0	0	0
Total costs	**24.3**	**61.6**	**51.5**	**67.5**	**80.3**
Cost per tonne (€/tonne)	**2.8**	**7.2**	**6.2**	**8.2**	**9.7**
Cost per pig (€ / pig prod.)	**1.3**	**3.5**	**2.8**	**3.8**	**4.4**

Note:
*(solid fraction/liquid fraction)
Source: Own calculations

also in terms of being able to fulfil the nutrient requirement. It is possible to apply the fractions so purchase of mineral fertiliser is not needed. This would reduce the cost further by €2,685 per year.

Source separation in the stable followed by screw press

The idea behind this technology is to carry out the separation in the stable and so the output from the stable is a liquid and a solid fraction. The solid fraction is then channelled through a screw press. The liquid part from this process is joined with the liquid part from the stable so that only two products come out of the process, namely a solid fraction from the screw press and a combined liquid product from the stable and screw press. Compared to the other separation techniques, this technique does not take as much P away in the solid fraction.

A stable with source separation increases the total investment by 11% or €14,500 for a stable which can produce 18,000 finishing pigs a year (Høj, 2009). In relation to the total yearly amount of slurry of 8,280 tonnes from the stable, this increases the costs by 1.74

per tonne slurry which is processed. No additional costs related to energy use in the stable are included. On top of that comes the cost for the press screw, which is €3,650 annually. The total cost, including 2% maintenance, is therefore €19,100 per year. It is assumed that the utilisation of the liquid fraction is a little lower than the others and so it is set at 80%. Together with a higher loss in the stable, this system has the lowest N value on the field (56%) (See appendix Table A2).

4. Results

The analysis shows that separation can be a valuable alternative to transport of slurry if the transport distance is 30 km or more, but the cheapest option is to distribute the slurry near the farm on your own fields. In livestock intensive areas, renting a larger area to spread the slurry might cost up to €200 per ha on top of the crop return and this increases the costs from €2.8. to €7.7 per tonne (see table 4). In this case, separation can be a viable alternative.

The analysis shows that decanter separation is the cheapest option as the separation costs are lower than for the other technologies (flocculation and source separation). In order to achieve this low cost per tonne, a mobile decanter has been chosen. If a stationary decanter is the only option, the costs per tonne will increase the separation costs from €0.7 to €2.0 per tonne, increasing the total costs to €7.5 per tonne. The costs are then similar to the costs of flocculation and increased transport. With the separation technologies, the solid fraction can be transported a long distance without increasing the costs dramatically, as an increase from 30 to 50 km only increases the total costs by €0.13 per tonne. In cases where the receiver pays for the application this would reduce costs by €1.7 per tonne.

Source separation comes out as the most expensive option, not so much because of the separation costs, but mainly because a larger amount is left in the solid fraction and so the transport costs are somewhat higher. The costs here are more sensitive to transport distance. The separation and application costs are similar to the costs when using flocculation (mobile system). The advantage of renting / buying land as opposed to slurry agreements and separation combined with export of the solid fraction, is that you keep the full value of the nutrients in the farm system. In cases where the solid fraction was sold at full value, separation technologies would be more profitable for the husbandry farmer. Although the value of the solid fraction is between €9,400 and €14,765, it assumed that the farmer receiving the solid fraction will not pay anything, based on current practice.

As previously mentioned, burning the solid fraction might be an option if the farmer is located near a large plant which can burn the solid fraction. This would only reduce the application costs and the transport would still have to be paid by the farmer. The fraction would not have any sales value, although it would generate heat. With respect to biogas, the farmer could export the solid fraction to a biogas plant, but it is assumed that the plant, based on the current price structure does not pay for this fraction. New farm separation plants might even have to pay to deliver the solid fraction to the biogas plant even though the delivered product gives above average gas yield. With higher prices on gas / electricity, the biogas plant might be able to pay farmers according to the gas potential they deliver.

At one of the newest biogas plants in Denmark (Morsø Bioenergy, 2009), a combination of farm separation and separation at the biogas plant is used. The biogas production per tonne is 3–4 times higher from the solid fraction than slurry (Møller *et al*., 2004). The analysis here indicates that using flocculation is the best in terms of providing full nutrient coverage with the liquid fraction.

An increase in prices of mineral fertiliser has already increased the willingness among arable farmers to receive slurry. This again reduces the need for separation and long distance transport as more area is available nearby. Higher prices on mineral fertiliser will also make it possible for animal farms to be paid for the animal manure. With the current set up, there is an income transfer from animal to arable farms as arable farms do not pay for the value of the slurry they receive.

Experiences in Denmark have shown that land prices increased in areas where the average livestock density was around 1.2 LU per hectare based on the agricultural area in the Municipality. The maximum in Denmark is 1.4 LU per hectare for pig farms and 1.7 / 2.3 LU per ha for dairy farms, depending on the share of certain crops in the crop rotation (Anonymous, 2010).

As shown in this analysis, the key parameters are how much you have to pay for additional land (buy, rent or slurry agreements), how far the slurry / solid fraction has to be transported, how much the farmer receiving is willing to pay and the costs of the separation.

The conclusions are in line with the results of the analyses which was conducted by The Danish Advisory Centre (Landscenteret, 2009) using a spread sheet model to advise farmers. When farmers are faced with options of either investing in separation, making a slurry agreement, renting land or buying more land, the conclusion is that renting land is often the cheapest, followed by slurry agreements and separation. Buying land comes out as the most expensive option, but this option will, on the other hand give the farmer more long term certainty on the land available (Landscenteret, 2009).

5. Conclusion

The conclusion is that it is not profitable to invest in separation technologies unless the farm is situated in a very livestock intensive area where it is difficult to get rid of the slurry. In general, the separation gives an additional cost which is difficult to justify unless the alternative transport distance is high or land prices are high. The analysis show that it is important to look at the entire chain as the separation technologies have a higher loss of N in storage and application costs are higher. The paper shows that regulation, lower livestock numbers and changes in feeding have made separation less favourable over time. The future for separation in Denmark seems to be in relation to biogas plants. Burning of the solid fraction in Denmark has not been as successful as expected, as it is only allowed and economic viable on large heating plants.

The economics are very much dependant on the neighbouring farms' attitude to slurry and other fractions. The farm exporting will often lose the value of the slurry / solid fraction, but might also have to apply it on the other farm paying the application costs. This will benefit arable farmers.

The policy implications are that legislation which ensures harmony between animal production and agricultural land reduces the use of separation. However, in a time where energy from slurry is a valuable renewable energy source, separation of slurry on the farm or at the biogas plant is an option. For this to happen the value of the biogas has to be such that it can pay for the cost of separation. The high values of fertiliser experienced in 2008 made many farmers realise that animal manure has a value. In the livestock intensive areas in the world (e.g. The Netherlands) separation can provide an opportunity to distribute manure better, but findings from Denmark indicate that it might be difficult to sell the solid fraction. When farm separation is combined with biogas production, only the solid fraction needs to be transported to the biogas plant, but here the separation cost will be relatively high.

About the author

Brian Jacobsen is a graduate from the Royal Veterinary and Agricultural University (RVAU) which is now part of University of Copenhagen. He has a M.Sc. from Reading University and a Ph.D. from RVAU. Current research deals with environmental economics and the costs of reducing N- and P-losses, ammonia emission and emission of green house gases from agriculture. He is also involved in the economics related to the biogas production and the implementation of the Water Framework Directive in Denmark.

Acknowledgements

I am thankful for the research money from the Ministry of Food, Agriculture and Fisheries provided given to the GYLLESEP project. I am grateful to Shirley Jacobsen for proof reading and to two anonymous reviewers who provided very detail comments on earlier drafts of the paper.

REFERENCES

AL-2 (2010). Information sheet about separation. http://uk.al-2teknik.dana9.dk/ Accessed on the 3th November 2011

Anonymous (2010). *Bekendtgørelse om husdyrhold og arealkrav mv. Nr. 947 fra 2006 and Bekendtgørelse af lov om landbrugsejendomme from 2010* [Legal requirements regarding livestock and area requirement]. https://www.retsinformation.dk/Forms/R0710.aspx?id=8750 Accessed on 3th November 2011.

Anonymous (2011). *Bekendtgørelse af lov om jordbrugets anvendelse af gødning og om plantedække. LBK nr 415 af 03/05/2011* [Note on legal requirement about use of fertilizer and crop cover] https://www.retsinformation.dk/Forms/R0710.aspx?id=137028. Accessed on the 3rd of November 2011.

Birkmose, T. and Zinck, A. M (2008). *Status på afbrænding af husdyrgødning i Danmark.* [Status on the burning of animal manure in Denmark]. Notat fra Landscenteret og Dansk Landbrug. http://www.landbrugsinfo.dk/Planteavl/Filer/lpart119_b1.pdf. Accessed on the 3rd of November 2011.

Birkmose, T.; Sørensen, P. and Rubæk, G. (2003). *Utilization and losses of nitrogen and phosphorus from field applied slurry separation products*. Ramiran præsentation. http://www.ramiran.net/doc06/O-24%20Birkmose.pdf Accessed on the 3rd of November 2011.

Brower, F.; Hellegers,P., Hoogeveen, M. and Luesink, H. (1999). *Managing nitrogen pollution from intensive livestock production in the EU*. Report 2.99.04. LEI, The Hague.

Burton, C.J. (1997) *Manure Management – Treatment Strategies for Sustainable Agriculture*. Silsoe Research Institute, Silsoe, UK.

Burton, C.H. (2007). The potential contribution of separation technologies to the management of livestock manure. *Livestock Science*, 112, 208–216.

The European Commission (1991). *The Nitrate directive*. Council Directive 91/676/EEC. http://ec.europa.eu/environment/water/water-nitrates/directiv.html Accessed on the 3rd of November 2011.

The European Commission (1992). *The Habitat Directive.* Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm. Accessed on the 3rd of November 2011.

The European Commission (2000). *The Water Framework directive,* Council directive 2000/60/EC, http://ec.europa.eu/environment/water/water-framework/index_en.html. Accessed on the 3rd of November 2011.

The European Commission (2010). *The implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2004–2007*. Report from the Commission to the Council and the European Parliament. http://ec.europa.eu/environment/water/water-nitrates/pdf/sec_2011_909.pdf. Accessed on the 3rd of November 2011.

Danish Plant Directorate (2009). *Gødningsnormer 2009–2010*. [Danish Fertiliser norms 2009–2010] Plantedirektoratet.

Defra (2011). *Soil Nutrient Balances England – Provisional estimates for 2010. July 2011.* http://www.defra.gov.uk/statistics/files/defra-stats-foodfarm-environ-obs-research-soilnutrientbalance-statsnotice-england-110728.pdf Accessed on the 3rd of November 2011.

Defra (2010). *Fertiliser manual (RB209).* Defra. England http://www.defra.gov.uk/food-farm/land-manage/nutrients/. Accessed on the 3rd of November 2011.

Dubgaard, A.; Nissen, C.J. Jespersen, H.; Gylling, M.; Jacobsen, B.H.; Jensen, J.D.; Hjort-Gregersen, K. Kejser, A.T. og Helt-Hansen, Julie. (2010). *Økonomiske analyser for landbruget af en omkostningseffektiv klimastrategi.* [Economic analyses for Agriculture of a cost efficient strategy to reduce Green House Gas Emissions]. Report no. 205 Ministry of Food, Agriculture and Fisheries, Denmark. http://www.foi.life.ku.dk/Publikationer/FOI_serier/Nummererede_rapporter.aspx#2010. Accessed on the 3rd of November 2011.

Frandsen, T.Q. (2010). *Metanudbytter af fiber fraktion fra gylleseperation.* [Methane yields from the solid fraction from slurry separation]. Note. Knowledge Centre for Agriculture. Århus, Denmark.

Fuchs, C., Bogatov, V and Eimannsberger, J. (2011). Competitiveness and Risk of Crop Production, Milk Production and Biogas Production with Respect to Regional Resources. *18th International Farm Management Congress: Thriving in a Global World - Innovation, Co-operation and Leadership*. March 20–25, Christchurch, New Zealand.

FVM (2005). *Rapport fra arbejdsgruppen om afbrænding af fraktioner af husdyrgødning*. [Report from the working group on the burning of fractions from Animal Manure] Ministry of Food, Agriculture and Fisheries, Denmark

Government of Denmark (2009). *Grøn Vækst.* [Green Growth]. April 2009. Copenhagen. Denmark. http://www.mim.dk/NR/rdonlyres/D5E4FC9A-B3AC-4C9A-B819-C42300F23CCA/

0/GROENVAEKST_2904rapporten.pdf Accessed on the 3rd of November 2011

Hansen, M.N., Sommer, S.G., Hutchings, N.J. and Sørensen, P. (2008). *Emissionfaktorer til beregning af ammoniakfordampning ved lagring og udbringning af husdyrgødning.* [Emission factors used to calculate ammonia emissions from storage and application of animal manure]. DJF Husdyrbrug no. 84. Det Jordbrugsvidenskabelige Fakultet, University of Aarhus. Denmark.

Hansen, M.N., Kristensen, J.K. and Kristensen, E.F. (2009). *Forbrænding af fiberfraktionen fra separeret husdyrgødning.* [The Burning of the fiber fraction from animal manure]. Information note. AgroTech and DJF, University of Aarhus.

Hashøj Biogas (2011). *Omkostningerne ved opgradering af biogas kan halveres.* [The cost of upgrading biogas can be halved]. http://www.biopress.dk/PDF/FiB_37-2011_03.pdf Accessed on the 3rd of November 2011

Hjorth, M.; Christensen, K.V., Christensen, M.L. and Sommer, S.G. (2010). Solid-liquid separation of animal slurry in theory and practice, A review. *Agron. Sustain. Dev*., 30, 153–180.

Hjorth-Gregersen, K. og Christensen, J. (2005). *Afbrænding af fiberfraktion fra separeret gylle – Drifts- og samfundsøkonomiske analyser.* [Burning of Fiber Fractions from separated Slurry]. Note. Institute of Food and Resource Economics. Denmark.

Husdyrgodkendelse (2011). *Ansøgningssystemet for miljøgodkendelse af husdyrbrug. Miljøministeriets Informationscenter* [Application system for environmental approval of animal farms]. www.husdyrgodkendelse.dk Accessed on the 3rd of November 2011

Høj, P. (2009). *Investering i kildesepareringsstald overfor traditionel slagtesvinstald*. [Investment i source separation building for pigs compared with traditional building for pigs for slaughter]. Note from Svend Aage Christiansen A/S. Denmark.

Infarm (2011). *Slurry Acidification.* http://www.infarm.dk/documents/00095.pdf. Accessed on the 3rd of November 2011

Jacobsen, B.H.; Abildtrup, J.; Andersen, M., Christensen, T.; Hasler, B.; Hussain, Z.B.; Huusom, H.; Jensen, J.D.; Schou, J.S. og Ørum, J.E. (2004). *Omkostninger ved reduktion af landbrugets næringsstoftab til vandmiljøet* [Costs of Reducing Nutrient Losses from Agriculture]. Report no. 167. Danish Research Institute of Food Economics (English summary).

Jacobsen, B.H.; Sørensen, C.G. og Hansen, J.F. (2002a). *Håndtering af husdyrgødning – en teknisk og økonomisk systemanalyse.* Report no. 138. Danish Research Institute of Food Economics, Denmark (English summary).

Jacobsen, B.H.; Hjorth-Gregersen; Sørensen, C.G. and Hansen, J.F. (2002b). *Separation af gylle – en teknisk-økonomisk systemanalyse.* Report no. 142. Danish Research Institute of Food Economics. Denmark. (English summary).

Jacobsen, B.H. and Hjorth-Gregersen, K. (2003). An economic and environmental analysis of slurry separation. *14th International Farm Management Congress: Farming at the Edge,* 10th–15th August, Perth, Australia [Accessed 3rd November 2011]

Jacobsen, B.H., Jespersen, H.M. and Dubgaard, A. (2010). *Ligevægtspris for biogas under forskellige forhold og konsekvens af upgradering til naturgas.* [Break even price for biogas under different conditions and the consequence of upgrading biogas for the natural gas grid]. Note for the Ministry of Agriculture.

Jacobsen, B.H. (2011a). Reducing ammonia emission in Europe – Costs, Regulation and targets with focus on Denmark. *18th International Farm Management Congress: Thriving in a Global World - Innovation, Co-operation and Leadership*. March 20–25, Christchurch, New Zealand.

Jacobsen, B.H, (2011b). Danish Biogas Plants for Green Livestock: Bio energy production and Nutrient redistribution. Invited Paper for *Global Green Growth Seminar on Green Korea: Challenges, Strategy and Cooperation,* Seoul, South Korea, 15th September. http://www.greenkorea2011.org/archive/presentation2.asp. Accessed on the 3rd of November 2011

Jensen, P.N. (2010). *Status for miljøeffekten af miljøregulering og anden arealregulering.* [Status for the environmental effect of environmental regulation and other types of regulation of the area] Notat. NERI, Aarhus University.

Jensen, T.K. (2009). *Biogas til nettet.* [Biogas for the Grid]. Projekt report. Dansk Gasteknisk Center.

Jørgensen, K. and Jensen, L. S. (2010). *Fibre fra gylleseperation – hvor stor er forskellen i deres kvalitet og hvordan anvendes de optimalt?* [Fiber from slurry separation – how large is the difference in quality and how can they be used optimally?] Danish Crop Conference 2010, pp. 372–373.

Kai, P. (2010). *Description of fractions from Source Separation*. Note from the GYLLESEP project.

Landscenteret og KU (2007). *Status over anvendelse af gylleseparation i Danmark.* [Status over the use of slurry separation in Denmark]. Note. Knowledgecentre for Agriculture and University of Copenhagen.

Landscenteret (2009). *Program til beregning af harmoni.* [Model for calculation the required area for animal farms]. Spreadsheetprogram.

Maabjerg BioEnergy (2005). *Miljømæssige, energimæssige og økonomiske konsekvenser af Maabjerg Bioenergi.* [Environmental, energy and economic consequences of Maabjerg Bioenergy]. Summary.Report. http://www.maabjerg-bioenergy.dk/. Accessed on the 3rd of November 2011

Miljøstyrelsen [Danish Environmental Agency] (MST) (2009a). *Fodring*. [Feeding] http://www.mst.dk/NR/rdonlyres/091AB3EB-6EB1-4808-AF75-F091721DFD57/0/Udkast_Svin_fodring_fosfor.pdf. Accessed on the 3rd of November 2011

Miljøstyrelsen [Danish Environmental Agency] (MST) (2009b). *Overdækning af fiberfraktionen fra separeret gylle* [Cover of the fiber fraction from slurry]. BAT blad. http://www.mst.dk/NR/rdonlyres/A17F76D8-10E9-4305-A5C1-E961B5E359A9/0/Udkast_overd%C3%A6kningaffiberfraktioner.pdf. Accessed on the 3rd of November 2011

Miljøstyrelsen [Danish Environmental Agency] (MST) (2009c). *Præcisering af lovgrundlaget og afklaring af en række fortolkningsspørgsmål vedr. forbrænding og forarbejdning af husdyrgødning.[Interpretating of the legal requirement and answers to questions regarding the burning and processing of animal manure]* Note.

Miljøstyrelsen [Danish Environmental Agency] (MST) (2010). *Separation af gylle med decanter centrifuge* [Separation of slurry using decanter technology] http://www.mst.dk/NR/rdonlyres/D167C805-F3FD-471F-9FC4-6158653426CE/0/Udkast_gylleseparering_dekantercentrifuge.pdf. Accessed on the 3rd of November 2011

Morsø Bioenergi (2009). Biomasse behandling og energiproduktion [Biomass treatment and energy production] http://www.biogasdk.dk/down/semdec07/Morsoe-Bioenergi.pdf. . Accessed on the 3rd of November 2011

Møller, H.B., Lund, I. and Sommer, S.G. (2000). Solid-liquid separation of livestock slurry: efficiency and cost. *Journal of Bioresource Technology*, 74, (2000), 223–229.

Møller, H.B. and Sommer, S. (2002). *Solid liquid separation of livestock slurry.* Helcom 23/2002 Seminar. http://agrienvarchive.ca/bioenergy/download/S1-Sommer_DK.pdf. Accessed on the 3rd of November 2011

Møller, H.B., Sommer, S.G. and Ahring, B.K. (2004). Methane productivity of manure, straw and solid fractions of manure. *Biomass and Bioenergy*, 26, 485–495.

Moller H.B, Hansen J.D, Sorensen C.A.G (2007) Nutrient recovery by solid-liquid separation and methane productivity of solids. Transactions from ASABE) Amercian Society of Agricultural and Biological Engineemers, 50, 193–200. http://asae.frymulti.com/azdez.asp?JID=3&AID=22400&CID=t2007&v=50&i=1&T=2. Accessed on the 3rd of November 2011

Nielsen, L.H.; Hjort-Gergersen, K.; Thygesen, P. and Christensen, J. (2002). *Samfundsøkonomiske analyser af biogasanlæg [Socioeconomic analyses of biogas plants].*

Report no. 136. Danish Research Institute of Food Economics. (English summary)

Oenema, O. and Berentsen, P.B.M. (2005). *Manure Policy and Minas: Regulating nitrogen and phosphorus surpluses in Agriculture of the Netherlands*. OECD report. (2004),67.

Petersen, J. and Sørensen, P. (2008). Loss of nitrogen and carbon during storage of the fibrous fraction of separated pig slurry and influence on nitrogen availability. *Journal of Agricultural Science*, 146, 430–413.

Petersen, J. and Sørensen, P. (2008). *Fastlæggelse af udnyttelse I husdyrgødningen*, [The uttilisation of animal manure] DJF, Århus Universitet. http://www.dmu.dk/fileadmin/Resources/DMU/Vand/11_goedningsvirkning.pdf. Accessed on the 3rd of November 2011

Schou, J.S.; Gyldenkærne, S., Grant, R., Elmegaard, N., Palmgren, E. and Levin, G. (2006) *Miljøkonsekvenser ved afbrænding af husdyrgødning med sigte på energiudnyttelse - Scenarieanalyse for et udvalgt opland.* [Environmental consequences related to the burning of animal manure with focus on energy utillisation]. Report NERI, no. 575

Statistics Denmark (2010a). *Landbrug 2009* [Agriculture 2009]. Danmarks Statistik.

Statistics Denmark (2010b). *Økonomien i landbrugets produktionsgrene 2009* [Income in Agricultural enterprises in 2009]. Danmarks Statistik.

Sørensen, C.G. and Møller, H.B. (2006). Operational and Economic modelling and optimization of mobile Slurry Separation. *Applied Engineering in Agriculture*, Vol. 22, 2, 185–193.

Sørensen, P. (2006). *The fate of nitrogen from animal manure in soil crop systems: Experiences with pig and cattle slurries*. DJF, University of Århus. http://www.aral.lom.it/public/upload/00000311_Rel_03_Sorensen.pdf. Accessed on the 3rd of November 2011

Videncenteret (2008). *Produktion af husdyrgødning fordelt på kommuner.* [Production of animal manure in different Municipalities]. Videncenteret for Landbrug. http://www.landbrugsinfo.dk/Energi/Biogas/Filer/pl_10_383_b2.pdf. Accessed on the 3rd of November 2011

Videncenteret (2010). *Budgetkalkuler 2008–2010*. [Farm budget estimates 2008–2010]

Vinter, F. P. (2008). *Udvikling i landbrugets fosforoverskud og forbrug af foderfosfat*. [Development in the phosphorus surplus from Agriculture]. Notat til vandmiljøplan III. Faculty of Agricultural Sciences, University of Aarhus.

Webb, J., Ryan, M., Anthony, S.G., Brewer, A., Laws, J., Aller, M.F. and Misselbrook, T. H. (2006). Cost-effective means of reducing ammonia emissions from UK agriculture using the NARSES model. *Atmospheric Environment*, 40, pp. 7222–7233.

Appendix

Table A1: Case farm with 250 LU finishing pigs (18,000) and 8,460 tonnes of slurry

Scenario	1	2	3	4
Stable	Traditional	Traditional	Traditional	Source separation
Separation technique	None	Decanter (mobil)	Flocculation (mobil)	Screw press
Storage	Storage with lit (not solid)	Storage with lit and cover on solid fraction	Storage with lit and cover on solid fraction	Storage with lit and cover on solid fraction
Field	Slurry	Liquid fraction	Liquid fraction	Liquid fraction
Export	—	Solid fraction	Solid fraction	Solid fraction
Area on farm	357 / 203	203	203	203
Transport distance (slurry/ solid fraction) (km)	30	30	30	30

Table A2: N –balance for the four systems (liquid/solid) (8,460 tonne)

	Baseline	Decanter	Flocculation	Source separation
From animal	54.360	54.360	54.360	54.360
Loss in stable	−5.870 (−10,8%)	−5.870 (−10,8%)	−5.870 (−10,8%)	−5.870 (−10,8%)
From stable	48.489	48.489	48.489	48.489
Loss in storage *	−970 (−2%)	−4.121 (−2% / −28%)	−5.382 (−2% / −28%)	−6.895 (−2% / −28%)
From storage	47.520	44.368	43,107	41.594
Loss at application	−11.880 (−25%)	−10.146 (−15/−55%)	−9,339 (−10/−50%)	−11.162 (−15/45%)
Field effect (ab animal left)	**35.640 (66%)**	**34.221 (63%)**	**33,908 (62%)**	**30,432 (56%)**

Source: Hansen et al. (2008); Petersen and Sørensen (2008). The solid fraction is covered when stored. *Jacobsen et al. (2002); a loss of 30% was used. There are some uncertainties regarding the exact emissions. The figures in brackets show loss in liquid fraction / solid fraction.

Table A3: Content of nutrients in slurry from stable and application of mineral fertiliser to reach N-norms on case farms (357 ha, 1,4 LU/ha)

	From stable	From storage	On field	Effective application (per ha)	Crop requirement	Mineral fertiliser (per ha)
Total amount (tonne)	8,280	8,460	8,460	24		
Total N	54,360	47,520	35,640	100	155	55
Total P	9,000	9,000	9,000	25	22	−3
Total K	23,580	23,580	23,580	66	70	4
Dry mater %	7,8	6,6				

Note: Requirements are based on Danish N-requirements (Plantedirektotatet, 2010).
In case the application is higher (e.g. 30 tonne per ha) the P surplus will increase, but the K requirement will be fulfilled by animal manure on its own.

Table A4: Content in slurry in scenario 1 and solid fraction in scenario 2–4

Scenario	1	2	3	4
Name	Baseline	Decanter	Flocculation	Source separation
Share (%)	100	10	10	38
Total N	100	25	35	47
Total P	100	60	55	59
Total K	100	10	10	40
Dry matter %	6,6	32	30	30
N-loss during storage (%)	2	28	28	28
Storage costs (€ /tonne)	2.3	2.4	2.4	2.4
Utilisation of N in manure (%)	75	45	50	50
Effective value (€/tonnes)	5.1	18.1	13.8	4.8
Application cost (€/tonne)	1.7	2.4	2.4	2.4
Transport cost (€/tonnes)	4.0	4.0	4.0	4.0
Methane (Nm3/tonnes)	10–20	60–70	70–85	45–65

Source: Jacobsen et al. , 2002b and Hansen et al. (2008)
Note: There are some uncertainties regarding the methane production per tonne.

The future contribution of bioenergy enterprises to rural business viability in the United Kingdom

GRAHAM TATE[1] and AURELIAN MBZIBAIN[1]

ABSTRACT

Bioenergy enterprises have been granted an official role in the UK in order to make a significant contribution to sustainability targets and yet our understanding of attitudes amongst farmers and rural entrepreneurs to these enterprises is yet to be fully understood. Financial support, electricity tariffs, the availability of advice and the profit foregone from other enterprises have all fluctuated. The level of adoption of the new technology is not as advanced as in other EU countries. This study seeks to discover why this could be by exploring the entrepreneurial, financial and motivational environments that bioenergy adopters are working in. The following hypotheses have been developed:

1. The entrepreneurial environment for bioenergy development in the UK is sympathetic to the needs of this emerging industry;
2. Adopters of bioenergy are positively motivated towards the venture; and
3. Farm based bioenergy enterprises make a positive contribution to overall farm business viability.

The UK government is looking to rural entrepreneurs to play a role in this through the adoption of bioenergy technologies which can contribute towards achieving the country's energy and climate change targets and at the same time offer potential farm enterprises that could be viable long-term contributors to farm enterprise sustainability (NFU, 2008). This study extends and applies the concepts of entrepreneurship environment and country institutional profiles to a specific domain of entrepreneurship in the land based bioenergy sector in the UK.

KEYWORDS: Bioenergy; entrepreneurship; entrepreneurial environment; viability; renewable energy

1. Introduction and literature review

Recent research outputs from the field of bioenergy have been many and this literature review contains a number of the most important papers that have been published of relevance to the UK. The institutional profile for entrepreneurship in the renewable energy sector is also considered and an examination of both themes leads to the formation of research objectives and hypotheses. The overall research objective is to identify variables that explain the behaviour of UK farmers and to construct a theoretical or conceptual framework to support research that explains the adoptive or non adoptive nature of the behaviour of UK farmers with respect to renewable energy (RE) enterprises. This paper is structured in four sections commencing with a detailed introduction and review of literature, followed by the conceptual framework and methodology where the findings from the literature review are summarised and the hypotheses formed, the knowledge gap is determined and the plan for the fieldwork is made in order to test the hypotheses. The pilot survey results are shown and discussed in the third section of the paper and this is followed by the conclusion.

The UK Government has formally recognised the need for a reduction in the climate changing impact of energy consumption. A number of environmental targets have been defined: to reduce the emissions of CO_2 by 80% by 2050 with a 26% reduction in CO_2 by 2020 together with the production of 10% of transport fuel; 12% of heat; and 30% of electricity from renewable sources (CCA, 2008, DECC, 2010). The Government is looking to the rural sector to play a substantial role in these developments (DEFRA, 2007; NFU, 2008) and RE is potentially an important opportunity that might become a viable long-term contributor to farm business sustainability. However it should also be noted that some RE technologies such as biomass and Miscanthus potentially involve an increased risk to the farmer. Typically there is the fixed capital expenditure on plant to handle the crop, combust it and on the rhizomes themselves, plus the potential prospect of committing land to a 15–20 year single enterprise use. There is also the inconsistent nature of the value of bioenergy outputs and government support payments. Thus it can be seen that although there is potential to increase farm business sustainability this might not be realised for all adopters.

[1] University of Wolverhampton Business School, City Campus North, Wolverhampton WV1 1AD, UK. Email: Graham.Tate@wlv.ac.uk

In the face of a decline in traditional agricultural support with pending CAP reform, production and income alternatives for farmers appear attractive. Plieninger (2006) has argued that bioenergy represents the most outstanding alternative for traditional agricultural production. Through bioenergy production, farm businesses may then be stabilised; production diversified and farmers remain in the business of farming, acknowledging that along the same timeline of bioenergy adoption it is likely that farmers will also have to adjust to climate change (Tate et al, 2010).

There are increasing concerns about the low level of adoption of bioenergy in the farm sector in the UK suggesting that government objectives might not be met (Sherrington et al., 2008). The UK Biomass Strategy suggests that to reach the technical potential of perennial energy crops such as short rotation coppice (SRC) willow and Miscanthus by 2020 will require 350,000 hectares of land. This represents a more than 20-fold increase on the current 15,546 hectares currently devoted to biomass in the UK (Sherrington and Moran, 2010 In Press). There is little agreement amongst scholars on the reasons for this limited deployment in the farm sector (Perry and Rosillo-Calle, 2008, Pollitt, 2010, Thornley and Cooper, 2008) and the need to more fully understand and model the processes and consequences of farmers' decisions remains (Willock et al., 1999). Researchers have argued that adoption is not merely a question of relative profitability of different systems, but also reflects the lifestyle decisions of producers and so any analysis which confines itself to farm level financial measurements will be missing important factors (Burton et al., 1999; Willock, 1999; Wallace and Moss, 2002; Greenbank, 2001).

One objective of farm diversification from the farmers' perspective is to enhance farm incomes and ensure the sustainability of the business (Plieninger, 2006; Ilbery et al., 2009). Policy makers are advocating a more entrepreneurial approach to farm business management because of its likely positive effects on business profitability and sustainability. What is known is that farmers, for whatever reason often find it difficult to be entrepreneurial (Tate, 2010) Unfortunately, there has been little research based upon entrepreneurs who own bioenergy enterprises, what motivates them to engage and what contribution to business viability and sustainability bioenergy might be making given that farmers have rarely been an empirical setting for entrepreneurship research (Carter, 1998, Carter, 2001, Sara and Rosa, 1998).

Vesala et al. (2007) studied the entrepreneurial identity of non farming and farming entrepreneurs. They concluded that portfolio farmers showed strong entrepreneurial traits including personal control, risk taking, innovativeness and a positive orientation towards the growth of their businesses. This was quite similar to non farming entrepreneurs. Carter (Carter, 2001) differentiated between monoactive, diversified and portfolio farmers. Alsos et al. (2003) categorised farmers as being pluriactive when they or their family members carried out non farming income earning activities. Thus it might be argued that farmers' interaction with the institutional environment will differ, in terms of their motivations and objectives, their appraisal of the business environment and the type of bioenergy investments and strategies that they will engage in. It has been suggested from a number of research projects that the targeting of Government policies towards RE would be enhanced if policy makers were more aware of these characteristics in farmers (Rosenqvist et al., 2000; Sara and Rosa, 1998; Alsos et al., 2003).

Researchers have often found that farmers are aware of and respond to internal and external factors in the operation of their businesses (Bowler et al., 1996; Barlas et al., 2001; Maye et al., 2009). This suggests that attention to these factors could reward Government and policymakers.

According to these authors, these factors permit farmers to adopt capital accumulation (expansion or profit maximisation) or economic survival strategies. Farmer's decisions to exploit their lands for bioenergy were dependent on economic factors (input and output prices), expected yields, timeliness of operations, availability of investment capital, subsidies and other socio cultural characteristics of farmers (Bokusheva et al. 2007, Rounsevell and Reay, 2009).

Gnyawali and Fogel (1994), Fogel (2001) and Zapalska et al. (2003) conceptualised five issues which affected entrepreneurial behaviour including: (i) government policies and procedures; (ii) socioeconomic conditions; (iii) entrepreneurial and business skills; (iv) financial assistance and (v) non-financial assistance.

Institutions and the policies that shape them appear to determine the allocation of farmers' entrepreneurial decisions. If entrepreneurial decisions are to be applied to productive investments, policy strategies need to be tailored to the institutional context of each economic region (Minniti, 2008). An assumption that is made in this study is that institutional dimensions affect the attitudes and intensions of entrepreneurs in the venture creation process (Fogel, 2001; Wallace and Moss, 2002; Willock et al, 1999; Burton et al., 1999).

Table 1: Internal and external factors affecting farm business operation

Internal factors	External factors
1. changing farm profitability	1. regulation by the state
2. employment status	2. market trends and opportunities
3. family size and family life course	3. availability of new technologies
4. pressures on farm incomes	4. physical environment
5. characteristics of those who run the farms	5. social trends
6. farm management experience	6. behaviour of agricultural support organisations
	7. location

Source: adapted from (Bowler et al., 1996; Barlas et al., 2001; Maye et al., 2009).

The **regulatory** pillar of the institutional theory of entrepreneurship is primarily driven by the provisions of government legislation, industrial agreements and standards; (Bruton et al., 2010). Busenitz et al. (2000) define this as consisting of laws, regulations and government policies which provide opportunities, support for businesses, reduces risks and assists the entrepreneurial effort to acquire productive resources.

The UK Biomass Strategy published in May 2007 (DEFRA, 2007) was presented as meeting the need for a coherent strategy for bioenergy deployment in the UK (Slade et al., 2009).The Renewables Obligations (RO) has been the main UK government policy instrument to support the development of RE since 2002. This is a system of tradeable permits or renewable obligations certificates (ROCs) that yield a revenue stream for RE producers. After years of its operation, it has been acknowledged (DECC, 2010) that the RO was not designed with small projects in mind. The RO favours mainly electricity based technologies while non-electricity technologies are disfavoured (Mitchell and Connor, 2004). Pollitt (2010) concluded that the real failure of the UK policy has been to gain practical support from investors while other instruments like the renewable transport fuel obligation, the climate change levy and the EU trading schemes have achieved very little impact.

Non financial assistance refers to any form of sponsorship provided to create an environment that is favourable to the creation and survival of businesses (Flynn, 1993). At creation, non financial assistance may help facilitate access to other types of resources needed by the nascent entrepreneur. Many organisations have emerged with the objective of providing non financial assistance to farmers interested in renewable energy in the UK. These include public and private sector organisations. The most prominent are government departments: Department for Environment, Food and Rural Affairs, Department of Energy and Climate Change; non departmental public bodies: Environment Agency, Research Councils and quasi autonomous government agencies: Carbon Trust, Energy Saving Trust and Ofgem (Slade et al., 2009). It might be expected that the more assistance farmers have, the more they will engage in renewable projects. Non financial assistance enhances the human, social and financial capital of entrepreneurs (Jenssen and Havnes, 2002). This has stopped short of widely available free business specific consultancy which has not been available to farmers and other rural entrepreneurs for some time.

Table 2: A timeline of key policy instruments in the UK

Year	Policy initiative
1989	Deregulation and Non Fossil Fuel Obligation (NFFO) set
1997	Government encouragement for biofuels
1998	Investment subsidies
2001	Carbon tax
2002	Renewables Obligation
2002	Capital grants
2010	Feed in tariffs

Source: adapted from Thornley and Cooper (2008 p. 908) and DECC (2010)

Table 3: Reasons for public opposition to a renewable energy project in Devon, UK

Major concern	Response
Haulage lorry traffic congestion	93%
Haulage lorry air pollution	86%
Credibility of the developer	85%
Air pollution	85%
Visual appearance of the community	84%
Odour	82%
Wastes	82%
Technological reliability	79%

Source: Upham and Shackley (2007)

The ability of the entrepreneur to put together financial resources is very important for the commencement, growth and subsequent survival of any business (Alsos et al., 2006). Financial incentives are particularly relevant for renewable energy deployment because they offer the possibility for farmers to carry out farm investments which might not be justified by purely potential economic returns. Incentives are also valid considering that the initial investment for Renewable Energy Technologies (RETs) is usually costly and of a capital nature. In effect, most countries involved in the promotion of this type of energy employ some form of financial support. This includes capital grant schemes and subsidies (DECC, 2009a), feed in tariffs (Campoccia et al., 2009), tax credits (Dautzenberg and Hanf, 2008), low rate loans (German Federal Ministry for the Environment Nature Conservation and Nuclear Safety, 2009); net pricing and net metering (Talavera et al., 2010). Most of the financial support is derived via government agencies (Pollitt, 2010).

Access to resources enhances the ability and willingness of entrepreneurs to invest (Fogel, 2001). It is estimated that between 2005 and 2008, the UK government support for RETs was estimated at about £8.5bn[2]. This covered subsidies and grant schemes, research and development and other support services (Pollitt, 2010). These investments are thought to have had limited impact (Thornley and Cooper, 2008) but this has not discouraged the provision of other grant schemes aimed at promoting RETs uptake (DECC, 2009a; DECC, 2009b, DECC, 2010). Additionally, energy generators receive support when they meet their renewable energy quotas in the form of ROC recycled funds (Ofgem, 2009) as well as guaranteed feed in tariffs for units of heat and electricity generated and used or sold to the national grid (DECC, 2010). Increasing oil prices and low prices for conventional agricultural commodities have made the production of biomass for electricity, heat and fuel production very interesting for farmers compared to the production of conventional agricultural products (Tharakan et al., 2005). However, recent increases in world commodity prices and most notably wheat and other grains have altered the perception of attractive financial returns to energy crop farmers. In mitigation it has been found that the security and stability of income from bioenergy contracts has been a positive feature of renewable energy production (Sherrington and Moran, 2010 In Press). Development

[2] At mid-October 2011 £1 sterling was equivalent to about $US 1.6 and €1.16.

of bioenergy projects is almost always accomplished at the level of the individual farm business, often run by a sole trader or partnership. Although this has the merit of organisational simplicity, seldom is the business risk or borrowing spread over more than one or two individuals. As a result, the type of cooperative fuel processing and burning plants and district heating systems seen in some European countries are not commonly available in the UK. This clearly is an issue that increases business risk for bioenergy participants and tends to add to the capital required for UK bioenergy ventures.

There are increasing concerns amongst land owners that red tape and regulation could make microgeneration unaffordable (Country Land and Business Association, 2010). It has been argued that entrepreneurs can be discouraged from investing if they have to comply with too many rules and procedural requirements, are expected to report to a wide range of institutions and have to spend a substantial amount of money and time on what is seen as 'red tape' (Soto, 2000 cited by Bruton et al. 2010). Any lack of familiarity with the different support mechanisms and an increased perception of risk is likely to make RE a less attractive proposition for investors (Connor, 2003). Knowledge of the views of entrepreneurs with regards to their experiences of public support and their need for such support has been very limited (Normann and Klofsten, 2009).

The **cognitive** pillar of the institutional theory has been defined as the knowledge and skills possessed by people in a country pertaining to the creation and operation of a new business (Manolova et al., 2008). This dimension can therefore operate at the individual level and influences the ability of the entrepreneur to invest. Recent trends in the agricultural landscape in Europe (globalisation, increasing energy prices, the CAP reform, recession, etc) have increased demands on the skills required by farmers to succeed in their activities. It is desirable that farmers acquire skills additional to those needed for primary production, in areas such as marketing, personnel management, communications and to realise new business opportunities (Rudman, 2008). Skills are defined as the "competencies required to accomplish tasks and activities related to the farm business which can be acquired by learning and experience" (De Wolf and Schoorlemmer, 2008). These skills are categorised into professional, management, opportunity, strategic, and cooperation/networking skills. These are the intangible resources embedded in the enterprise (Mc Elwee, 2008).

De Wolf and Schoorlemmer (2008) suggested that skills are required to follow cost reduction, value adding and diversification strategies as a response to the environmental context in which farms operate. In this sense, entrepreneurial skills are needed to enhance farm survival and at the same time, take advantage of opportunities that are created by the changing farm context (Vesala and Pysysiainen, 2008). The personal experience, knowledge, education, and training are the human resources which business founders bring to the enterprise (Rotefoss and Kolvereid, 2005). Firms are also able to improve on their human resource or social capital through capacity building and advice (Mole and Keogh, 2009).

Renewable energy technologies are new and demand new skills from farmers who are interested in investing in them or those that adopt them (Sherrington and Moran, 2010 In Press). Investments can be increased by improving the capacities of managers to handle these new activities (Bokusheva et al., 2007). Ernst (1999) showed that new energy technologies required managerial skills and farmers needed to stay updated to keep their projects in operation.

Domac et al. (2004) and Domac et al. (2005) found that a common constraint for bioenergy development in the EU was inadequate information and awareness among stakeholders in the economy, society and politics. A lack of awareness of the numerous advantages of biomass and bioenergy and their consequent poor acceptance has often been highlighted as an important disincentive for their use and adoption (NFU, 2005). One major challenge for the agricultural sector is to enable farmers to have access to information and develop entrepreneurial skills (Vesala et al., 2007). Skills and knowledge are also needed on: (i) how to legally protect a new business; (ii) how to deal and manage risk as well as (iii) where to find information about markets for their products (Busenitz et al., 2000). Farmers need trusted, clearly independent, practical and specific information at an individual farm level to help them make investment decisions and take on new ventures. Research can provide an understanding of the information and skills needs of entrepreneurs (Sherrington et al., 2008).

The **normative** pillar of the administrative theory of entrepreneurship refers to the degree to which residents of a country admire entrepreneurial activity and appreciate creative and innovative thinking (Kostova, 1997). The normative pillar also exerts influence because of the social obligation to comply, rooted in social necessity, in what an organisation should be doing. They are typically made up of values and norms, what is preferred and how things are to be done in line with the accepted values (Bruton et al., 2010). The normative pillar represents actions that organizations and individuals ought to take – behaviors that may not be rational in the economic sense but which individuals' think of as good nonetheless (Bruton et al., 2009).

With literature on institutional environments largely focused on the regulatory dimension, there is relatively little written on the normative dimension (Manolova et al., 2008). It is argued that a supportive normative environment is one in which: (a) entrepreneurship is admired; (b) society appreciates innovative and creative thinking as a route to success and (c) turning ideas into business is admired as a career path by society (Busenitz et al., 2000). Estay (2004) asserted that rapid entrepreneurial development in countries like the United States was partly explained by the fact that people who started and ran their enterprises were highly admired and entrepreneurship was considered as a career path and a route to success.

Micro-businesses generally pursue a number of economic and non-economic objectives relating to factors such as income levels, job satisfaction, working hours, control and flexibility. These objectives are derived from the individual's social and economic contexts (Greenbank, 2001). Sutherland (2010) noted that farm viability as a personal goal directly reflected farm community norms: that there is a social stigma attached to failure to maintain a successful farm. Estay (2004) noted that networks and family as well as the existence of strong links with those in the same sector gave confidence to the entrepreneur with his progress towards business creation. Zhang and Wong (2008) proposed that networks are particularly important in areas of weak institutions. These social and market networks may be formal or informal in nature improving access of the entrepreneur to valuable resources needed for the venture – connections, finance, counselling and advice, and legitimacy. Otherwise stated, networks help to reduce market failures facilitating the activities of actors.

According to Roos et al (1999), there is a social dimension of bioenergy choice and social structures such as status, solidarity and conflicts influence the development of a bioenergy market. Social criteria have been consistently identified as being decisive in making bioenergy projects viable (Buchholz et al., 2009). Also, many farmers think that the production of bioenergy is fundamentally a "good" thing and it was widely thought that it could be a strong incentive for energy production in the future (Sherrington et al., 2008).

There appears to be a need for research concerning the experiences of UK farmers who have adopted or are considering the adoption of RE enterprises. With some of the research reported in this paper a period of time has elapsed which has coincided with a change in the business environment within which potential RE adopters are operating. There is no published research that applies the administrative theory of entrepreneurship to UK farmers which the authors of this paper are aware of. This paper seeks to apply the principles of the regulatory, cognitive and normative pillars of the administrative theory of entrepreneurship to a sample of farmers in the West Midlands with the assistance of the regional office of the NFU. As a result of this literature review and following the identification of the knowledge gap with respect specifically to RE enterprises and UK farmers the following hypotheses have been developed:

H1: The entrepreneurial environment for bioenergy development in the UK is sympathetic to the needs of this emerging industry;
H2: Adopters of bioenergy are positively motivated towards the venture; and
H3: Farm based bioenergy enterprises make a positive contribution to overall farm business viability.

2. Proposed conceptual framework for the study and methodology

Upreti and van der Horst (2004) studied the causes and consequences of public opposition to the development of the North Wiltshire Biomass Energy plant. The authors suggested that when an external development process posed threats on the values and expectations of people, they developed mistrust - mistrust increased if the benefits of the proposed project were not clear to the local people. Upham and Shackley (2007) assessed local opinion to a proposed biomass gasifier in Devon

In another study of conflicts over biomass energy development in England and Wales, the Arable Biomass Renewable Energy project (ARBRE), the North Wiltshire Biomass Power Plant (NWBPP) and the Newbridge Integrated Wood Processing Plant were studied (Upreti, 2004). Two contrasting attitudes from the community and developers were observed: the 'Not In My Back Yard (NIMBY)' attitude by the locals and the 'There is No Alternative (TINA)' attitude of developers. Negative public opinion is a strong disincentive for renewable energy deployment especially when enterprises create negative externalities. This is very likely to affect the willingness of any investor interested in such a venture.

Rural entrepreneurship researchers have advised on the need to clearly determine the unit of analysis in studies of the agricultural sector (McElwee, 2005; 2006 and Carter, 2001). This is because farmers are considered to be entrepreneurially active individuals and directing the strategy of the businesses that they are responsible for (McElwee, 2008). McElwee and Smith (2010) suggested that there is a need to determine whether the unit of analysis is the farmer or the farm. In this study, we are interested in the farmer and the farm.

Kostova, Busenitz et al. and Manolova et al. measured constructs of the institutional environment as they affected the domain of entrepreneurship as a whole at the macro level. In this study, we seek to apply the dimensions to the farm sector. This micro institutional view differs from the macro-institutional perspective.

The conceptual framework is a model that combines the three pillars of the institutional theory of entrepreneurship with the elements for the determination of the new venture creation process, giving rise to the entrepreneur's decision to either adopt or not to adopt a new enterprise. In this case it is being applied to RE enterprises, although it could be applied to any new enterprise or business venture.

The conceptual framework proposed to be employed is shown in Figure 1 below:

The conceptual framework has been produced from the findings of the review of literature and these are combined and provide the basis for testing the hypotheses as follows:

Hypothesis 1 will be tested by the questions in sections 1, 2 and 3 of the questionnaire. The questions in these sections focus on the regulatory, cognitive and normative dimensions respectively of the institutional environment of the conceptual framework.
Hypothesis 2 will be tested by the questions in sections 4, 5 and 6 of the questionnaire and the focus of this part of the research is on the sections of the conceptual framework that deal with the venture creation process and the farmers' decision for or against the adoption of RE.
Hypothesis 3 will be tested in the qualitative or case study phase of the research which will be forthcoming in 2013.

The study area is the West Midlands Region of the UK. This is because the region is quite accessible to the researcher. Also, this region is a possible lead region for bioenergy (DEFRA, 2010). By considering areas of potential bioenergy production the study could be more relevant than a nationwide study (Sherrington and Moran, 2008).

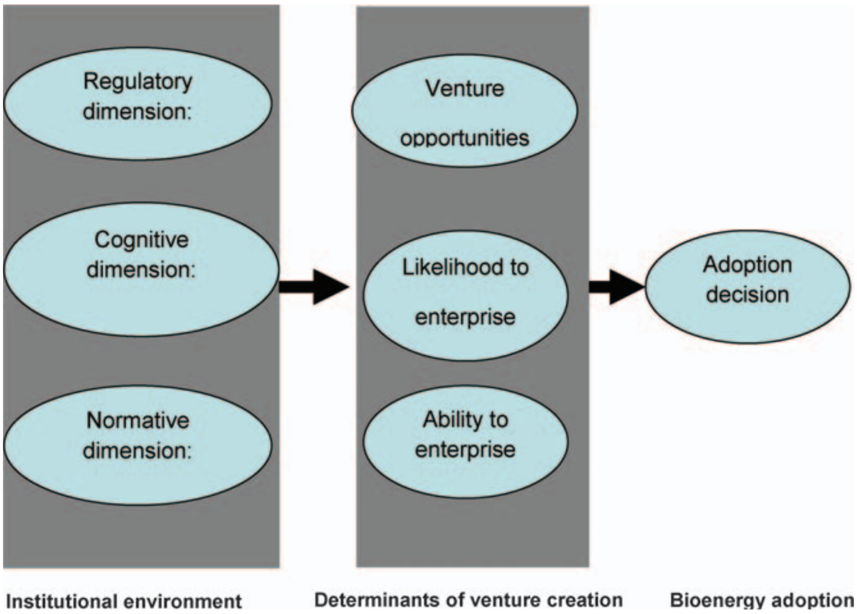

Figure 1: Proposed conceptual framework
Source: adapted from Kostova, 1997; Busenitz et al., 2000; Lim et al., 2010; Gnyawali and Fogel,1994.

The study will be undertaken in three stages, these being:

Pilot study

The original intention of the pilot survey was to interview a sample of nine farmers; three RE adopters, three who have weighed up the options and decided not to adopt and three others who were yet to consider RE. It was felt that farmers in these categories would be best placed to participate in the pilot. A draft questionnaire was used and the results from this pilot survey are reported below.

Quantitative phase

The survey of a statistically significant stratified sample of farmers was carried out after the pilot survey. The National Farmers' Union West Midlands Regional Office were happy to cooperate with this project and consequently a sample of 2000 members of the West Midlands Region, including the counties of Staffordshire, Shropshire, Herefordshire, Worcestershire and Warwickshire were surveyed in February 2011. The response from the sample was 402 completed questionnaires, of which 395 were useable, representing a response rate of 20.1%. The results from this sample are currently being examined using a variety of approaches including factor analysis.

Qualitative Phase

The intention is to sample examples of a selection of RE enterprises, including solar, biomass, anaerobic digestion, wind and hydro and to undertake a set of detailed financial case studies that assess both the capital investment and annual transactions that go to make up overall enterprise financial viability. The qualitative research phase will deal with case studies sampled from the quantitative phase. This phase of the research will employ DCF/IRR techniques to assess potential investment viability. The unit of analysis here is the RE enterprise.

Based on these results and the key explanatory variable of the quantitative research, a predictive capital decision making model for the bioenergy sector is foreseen comprising of both qualitative and quantitative business drivers which will explain the financial viability of farm based enterprises. This model should provide a basis for policy formulation as well as serve as an investment decision tool for rural entrepreneurs as potential adopters. There are well established financial assessment methods for evaluating the viability of energy technologies (Ericsson et al., 2009). These methods consider profit maximisation as the main objective behind farmers decisions to adopt (Sherrington and Moran, 2010 In Press) even though there is strong evidence that farmers often pursued a multitude of objectives and not only profit maximisation (Greenbank, 2001, Wallace and Moss, 2002 and Willock et al., 1999).

3. Pilot survey results

The pilot survey was carried out in order to develop a valid and reliable postal survey instrument for the quantitative phase of the study. Originally it was hoped that nine farmers would participate and these were randomly sampled from the category 'farmers' in the West Midlands from the website Yell.com, however two found that they could not in the end participate and seven farmers were finally interviewed. The pilot sample included some who had adopted RE, some who had considered RE and decided not to adopt the technology and others who were yet to consider it. Results of the pilot survey suggested that key issues could be grouped into six main headings: (1) Regulatory and government, (2) Normative and social acceptability, (3) Information, knowledge and cognitive skills development, (4) Farmers attitudes towards RE, (5) Motivations conducive to RE investment, and (6) Barriers to RE investment, resources and self efficacy. The draft questionnaire contained questions on these main areas and this was followed by a section designed to elicit demographic information. The questionnaire consisted of questions that sought to elicit two main types of responses. There were those that required a scale response from the interviewee and these responses were coded by way of the use of Likert scales. There were also open ended and semi-open ended questions that were used to collect information that required the interviewee either to compose a short sentence or to select a category within which the appropriate response was contained such as the question on farm type which was in Section 7 on Farm Business Characteristics. The pilot was administered by visiting the seven pilot survey participants and requesting that they complete the proforma under the supervision of the researcher, voicing any concerns they might have about what appeared to be confusing or ambiguous terminology. These observations were recorded and taken back for consideration and reflection with the project supervisor. Slight amendments were made, including a shortening of the survey from seven pages to six with the final survey instrument being dispatched by Royal Mail in February 2011 with a deadline for completion as March 14 2011 if participation in a draw was to be guaranteed. The final questionnaire is at Appendix 1.

4. Conclusion

This paper has developed a conceptual framework to progress the study of the potential contributions of bioenergy to farm business sustainability in the West Midlands of the UK and proposed a methodology to realise the study. The research is likely to show that the low level of adoption of RE enterprises and especially bioenergy on land based enterprises in the UK will be explained by variables in the regulatory, cognitive and normative dimensions of the country institutional profiles of entrepreneurship (Busenitz et al 2000). These variables affect the venture creation process and the farmers' decision to adopt bioenergy technology rests on his assessment of the opportunities offered by the institutional fabric, the willingness to enterprise and the ability for enterprise.

The qualitative phase of the research will investigate the financial viability (Turner and Taylor 1998) of a wide range of potential farm enterprises in the renewable energy sector and to construct web-based computer software that farmers can use to forecast enterprise viability. In this paper both a framework and a methodology are proposed to investigate the interaction between farmers and the institutional environment. Mitchell et al. (2000) suggested that such a combination of concepts from entrepreneurship cognition research and institutional theory provided finer grained explanations for entrepreneur's venture creation decisions. This paper has argued that this novel, selective approach is more comprehensive than other established approaches used to study adoption of bioenergy on farms in the UK (Sherrington et al., 2008, Sherrington and Moran, 2008).

Bioenergy technologies and their adoption is claimed to be of increasing importance (DEFRA 2007, NFU, 2008) by the UK government and as a result has become worthy of detailed study. Nevertheless UK farmers and rural entrepreneurs are not in the strongest competitive position, faced with irregular policy changes that impact upon adopters and most importantly potential adopters, the lack of a developed cooperative infrastructure which might spread risk and an underdeveloped bioenergy engineering industry. On top of these constraints there is the current difficulty in sourcing funds for capital investment generally due to the ongoing effects of the 2008 banking crisis and widespread and complex planning controls, which might be expected on the relatively densely populated mainland of the UK. We must also be mindful that there is the UK government's new found enthusiasm for nuclear energy that will come on stream from 2017 onwards, possibly in the long term raising questions in the future about the viability and acceptability of alternative sources of energy production.

About the authors

Dr Graham Tate (Graham.Tate@wlv.ac.uk) is a senior lecturer in Business Strategy and Enterprise at the University of Wolverhampton Business School. He has more than 25 years experience of rural consultancy, research and teaching in the fields of farm business management, rural enterprise and diversification, entrepreneurship and business management. His current research activity includes studies of business viability post sugar beet, the enterprise implications of renewable energy technologies and the financial impact of herd disease breakdowns.

Aurelian Mbzibain (A.mbzibain2@wlv.ac.uk) is a full time PhD researcher at the University of Wolverhampton Business School. He holds an International Erasmus Mundus Masters of Rural Development from Ghent University Belgium, Agro Campus Rennes France and Humboldt University Berlin Germany. He has more than five years international rural development experience. Current research includes the viability of renewable energy enterprises in the UK farm sector and rural entrepreneurship.

Acknowledgements

The authors and the University of Wolverhampton would like to express their gratitude to the John Oldacre Foundation for the sponsorship of this research paper presentation and associated studentship. They are also grateful for the helpful comments of two anonymous referees.

REFERENCES

Alsos, A. G., Ljunggren, E. And Pettersen, L. T. (2003) 'Farm-based entrepreneurs: what triggers the start-up of new business activities? *Journal of Small Business and Enterprises Development*, 10 (4), 435–443.

Alsos, G. A., Isaksen, E. J. And Ljunggren, E. (2006) 'New Venture Financing and Subsequent Business Growth in

Men- and Women-Led Businesses'. *Entrepreneurship: Theory and Practice*, 30 (5), 667–686.
Barlas, Y., Damianos, D., Dimara, E., Kasimis, C. And Skuras, D. (2001) 'Factors influencing the integration of alternative farm enterprises into the agro-food system'. *Rural Sociology*, 66 (3), 342–358.
Bokusheva, R., Valentinov, V. And Anpilogova, V. (2007) 'The investment behaviour of Russian Farms'. *Post Communist Economies,* 19 (1), 53–71.
Bowler, I.,Clark, G. And Crockett, A. (1996) 'The development of alternative farm enterprises: a study of family labour farms in the Northern Pennines of England'. *Journal of Rural Studies*, 12 (3), 285–295.
Bruton, G. D., Ahlstrom, D. And Puky, T. (2009) 'Institutional differences and the development of entrepreneurial ventures: A comparison of the venture capital industries in Latin America and Asia'. *Journal of International Business Studies,* 40 (5), 762–778.
Bruton, G. D., D. Ahlstrom, *et al*. (2010). 'Institutional Theory and Entrepreneurship: Where Are We Now and Where Do We Need to Move in the Future?' *Entrepreneurship: Theory & Practice* 34(3): 421–440.
Buchholz, T., Rametsteiner, E., Volk, T. A. And Luzadis, V. A. (2009) 'Multi Criteria Analysis for bioenergy systems assessments'. *Energy Policy*, 37 (2), 484–495.
Burton, M., Rigby, D. And Young, T. (1999) 'Analysis of the Determinants of Adoption of Organic Horticultural Techniques in the UK'. *Journal of Agricultural Economics*, 50 (1), 47–63.
Busenitz, L. W., Gomez, C. And Spenser, J. W. (2000) 'Country institutional profiles: unlocking entrepreneurial phenomena'. *Academy of Management Journal*, 43 (5), 994–1003.
Campoccia, A., Dusonchet, L., Telaretti, E. And Zizzo, G. (2009) 'Comparative analysis of different supporting measures for the production of electrical energy by solar PV and Wind systems: Four representative European cases'. *Solar Energy*, 83 (3), 287–297.
Carter, S. (1998) 'Portfolio entrepreneurship in the farm sector: indigenous growth in rural areas'? *Entrepreneurship and regional development*, 10 (1), 17–32.
Carter, S. (2001) 'Multiple business ownership in the farm sector. Differentiating monoactive, diversified and portfolio enterprises'. *International Journal of Entrepreneurial Behaviour and Research,* 7 (2), 43–59.
CCA (2008) Climate Change Act CHAPTER 27. London. UK. http://www.opsi.gov.uk/acts/acts2008/pdf/ukpga_20080027_en.pdf (accessed January 14, 2009)
Connor, P. M. (2003) 'UK renewable energy policy: a review'. *Renewable and Sustainable Energy Reviews,* 7 (1), 65–82.
Country Land and Business Association (2010) Press Release: 'Microgenerators are overcharging'. http://www.cla.org.uk/News_and_Press/Latest_Releases/Renewable_Energy/Red_Tape/1003704.htm/ (accessed June 16, 2010)
Dautzenberg, K. And Hanf, J. (2008) 'Biofuel chain development in Germany: Organisation, opportunities, and challenges'. *Energy Policy*, 36 (1), 485–489.
DECC (2009a) *Bioenergy Capital Grants Scheme (Round 6*). Department of Energy and Climate Change. London
DECC (2009b) *Reform of the Renewables Obligation: Government response to the statutory consultation on the Renewables Obligation Order 2009*. Department of Energy and Climate Change. London
DECC (2010) *Renewable Heat Incentive- Consultation on the proposed RHI financial support scheme*. Department of Energy and Climate Change. London
DEFRA (2007) *UK Biomass Strategy*. London
Domac, J., Healion, K., Lunnan, A., Madlener, R., Nilsson, N. S., Richards, K., White, B., Yagishita, T. And Segon, V. (2004) Educational work of the IEA bioenergy task 29: socio-economic drivers in implementing bioenergy projects. 2nd World Biomass Conference-Biomass for Energy, Industry and Climate Protection. Rome, Italy.
Domac, J., Richards, K. And Segon, V. (2005) IEA bioenergy task 29: socioeconomic drivers in implementing bioenergy IEA bioenergy task 29.
Emerson, H. And Macfarlane (1995) 'Comparative Bias between Sampling Frames for Farm Surveys'. *Journal of Agricultural Economics,* 46 (2), 241–251.
Ericsson, K., Rosenqvist, H. And Nilsson, L. J. (2009) 'Energy crop production costs in the EU'. *Biomass and Bioenergy,* 33 (11), 1577–1586.
Ernst, M., Rodecker, J., Luvaga, E., Alexander, T., Klienbenstein, J. And Miranowski, J. (1999) The viability of methane production by anaerobic digestion on Iowa swine farms. Iowa, Iowa State University Department of Economics Staff Paper.
Estay, C. (2004) 'Setting up businesses in France and the USA: A cross cultural analysis'. *European Management Journal,* 22 (4), 452–463.
Flynn, D. M. (1993) 'Sponsorship and the survival of new organizations'. *Journal of Small Business Management,* 31 (1), 51–62.
Fogel, G. (2001) 'An analysis of entrepreneurial environment and enterprise development in Hungary'. *Journal of Small Business Management,* 39 (1), 103–109.
Gnyawali, D. R. And Fogel, D. S. (1994) 'Environments for entrepreneurship development: key dimensions and research implications'. *Entrepreneurship: Theory and Practice*, 18 (4) 43–62.
German Federal Ministry For The Environment Nature Conservation And Nuclear Safety (2009) *Renewable energy sources in figures-national and international development.* German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. Berlin
Greenbank, P. (2001) 'Objective setting in the micro-business'. *International Journal of Entrepreneurial Behaviour and Research,* 7 (3), 108–127.
Howard, D. C., Wadsworth, R. A., Whitaker, J. W., Hughes, N. and Bunce, R. G. H. (2009) 'The impact of sustainable energy production on land use in Britain through to 2050'. *Land Use Policy*, 26 (1), S284–S292.
Ilbery, B., D. Watts, *et al*. (2010). 'Attitudes of food entrepreneurs towards two grant schemes under the first England Rural Development Programme, 2000–2006'. *Land Use Policy,* 27(3), 683–689.
Jenssen, I. J. And Havnes, A. P. (2002) 'Public Intervention in the entrepreneurial process. A study based on three Norwegian cases'. *International Journal of Entrepreneurial Behaviour and Research,* 8 (3), 173–187.
Kostova, T. (1997) Country institutional profiles: concepts and measurement. *Academy of Management Proceedings,* 180–184.
Manolova, T. S., Rangamohan, E. V. And Bojidar, G. S. (2008) 'Institutional environments for entrepreneurship: evidence from emerging economies in Eastern Europe'. *Entrepreneurship: Theory and Practice,* 32 (1), 203–218.
Maye, D., Ilbery, B. And Watts, D. (2009) 'Farm diversification, tenancy and CAP reform: results from a survey of tenant farmers in England'. *Journal of Rural Studies*, 25 (3), 333–342.
McElwee, G. (2005) A literature review of entrepreneurship in agriculture (draft deliverable) Developing entrepreneurial skills of farmers SSPE-CT-2005-006500. ESoF Entrepreneurial Skills of Farmers.
McElwee, G. (2006) 'Farmers as entrepreneurs:: developing competitive skills'. *Journal of Developmental Entrepreneurship,* 11 (3), 187–206.
McElwee, G. (2008) 'A taxonomy of entrepreneurial farmers'. *International Journal of Entrepreneurship and Small Business,* 6 (3), 465–478.
Mitchell, C. and Connor, P. (2004) 'Renewable energy policy in the UK 1990–2003'. *Energy Policy*, 32 (17), 1935–1947.
Minniti, M. (2008) 'The role of government policy on entrepreneurial activity: productive, unproductive, or destructive ?' *Entrepreneurship: Theory and Practice*, 32 (5), 779–790.
Mole, K. F. And Keogh, W. (2009) 'The implications of public sector small business advisers becoming strategic sounding boards: England and Scotland compared'. *Entrepreneurship and Regional Development,* 21 (1), 77–97.

NFU (2005) *Agriculture and climate change report*. National Farmers' Union. 55 pages

NFU (2008) Bioenergy Information. NFU Bioenergy Information. National Farmers Union. http://www.nfuonline.com/x7890.xml

Normann, C. And Klofsten, M. (2009) 'An entrepreneurship policy programme. Implications and expectations'. *Entrepreneurship and Innovation,* 10 (1), 33–43.

OFGEM (2009) Ofgem 2008–2009 annual report: *Protecting energy consumers interests now and for the future*. Office of Gas and Electricity Markets.

Perry, M. and Rosillo-Calle, F. (2008) 'Recent trends and future opportunities in UK bioenergy: Maximising biomass penetration in a centralised energy system'. *Biomass and Bioenergy*, 32 (8), 688–701.

Plieninger, T., Bens, O. and Reinhard, F. H. (2006) 'Perspectives of bioenergy for agriculture and rural areas'. *Outlook on Agriculture,* 35 (2), 123–127.

Plieninger, Thiel, A., Bens & Huttl (2009) 'Pathways and pitfalls of implementing the use of woodfuels in Germany bioenergy sector'. *Biomass and Bioenergy*, 33(3), 384–392.

Pollitt, G. M. (2010) *UK renewable energy policy since liberalisation*. Cambridge Working Paper in Economics, 1007, 69.

Rosenqvist, H., Roos, A., Ling, E. And Hektor, B. (2000) 'Willow growers in Sweden'. *Biomass and Bioenergy,* 18(2), 137–145.

Rotefoss, B. and Kolvereid, L. (2005) 'Aspiring, nascent and fledgling entrepreneurs: an investigation of the business start-up process'. *Entrepreneurship and Regional Development,* 17 (2), 109–127.

Rounsevell, M. D. A. and Reay, D. S. (2009) 'Land use and climate change in the UK'. *Land Use Policy,* 26 (1), S160–S169.

Rudman, C. (2008) *Entrepreneurial skills and their role in enhancing the relative independence of farmers*: Results and recommendations from the research project Developing Entrepreneurial Skills of Farmers.

Sara, C. and Rosa, P. (1998) 'Indigenous rural firms: farm enterprises in the UK'. *International Small Business Journal*, 16 (4), 12.

Sherrington, C. and Moran, D. (2008) *Farmer attitudes and intentions towards adoption of perrennial energy crops in the UK. An application of the Theory of Planned Behaviour*. 16th European Biomass Conference & Exhibition, From Research to Industry & Markets. Feria Valencia, Spain.

Sherrington, C. and Moran, D. (2010) 'Modelling farmer uptake of perennial energy crops in the UK'. In Press. *Energy Policy*, x, xxx. doi:10.1016/j.enpol.2010.02.034

Sherrington, C., Bartley, J. and Moran, D. (2008) 'Farm-Level constraints on the domestic supply of perennial energy crops in the UK'. *Energy Policy*, 36 (7), 2504–2512.

Slade, R., Panoutsou, C. and Bauen, A. (2009) 'Reconciling bio-energy policy and delivery in the UK: Will UK policy initiatives lead to increased deployment'? *Biomass and Bioenergy*, 33 (4), 679–688.

Sutherland, L. (2010) 'Environmental grants and regulations in strategic farm business decision-making: A case study of attitudinal behaviour in Scotland'. *Land Use Policy,* 27, 415–423.

Tate, G. J. (2010). Entrepreneurship and the environment for rural SMEs in the Shropshire Hills, UK 1997–2009. *The Journal of Entrepreneurship,* 19 (2), 191–207.

Tate, G. J., Hughes, G., Temple, M., Boothby, D. and Wilkinson, M. (2010). Changes to farm business management under extreme weather events - likelihood of effects and opportunities in the UK. *Journal of Farm Management,* 14 (1), 67–86.

Tharakan, J. P., Volk, A. T., Lindsey, A. C., Abrahamson, L. P. and White, E. H. (2005) 'Evaluating the impact of three incentive programs on the economics of cofiring willow biomass with coal in New York State'. *Energy Policy*, 33 (3), 337–347.

The Rural Economy and Land Use Programme (2009) *Assessing the social, environmental and economic impacts of increasing rural land use under energy crops*. Policy and Practice Notes. London, RELU.

Thornley, P. and Cooper, D. (2008) 'The effectiveness of policy instruments in promoting bioenergy'. *Biomass and Bioenergy*, 32 (10), 903–913.

Turner, J. and Taylor, M. (1998). *Applied Farm Management*. Blackwell, Oxford.

Upham, P. and Shackley, S. (2007) 'Local public opinion of a proposed 21.5 MW(e) biomass gasifier in Devon: Questionnaire survey results'. *Biomass and Bioenergy*, 31 (6), 433–441.

Upreti, B. R. (2004) 'Conflict over biomass energy development in the United Kingdom: some observations and lessons from England and Wales'. *Energy Policy,* 32 (6), 785–800.

Upreti, B. R. and Van Der Horst, D. (2004) 'National renewable energy policy and local opposition in the UK: the failed development of a biomass electricity plant'. *Biomass and Bioenergy*, 26 (1), 61–69.

Vesala, K. M., Peura, J. and McElwee, G. (2007) 'The split entrepreneurial identity of the farmer'. *Journal of Small Business and Enterprises Management*, 14 (1), 48–63.

Vesala, K. M. and Pyysiäinen, J. (2008) Understanding entrepreneurial skills in the farm context (Work Package 4). IN RUDMAN, C. (Ed.) *Entrepreneurial skills and their role in enhancing the relative independence of farmers: Results and recommendations from the research project Developing Entrepreneurial Skills of Farmers*.

Wallace, M. T. and Moss, B. (2002) 'Farmer Decision making with Conflicting Goals: A recursive Strategic Programming Analysis'. *Journal of Agricultural Economics*, 53 (1), 82–100.

Willock, J., Deary, I. J., Edwards-Jones, G., Gibson, G. J., McGregor, M. J., Sutherland, A., Dent, J. B., Morgan, O. and Grieve, R. (1999) 'The Role of Attitudes and Objectives in Farmer Decision Making: Business and Environmentally Oriented Behaviour in Scotland'. *Journal of Agricultural Economics,* 50 (2), 286–303.

Zapalska, A. M., Dabb, H. and Perry, G. (2003) 'Environmental factors affecting entrepreneurial activities: Indigenous Maori entrepreneurs of New Zealand'. *Asian Pacific Business Review*, 10 (2), 160–177.

Zhang, J. And Wong, P.K. (2008) 'Networks versus market methods in high-tech venture fundraising: the impact of institutional environment'. *Entrepreneurship and Regional Development*, 20 (5), 409–430.

Appendix 1: Final Quantitative Phase Questionnaire

UNIVERSITY OF WOLVERHAMPTON BUSINESS SCHOOL

With the assistance of

NFU The Voice of British Farming

RESEARCH TITLE:
RENEWABLE ENERGY AND THE FARMER: A VIABLE BUSINESS PROPOSITION?

Introduction:

Faced with the challenge of climate change, renewable energy could be an important option to mitigate climate change and it may also prove to be a profitable farm business diversification. We'd like to learn more about the reasons why farmers find adoption of these technologies challenging.

Only a small proportion of the NFU membership has been randomly selected to participate, so your experiences and thoughts on the subject are very important. Please help us by answering the questions to the best of your ability. As an incentive, we will offer Marks and Spenser (M&S) **vouchers worth fifty (£50) pounds** each to three farmers returning their completed questionnaires by **March 14, 2011**.

The results of the study will document the factors which help or hinder uptake of renewable technologies by farmers in the West Midlands. It will also help us to understand the motivations behind the decision to invest (or not) in renewables.

The questionnaire should take about 25 minutes to complete. We are aware that Spring is fast approaching and you should be getting very busy. We hope you could find time within your very busy schedule to help complete it. Please kindly return the completed questionnaire to me by March 14, 2011 in the enclosed freepost envelope.

If you have any questions or would like further information, please do not hesitate to telephone me on 01902323863 or email me at a.mbzibain@wlv.ac.uk. **I am grateful for your kindness, and thank you for your generous help in completing this questionnaire to help me with my postgraduate research.**

(1) Please tick here to indicate that you have understood the purpose of this study ☐

(2) Please tick here to indicate that your participation in this study is completely voluntary ☐

(3) If you would love to take part in the draw to win a £50 M&S voucher, please tick here ☐

(4) If you would like to receive a summary of the research findings please provide me an email address:

____

SECTION 1: RENEWABLE ENERGY (RE) REGULATIONS AND POLICIES

For each of the following statements, **please tick ✓ the box** that matches your view most closely.

1.1 Government and council support	Strongly disagree	⇨	Unsure	⇨	Strongly agree
Government organisations assist farmers to start RE enterprises...............	❑1	❑2	❑3	❑4	❑5
Government sponsors organisations that help farmers invest in RE...........	❑1	❑2	❑3	❑4	❑5
Current policies encourage farmers to adopt RE on their farms..................	❑1	❑2	❑3	❑4	❑5
Councils provide support for farmers who want to set up RE on farms.....	❑1	❑2	❑3	❑4	❑5
Government grants are accessible for farmers starting RE enterprises......	❑1	❑2	❑3	❑4	❑5
Banks have funds available for farmers for starting RE enterprises............	❑1	❑2	❑3	❑4	❑5
1.2 Procedures to set up renewable energy enterprises					
Farmers have to comply with too many procedure requirements..............	❑1	❑2	❑3	❑4	❑5
Procedures for grid connection **discourage** farmers from generating RE...	❑1	❑2	❑3	❑4	❑5
Local council planning procedures **discourage** farmers to invest in RE.......	❑1	❑2	❑3	❑4	❑5

SECTION 2: STANDING OF ENTREPRENEURS, PUBLIC PERCEPTION AND SOCIAL NORMS

For each of the following statements, **please tick ✓ the box** that matches your view most closely.

2.1 Standing of entrepreneurs/ public perception	Strongly disagree	⇨	Unsure	⇨	Strongly agree
People in the UK tend to admire those who start their own businesses...	❑1	❑2	❑3	❑4	❑5
Farmers with successful businesses are admired	❑1	❑2	❑3	❑4	❑5
People **do not** have a favourable attitude towards renewable energy	❑1	❑2	❑3	❑4	❑5
People in the UK care a great deal about climate change	❑1	❑2	❑3	❑4	❑5
2.2 Social norms					
Because of climate change, investing in RE is a moral obligation	❑1	❑2	❑3	❑4	❑5
Most people that I look up to for advice think it is good to invest in RE.....	❑1	❑2	❑3	❑4	❑5

SECTION 3: PUBLIC AWARENESS, INFORMATION AND TRAINING PROGRAMMES

For each of the following statements, **please tick ✓ the box** that matches your view most closely.

3.1 Public awareness, information and training	Strongly disagree	⇨	Unsure	⇨	Strongly Agree
Most farmers know where to find relevant information about RE..............	❑1	❑2	❑3	❑4	❑5
Farmers are familiar with the government financial support mechanisms/packages available to them..	❑1	❑2	❑3	❑4	❑5
There many training programmes for farmers on RE topics........................	❑1	❑2	❑3	❑4	❑5

SECTION 4: PERCEPTIONS ON RENEWABLE ENERGY BUSINESS OPPORTUNITIES

For each of the following statements, **please tick ✓ the box** that matches your view most closely.

4.1 Your perceptions on RE business opportunities	Strongly disagree	⟹	Unsure	⟹	Strongly agree
a) There are new market opportunities in RE if I want to exploit them.....	❑1	❑2	❑3	❑4	❑5
b) RE can help improve the economic success of my business....................	❑1	❑2	❑3	❑4	❑5
c) Renewable energy production is not a viable option compared to my existing farm business activities	❑1	❑2	❑3	❑4	❑5
d) If I start a RE enterprise it will help me achieve other important non economic goals in my life	❑1	❑2	❑3	❑4	❑5

SECTION 5: INTENTION AND DECISION-MAKING

For each of the following questions, please **tick** ✓the box that matches your view most closely.

5.1 (a) Have you already adopted any form of renewable energy enterprise on your farm?

Yes....... ❑1 No........ ❑2 **➔IF NO, PLEASE SKIP TO QUESTION 5.2 ON THE NEXT PAGE**

b) If yes, when did you set it up? (*Please write the year*) ___________________

c) What was the source of funding for this project? Please **tick ✓all** the appropriate boxes.

Bank ❑1 Government grant/subsidy ❑2 Personal Savings ❑3 Business ❑4 Other_________

d) Kindly indicate which type (s) of renewable energy enterprise (s) you have adopted? *(You can tick more than one)*

Miscanthus....... ❑1	Short rotation coppice.. ❑2	Combine heat power................................ ❑3
Wind turbine.....❑4	Anaerobic digesters....... ❑5	Woodchip/biomass pellet production.... ❑6
Biomass boiler..❑7	Solar.................................❑8	Other .... ❑9

e) To what extent has the adoption of the enterprise contributed to your farm business performance?

Highly deteriorated	Deteriorated	Remained the same	Slightly Improved	Significantly improved
❑1	❑2	❑3	❑4	❑5

f) In comparison to your conventional farming activities, what proportion of your total farm income was derived from the renewable energy enterprise (s) in 2009 (IF AT ALL)? ____________ %

g) Can you kindly indicate the level of contribution of the RE enterprise to your total farm income in 2009?

Not sure.. ❑1 £ 0 ❑2 £1- £10 000...❑3 £10000 - £25000...❑4 > £25 000...❑5

h) How likely is it that you will expand the renewable energy enterprise (s) on your farm in the next 5 years?

Very unlikely ❑1 Unlikely ❑2 Undecided ❑3 Likely ❑4 Very likely ❑5

➔ PLEASE NOW SKIP TO QUESTION 5.3 ON THE NEXT PAGE

5.2(a) How interested are you in setting up some form of renewable energy enterprise on your farm?

Very uninterested ❑1 Uninterested ❑2 Undecided ❑3 Interested ❑4 Very interested ❑5

b) How much consideration have you given to establishing a renewable energy enterprise on your farm?

None whatsoever ❑1 Have thought about it ❑2 Considered but undecided ❑3

Considered and interested ❑4 Considering implementation ❑5

c) How likely is it that you will set up some form of RE enterprise on your farm within the **next five (5) years?**

Very unlikely ❑1 Unlikely ❑2 Undecided ❑3 Likely ❑4 Very likely ❑5

d) Which enterprise are you most likely to adopt **first**? IF AT ALL *(Please kindly tick **only one** box)*

Miscanthus....... ❑1 Short rotation coppice ❑2 Combine heat power................................ ❑3

Wind turbine.... ❑4 Anaerobic digesters....... ❑5 Woodchip/biomass pellet production.... ❑6

Biomass boiler ❑7 Solar................................❑8 Other .... ❑9

➔PLEASE GO TO 5.4 IF YOU DO NOT INTEND TO ADOPT ANY RE ENTERPRISE IN THE FUTURE

5.3 Please kindly **rank 4 items** in order of importance to you as regards why you would adopt (or why you adopted) the RE enterprise mentioned on your farm. Number the most important 1, the next important 2 and so on.

To take advantage of grants/subsidies................. ❑ To dispose of farm waste..❑

To diversify farm income....................................... ❑ To cut farm business costs......................................❑

To help meet government energy targets............ ❑ To provide environmental benefits.....................❑

To take advantage of market opportunities......... ❑ Other (please specify)________________________

5.4 If you do not intend to invest in any form of RE enterprise in the near future, please **kindly write** in order of importance, **3 most** important reasons for not doing so. Where 1 = most important, the next important 2, …

1) ____

2) ____

3 ____

SECTION 6: YOUR ABILITIES, RESOURCES and FARM BUSINESS MOTIVATIONS

For each of the following statements, **please tick** ✓ the box that matches your view most closely.

6.1 How much confidence do you have in your ability to…?

Abilities	Very little ⇨		Unsure	⇨	Very High
a) Identify new business opportunities and act on them.............................	❑1	❑2	❑3	❑4	❑5
b) Find the right technology that is needed for the farm.............................	❑1	❑2	❑3	❑4	❑5
c) Estimate financial viability of a renewable energy enterprise................	❑1	❑2	❑3	❑4	❑5
d) Raise enough funds to start a renewable energy enterprise..................	❑1	❑2	❑3	❑4	❑5
e) Lead the planning permission process at local council level....................	❑1	❑2	❑3	❑4	❑5
f) Organise and maintain financial records of your farm business.............	❑1	❑2	❑3	❑4	❑5

6.2 To what extent do you agree or disagree with the following statements about your business networks?

Support of friends and business networks	Strongly disagree	⇨	Unsure	⇨	Strongly agree
My family has social relationships that can help my business	❑1	❑2	❑3	❑4	❑5
I have friends and family that can assist my business development	❑1	❑2	❑3	❑4	❑5
I have business networks that I can rely on in case of difficulties	❑1	❑2	❑3	❑4	❑5
The knowledge that is necessary to exploit potential opportunities in RE is very similar to the knowledge that you already possess	❑1	❑2	❑3	❑4	❑5

6.3 To what extent do you agree or disagree with the following statements about your goals?

Business goals	Strongly disagree	⇨	Unsure	⇨	Strongly agree
a) My goal is to grow my farm business as much as I can	❑1	❑2	❑3	❑4	❑5
b) I prefer to have a farm size that I can manage myself without help	❑1	❑2	❑3	❑4	❑5
c) My goal is to maximise farm profit	❑1	❑2	❑3	❑4	❑5
d) I am an entrepreneur and will start a business given opportunities	❑1	❑2	❑3	❑4	❑5
e) I enjoy being independent	❑1	❑2	❑3	❑4	❑5
f) I am ready to take significant risks if the possible rewards are high	❑1	❑2	❑3	❑4	❑5
g) My highest goal is to pass on the farm business to the next generation	❑1	❑2	❑3	❑4	❑5

SECTION 7: FARM BUSINESS CHARACTERISTICS

Please kindly **tick** ✓ the boxes that apply in the following questions.

7.1 Predominant farm type

- Cereals ❑1
- General cropping ❑2
- Horticulture ❑3
- Speciality Pigs ❑4
- Speciality poultry ❑5
- Grazing livestock (LFA) ❑6
- Grazing livestock (lowland) ❑7
- Dairy ❑8
- Mixed ❑9
- Other (please specify) ____________

7.2 Total farm area (ha)

- Under 5 ha ❑1
- 5 – 20 ha ❑2
- 20 – 50 ha ❑3
- 50 - 100 ha ❑4
- 100 and above ❑5

7.3 Structure of the farm business

- Sole proprietorship ❑1
- Family partnership (e.g. father & son) ❑2
- Partnership with non family ❑3
- Limited Company ❑4
- Co-operative ❑5
- Other (specify) ❑6

7.4 Tenure

- Wholly tenanted ❑1
- Mainly tenanted ❑2
- Mainly owned ❑3
- Wholly owned ❑4

7.5 Annual value of total sales of agricultural products in 2009

- Under £50 000 ❑1
- £50 000 - £99 999 ❑2
- £100 000 - £499 999 ❑3
- £500 000 and over ❑4

7.6 Share of family income from agriculture in 2009

- Under 25% ❑1
- 25 – 49% ❑2
- 50 – 74% ❑3
- 75% and over ❑4

7.7 Farm made a loss or a profit over past 5 years?

Significant profit.......................... ❑1
Moderate profit.......................... ❑2
Break even .... ❑3
Moderate loss............................. ❑4
Significant loss .... ❑5

7.8 New activities within the farm in the past five years

Please **tick ✓ each (a - f)** of the following statements

	Yes	*No*
(a) Energy crops/ Renewable energy..................	❑1	❑2
(b) Accommodation or catering	❑1	❑2
(c) Agricultural contracting..................................	❑1	❑2
(d) Non-agricultural contracting	❑1	❑2
(e) Food preparation and packaging	❑1	❑2
(f) Others (please specify) _________________		

7.9 In comparison to your conventional farming activities, what proportion of your total income was derived from these other activities within the farm in 2009? ____________ %

7.10 Do you have/manage any other additional businesses out of agriculture? (Please write number)________

7.11 In comparison to your conventional farming activities, what proportion of your total income was derived from these other business activities out of agriculture in 2009? ____________ %

SECTION 8: FARMER CHARACTERISTICS

Please **tick ✓** the appropriate boxes in the following questions.

8.1 Are you male or female? Male ❑1 Female ❑2

8.2 Please indicate your age
Less than 35.................... ❑1
35 – 44 years ....❑2
45 – 54 years .... ❑3
55 – 64 years .... ❑4
65 years and over...........❑5

8.3 Years of experience in agriculture
Under 5 years..................❑1
5 – 14 years.....................❑2
15 – 24 years...................❑3
25 years and over...........❑4

8.4 Education attainment
Below secondary.....................❑1
Secondary.................................❑2
University degree....................❑3
Post University degree...........❑4
Not undertaken formal study❑5

8.5 Have you undergone training in any of these areas?
Agriculture...................... ❑1
Management.................. ❑2
Finance........................... ❑3
Marketing....................... ❑4
Other subject _________

Thank you very much for your time and help.

Now please kindly return the completed questionnaire to me by March 14, 2011 in the enclosed envelope to:

Aurelian Mbzibain
University of Wolverhampton Business School
City Campus North, Room MN005, Nursery Street
Wolverhampton. WV1 1AD

Market orientation and firm performance across value disciplines in the Illinois beef sector

ERIC T. MICHEELS[1] and HAMISH R. GOW[2]

ABSTRACT

Previous research studies have suggested market oriented firms achieve superior performance relative to their peers (Narver and Slater, 1990). Furthermore, researchers have suggested that firms that can clearly define their value discipline will also benefit. Recent studies have shown that highly market oriented and innovative firms are able to define more clearly their chosen value discipline. This study extends that research by examining firm performance across value disciplines. Using a sample of Illinois beef producers, we find that levels of market orientation and performance are not equal across value disciplines. Our results show the level of market orientation is lowest for firms with an operational excellence value discipline and highest for a customer intimacy/product leadership value discipline. Furthermore, our findings show that firms with high market orientation scores outperform firms with low market orientation scores regardless of degree of value discipline clarity.

KEYWORDS: Firm performance; market orientation; value chain; value discipline clarity

1. Introduction

Agricultural producers continually strive to improve performance. Farmers can improve performance through a combination of improved yields, lower costs of production or through higher marketing returns. Efficiency gains and increased yields may be a product of superior managerial ability, the control of more productive assets or by superior awareness of new technologies, which may put the firm at an advantage as other firms may be behind on the learning curve. Looking at profitability from the revenue side of the equation, superior performance may be a result of the firm's ability to sell their production at the higher prices or by their ability to provide products that more precisely meet the needs of the market. Buyers and consumers may reward firms that are able to more precisely meet their needs on a consistent basis, recognizing that needs are dynamic (Ravald and Gronroos, 1996).

Barbieri and Mshenga (2008) suggest that farmers can improve farm-gate receipts by selling value-added products. However, in order to succeed in the value-added marketplace, firms will need to be able to provide greater value than their rivals. Therefore, firms must be able to determine what the market values and how they can deliver products that provide more value than their rivals (Treacy and Wiersema, 1993). For this study, we are interested in the prevalence of clearly defined value disciplines in agriculture and if performance varies across value disciplines. Specifically, this study will examine the differences in market orientation and firm performance across several value disciplines within a sample of Illinois beef farms.

2. Literature Review

Factors affecting firm performance

Several literatures have examined the specific factors that contribute to superior performance. The agricultural economics literature has suggested that managerial ability has been shown to increase farm growth (Patrick and Eisgruber (1968) and farm performance (Ford and Shonkwiler, 1994). Recently, researchers have suggested improved performance of agricultural firms is driven by strategic management (Hansson, 2007), awareness of opportunities (Gow et al., 2003), superior financial management (Harrison, 2006; Purdy et al., 1997), firm size and rate of production (Gloy et al., 2002) increased asset turnover (Langemeier, 2010) and production type (Benson, 2008).

Evidence form the marketing literature also may shed some light on performance differences across agricultural firms. A market orientation is an organizational culture that focuses resources on the generation and dissemination of market intelligence in the search for products that deliver superior value to the market (Jaworski and Kohli, 1993). Empirical studies have shown market oriented firms are able to achieve superior performance relative to their peers (e.g. Kirca

[1] Department of Bioresource Policy, Business & Economics, University of Saskatchewan, Canada. Email: eric.micheels@usask.ca
[2] School of Economics and Finance, College of Business, Massey University, New Zealand. Email: h.r.gow@massey.ac.nz

et al., 2005; Menguc et al., 2007). While a production orientation may be dominant in agricultural contexts, recent research studies have shown that a market orientation also contributes to superior performance within the agri-food sector (Grunert et al., 2005; Johnson et al., 2009).

Superior business performance has also been shown to be achievable if the firm's market focus is distinctive, measureable and sustainable (Anderson et al., 2006). Jaworski and Kohli (1993) posit that highly market orientated firms are able to more easily discover opportunity gaps and consequently are able to provide innovative solutions that deliver superior value to consumers more rapidly than their competitors do. Furthermore, Narver et al. (1998) suggests that market oriented firms are able to define specifically how they provide value to the market. By focusing on a specific means of value provision, and a singular customer segment (Treacy and Wiersema, 1993), market oriented firms may be able to provide products that deliver exceptional value to their consumers more efficiently and effectively than other firms in the industry can.

Innovative agricultural producers may discover new methods to improve farm performance utilizing a combination of the strategies outlined in the agricultural economics and marketing literatures. Producers may find that superior managerial ability in combination with increased market awareness and a focus on a specific value discipline, may deliver performance benefits that exceed a simple linear combination of the various schools of thought. This research study leverages previous work from the agricultural economics, strategy and marketing literatures by examining performance differences across value disciplines within the context of the Illinois beef industry. While scholars have advanced the discussion of value disciplines (e.g. Treacy and Wiersema, 1993; Narver et al., 1998), currently no empirical study to date has attempted to examine the level of market orientation or firm performance of firms *across* value discipline strategies. Using survey data from Illinois beef producers, we examine 1) the choice of value discipline and 2) differences in market orientation and performance across value discipline choice. This study fills an important gap in the literature by examining how market orientation and value discipline choice influences performance within an agricultural context.

Value disciplines

The concept of value disciplines developed was first developed by Treacy and Wiersema (1993) and has been used in empirical studies to explain aspects of firm performance (for example, see Bick, Brown and Abratt, 2004). Value disciplines can be thought of as specific strategies that firms can employ which allow them to be more efficient at providing value to customers in a specific manner. The three value disciplines developed by Treacy and Wiersema (1993) are operational excellence, product leadership and customer intimacy.[3] Firms within a specific value discipline will have different operating and reporting structures that allow them to discover products that provide value in different ways to different buyer segments.

Specifically, firms with an *operational excellence* value discipline try to develop products that have low costs of acquisition and ownership. Firms that develop a *customer intimacy* value discipline provide value by delivering products to the market that meet a specific need while also building long-term relationships with buyers and customers. *Product leadership* firms focus on delivering value through innovativeness and by being the first to market or adopt a new technology.

Value delivery in agriculture

Agricultural firms employ a variety of strategies to provide superior value to their customers. Generic strategies for creating value revolve around the firm becoming either the low-cost producer or a provider of a differentiated product (Porter, 1985). Within the agri-food sector, the first input of the value chain is often an undifferentiated product (e.g. corn, soybeans, beef and pork) which may make product differentiation more difficult. Therefore, in highly competitive markets such as agricultural commodities, many firms attempt to be the 'low-cost' producer as managers are unable to influence the prices they receive. This leads the manager to focus internally toward reducing costs and improving efficiency in order to improve farm performance (Smyth et al., 2009). The allocation of resources towards efficiency effectively reduces the amount of resources (e.g. time) that the manager can direct to becoming more aware of consumers and changing market conditions. Whether by choice or by default, these firms are operating under an operational efficiency value discipline.

More recently, entrepreneurial commodity producers have begun to form differentiated value chains (e.g., alliances, direct marketing) that offer additional product and service attributes in an attempt to increase the value of production. An example within the context of the U.S. beef industry would be the shift to vertically coordinated production alliances. Since the 1990s, the amount of beef produced through production alliances has steadily increased (Drovers, 2008; Lamb and Beshear, 1998). Entrepreneurial beef producers form alliances to take advantage of valuable information and to leverage this information to provide a differentiable product to consumers (Schroeder and Kovanda, 2003). As providers of differentiated – and often branded – products, alliance producers have benefited from premium prices over the commodity offering. By moving away from commodity production, these entrepreneurial firms are also moving away from an operational efficiency value discipline. Some of the first movers and innovators may be operating under a product leadership value discipline (e.g. Power Genetics; Ishmael, 2008) while firms that focus on relationship development may be operating under a customer intimacy value discipline (e.g. direct marketers).

Even though entrepreneurial firms are beginning to respond to heterogeneous consumers by producing less homogeneous products, for many producers, eschewing the status quo is no guarantee of success. That is, in order to achieve and sustain success, firms must be able to express *how* they provide value to customers, and how this

[3] There may be other value disciplines, but the value disciplines developed by Treacy and Wiersema (1993) are the most cited in the literature.

method of provision is different from competitor offerings. Anderson and Narus (1998) suggest that in order to understand what customer's value, one must first understand the customer. That is, the value creation process begins from the consumer's perspective and continues upstream to the producers of the raw materials used in the manufacture of the product or service offering. It is important that firms are cognizant of the fact that customers are heterogeneous; consequently, the value disciplines of some firms will be incompatible with the value model of certain consumers. Heterogeneity might occur both across consumers and across products. In certain instances, consumers may wish to purchase a low-cost, low-fail product while in other situations a product more specifically tailored to the consumer would provide additional value. For instance, commodity ground beef might be preferred when preparing a meal during the week but branded steaks might be preferred when entertaining guests on the weekend. Within this framework, firms may be able to create value more efficiently through a demand-pull system where production occurs specifically to meet demand as opposed to a supply-push system where firms use minimum grades and standards to sort production to meet existing demand.

Aside from becoming more efficient in the allocation of resources, firms that use a market orientation to develop a clear value discipline may also become more effective marketers of their production. An increased awareness of the market, combined with an appropriate internal organization, may allow market oriented firms to develop a distinct value discipline that enables the firm to achieve higher prices or greater access to markets than before. Further, by specializing in one value discipline per product category or brand, market oriented firms may be able to increase the probability that their product creates superior value for the customer when compared to products of rival firms. This, in turn, may allow the firm to become more competitive in pricing the differentiated product. Firms without a clear value discipline may find themselves 'stuck in the middle' with average or even below average returns (Porter, 1985). Firms that are stuck in the middle may have higher costs of production relative to operationally excellent firms or may have similar products but higher prices relative to product leaders or customer intimacy firms.

3. Theoretical foundations and testable hypotheses

Porter (1985) discusses several generic strategies firms deploy within competitive markets, namely cost leadership and differentiation. Firms may also combine a focus strategy with either cost leadership or differentiation to "narrow the competitive scope within an industry" (Porter 1985, p. 15). By focusing on a specific group of consumers, firms may be better able to gather pertinent information and thus tailor products to a specific market. In the language of Day (1994), through a focus strategy the firm may be better positioned to establish (and protect from erosion by competitors) channel bonds and customer linkages. Customer value and satisfaction would increase when firms are able to focus on the specific measures that contribute to the value proposition of consumers. Furthermore, by focusing on developing one specific value discipline, market oriented firms would be able to deploy scarce resources more efficiently in the development of the capabilities needed for success.

A market orientation takes both an internal and external view of the firm (Narver and Slater, 1990). The external focus rooted in a market orientation emphasizes factors occurring outside the boundaries of the firm such as changes in customer needs and competitor actions. Conversely, the internal component of a market orientation examines the firm's motivation and capability to provide appropriate solutions to meet the needs of the market. White (1986) labelled the external processes the corporate strategy problem (i.e. 'where should we compete?') and the internal processes the business strategy problem (i.e. 'how do we compete?'). The order in which firms answer these questions is dependent on whether the firm is choosing a market dependent on its current capabilities or choosing to build capabilities needed to compete in a specific market (Homburg et al., 2004). The bifurcated characterization of a market orientation supports the suggestion by Chen (1996) that for behaviour to change, the firm must be aware of a need to change, be motivated to change and be capable of change. Market oriented firms may find themselves moving away from the status quo to develop a strategy that allows the firm to succeed within their specific market by developing systems and processes to gather information on customer needs and to utilize the knowledge gained from superior information into exploitable opportunities to meet these needs.

A market orientation would also lead to a clearer focus on value provision. By becoming more aware of customer needs and competitor offerings, firms can better position themselves to take advantage when opportunities present themselves. Narver et al. (1998) suggest that market oriented firms are able to more clearly articulate their value discipline, that is, they are more likely to operate along the boundary of the value triangle (Figure 1). Research studies have shown that a market orientation is associated with both low-cost and differentiation strategies (Slater and Narver, 1996), while Menguc et al. (2007) find a market orientation leads to the implementation of innovation and marketing strategies, but find no evidence suggesting a market orientation leads to the implementation of a low-cost strategy.

H1: Firms with a 'pure' value discipline are more market oriented than those in the middle of the value triangle.
H1a: Operationally excellent firms have lower market orientation scores than customer intimacy firms.
H1b: Operationally excellent firms have lower market orientation scores than product leadership firms.
H2: Firms with a 'hybrid' value discipline are more market oriented than those in the middle of the value triangle.

Success within a particular value discipline may depend on several factors including the amount and intensity of competition. Some firms may choose to adjust their value discipline to take advantage of emerging markets or to avoid competing in highly competitive markets (Kim and Mauborgne, 2005). While alertness enables firms to adopt more rapidly the required cultural and behavioural changes needed to

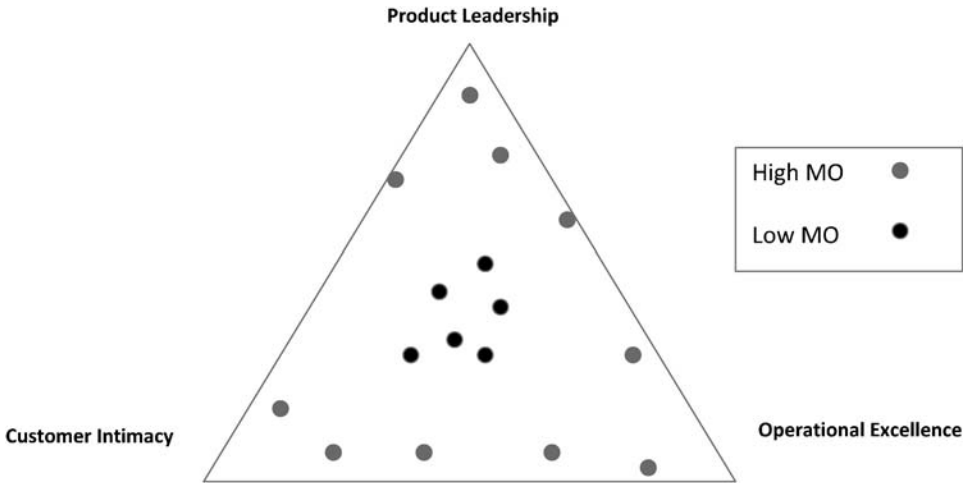

Figure 1: Hypothesized relationship between market orientation (MO) and the value triangle

be successful, moving to a new value discipline requires firms to be cognizant of consumer demands within a particular value discipline as well as their own capabilities. Following Chen (1996), firms may choose a value discipline based on the market orientation of the firm (awareness), the ability to achieve superior performance and potential competitive advantages (motivation) and the ability of the firm to develop and maintain that position (capability). Conversely, firms may develop strategies based on their current capabilities. The development of the vital capabilities within each value discipline may occur at varying rates across firms.

Firms with a clearly defined value discipline and the time to develop the appropriate capabilities may exhibit a 'pure' value discipline, exemplified by a position at or near one of the corners of the value triangle (Figure 2). Other firms may see an opportunity to provide value based on a 'hybrid' of two value disciplines, such as low-cost product leadership (fast second movers), or efficient customer relationship building (production alliances in the beef industry). A hybrid strategy could result from the firm moving from one value discipline to another, or it could be the manifestation of the actual strategic choice of the firm. Firms with a hybrid value discipline position themselves on the value triangle based on the level of importance they place on two competing value disciplines. Firms that lack a clearly defined value discipline may find themselves clustered in the middle of the value triangle.

H3: Firms with a 'pure' value discipline have higher performance than those in the middle of the value triangle.
H4: Firms with a 'hybrid' value discipline have higher performance than those in the middle of the value triangle.

4. Methodology

Data

We used a mailing list from the Illinois Beef Association containing the names and addresses of 1,568 beef producers located across the state. Respondents returned 343 usable surveys over two waves of surveying during May and November 2007, resulting in a response rate of 22.1%. For the purposes of this study, we limited

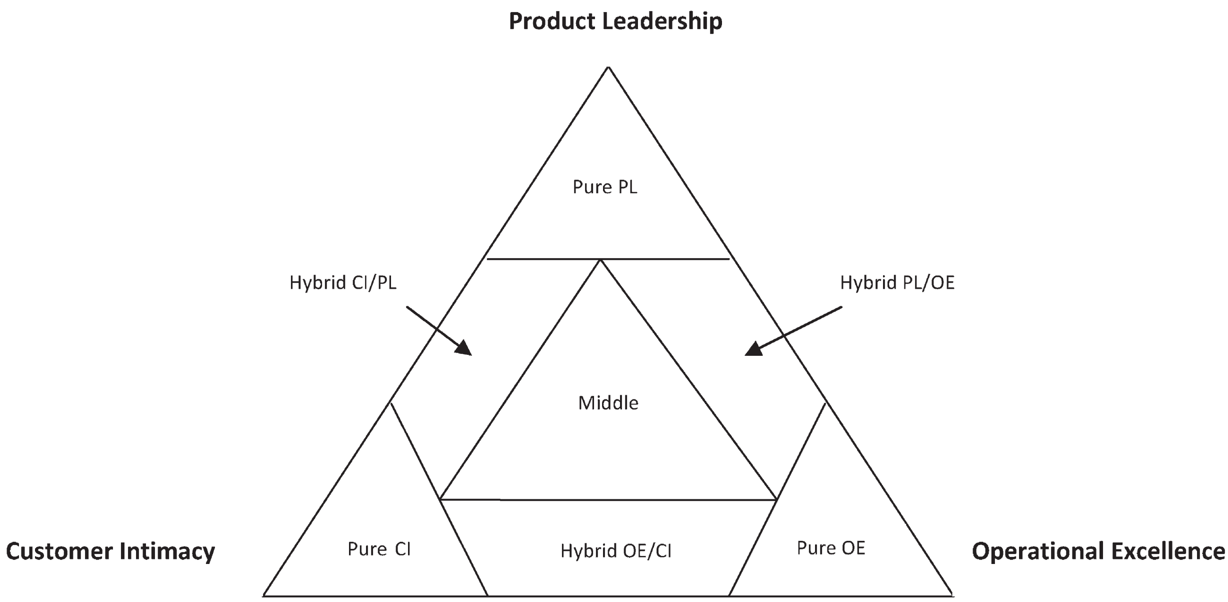

Figure 2: Stylized Strategic Choices within the Value Triangle

Table 1: Descriptive statistics of survey respondents

	Mean	Number	Percentage
Herd Size	225.91		
0–50		115	36.6
51–100		69	22.0
101–150		43	13.7
151–200		27	8.6
200 +		60	19.1
Corn Hectares[a]	215.38		
0–50.00		110	35
50.01–100.00		40	12.7
100.01–150.00		32	10.2
150.01 – 200.00		29	9.2
200.01		100	31.8
Experience (years)	32.41		
0–10		35	11.1
11–20		53	16.9
21–30		75	23.9
30 +		151	48.1

[a]n=311 as 3 respondents did not enter information on corn hectares.

analysis to firms with greater than 10 head to limit the influence of lifestyle farms or youth projects. After imposing this cut-off, 314 data points remained for analysis. Survey respondents were active in both the cow-calf and feedlot segments of the production channel with an average of 77 calves raised and 495 head of cattle fed out in each respective group.[4] Respondents had, on average, 32 years of experience.

We would classify the respondents as specialized beef producers judging by the average herd size and experience in raising beef on their farm (Table 1). While a plurality of respondents produce and market fewer than 50 head of cattle per year, over 41 per cent produce and market over 100 head of cattle per year. Furthermore, the majority of survey respondents grow fewer than 500 acres of corn. In addition, a clear majority of respondents have been producing beef on their farm for more than 20 years.

Common method variance and non-response bias

The use of single informants may introduce some bias due to 'halo effects,' which occur when indicators measuring dependent constructs are biased by the independent variables. However, we could not eliminate this bias through changes in sampling methodology, as agricultural firms are owner/manager operations where the person who determines the allocation of productive resources is often the same person that determines the level of satisfaction with financial performance. We checked for single method bias ex ante using Harmon's single factor test where we combined all variables in the analysis into a single factor and conducted a confirmatory factor analysis. Single informant bias is present when a single factor accounts for a significant amount of explained variance. Upon examination, the combined factor analysis resulted in seven factors with eigenvalues greater than 1.0, which accounted for 65.10% of the variance. The largest factor accounted for only 27.20% of the explained variance, therefore single informant bias is unlikely to be an issue with our data. We also tested for non-response bias using the procedures outlined in Armstrong and Overton (1977). As late respondents display similar characteristics to non-respondents, we tested for differences between early and late respondents in each wave of the survey. We did not observe any significant differences between early and late respondents suggesting non-response bias may not be an issue with the data.

Measurement Scales

We used previously tested and validated scales to assess the respondents' level of market orientation and self-identified performance. The measurement items asked respondents to rate their level of agreement with each item using a 6-point likert scale anchored with strongly disagree and strongly agree. We used the MKTOR scale developed by Narver and Slater (1990) to measure market orientation as it has shown consistent reliability across sample contexts (Farrell and Oczkowski, 1997). We measured the self-identified performance using a scale developed by Jaworski and Kohli (1993) along with several new items. The actual items used to measure market orientation and self-identified performance can be seen in Table 2. While objective performance measures would be preferred, researchers have shown self-identified performance to be highly correlated with objective performance measures (Dess and Robinson, 1984; Venkatraman and Remanujam, 1987). This is important as our sample is comprised of owner-managers of privately held firms who are generally unwilling to share personal financial information.

We used principal component factor analysis to arrive at measures for market orientation and subjective performance of the respondents. We retained measurement factors according to the criteria that they 1) possessed eigenvalues greater than one, and 2) when multiple factors were present, we retained only the three highest factors. Following the analysis, we observed three factors for the 15-item market orientation scale. The three factors corresponded to the components of a market orientation: customer focus, competitor focus and inter-functional coordination. Average variance extracted for each market orientation component is over 50%, indicating the scale accounts for more explained variance than random error. The seven-item performance scale reduced to two factors, measuring individual and comparative performance. These two factors accounted for 68.9% of the variation of the scale. Finally, we summed factor scores of market orientation and subjective performance for use in the subsequent analysis.

We measured the firm's choice of value discipline was measured using a scale developed by Micheels and Gow (2009).[5] In the survey, respondents allocated points to phrases that represented the various value disciplines across pricing, production, relationship building and quality (see Appendix).[6] We operationalize the choice of value discipline using a ternary plot where the combina-

[4] Some producers operate in both segments. Averages were taken from firms who feed out at least 50 head of cattle and who raise at least 20 calves.

[5] Detailed statistical properties of the scale are available in Micheels and Gow (2009).

[6] Customer intimacy score was the average score from Pricing S1, Production S2, Relationships S1, and Quality S1. Product leadership was the average score from Pricing S2, Production S1, Relationships S3, and Quality S3. Operational excellence was the average score from Pricing S3, Production S3, Relationships S2, and Quality S2.

Table 2: Reliability and Validity for Market Orientation and Firm Performance Scales

	Alpha	Variance Extracted	Factor Loadings	Corrected Item-to-total correlation
CUSTOMER ORIENTATION	0.744	57.63%		
We continuously try to discover additional needs of our customers of which they are unaware.			0.846	0.634
We incorporate solutions to unarticulated customer needs in our new products and services.			0.826	0.614
We innovate even at the risk of making our previous farming practices obsolete.			0.527	0.332
We work closely with lead customers to try to recognize their needs months or even years before the majority of the market may recognize them.			0.794	0.580
COORDINATION	0.753	57.57%		
We regularly visit our current and prospective customers.			0.718	0.503
We freely discuss our successful and unsuccessful customer experiences with our partners.			0.725	0.509
All of our business units (marketing**, production, research, finance and** accounting) are integrated in serving the needs of our target markets.			0.817	0.616
People on our farm understand how everyone can contribute to creating customer value.			0.772	0.557
COMPETITOR ORIENTATION	0.846	52.44%		
Employees on our farm share information concerning competitor's activities.			0.656	0.536
We regularly discuss competitor's strengths and weaknesses.			0.660	0.543
We target customers where we have an opportunity for competitive advantage.			0.615	0.494
Members of our farm collect information concerning competitor's activities.			0.758	0.643
We diagnose competitor's goals.			0.802	0.699
We identify the areas where key competitors have succeeded or failed.			0.758	0.633
We evaluate the strengths and weaknesses of key competitors.			0.797	0.679
OVERALL FIRM PERFORMANCE	0.834	68.98%		
The return on farm assets did not meet expectations last year*			0.819	0.637
We were very satisfied with the overall performance of the farm last year.			0.827	0.688
The return on production investments met expectations last year.			0.849	0.753
The cash flow situation of the farm was not satisfactory.*			0.779	0.553
The return on marketing investments met expectations last year.			0.712	0.657
The prices we receive for our product is higher than that of our competitors.			0.863	0.285
The overall performance of the farm last year exceeded that of our major competitors.			0.802	0.524

*Items were reverse coded.

tion of three components must equal 100. The new scale allows for the positioning of the farm onto a value triangle using an Excel program developed by Graham and Midgley (2000). Figure 3 shows the choice of value disciplines of survey respondents.

Classification into value disciplines

We categorized firms into stylized value disciplines based on their positioning within the value triangle. We placed firms who scored greater than or equal to 70 on any value discipline into the 'pure' form of that specific value discipline. Firms with a score of less than or equal to 15 on a singular value discipline, while simultaneously having a score less than 70 in the remaining value disciplines, were assigned a 'hybrid' value discipline. We categorized firms that expressed no clear value discipline as being 'stuck in the middle.'

5. Results

We used the Tukey-Kramer test to examine differences in market orientation and firm performance across value disciplines, as this test is robust when sample sizes across groups are unequal. The results of this study presented in Table 3 show levels of market orientation and performance across value discipline strategies. An examination of the results suggests that the data fail to show a clear pattern of market orientation and the degree of value discipline clarity leading us to reject hypotheses H1 and H2. Some interesting results do emerge, however. Market orientated firms choose not to operate within a pure operational excellence value discipline (or conversely that operationally excellent firms are not market oriented). Furthermore, firms operating with a hybrid value discipline that includes a significant portion of operational excellence character-

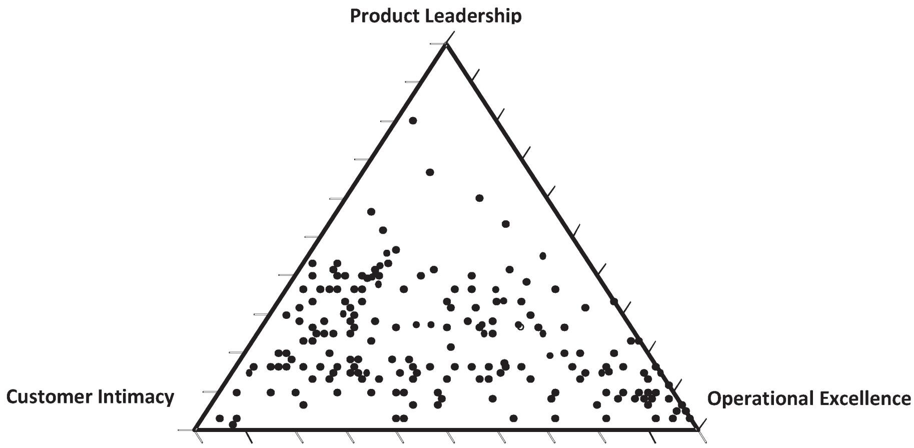

Figure 3: The Value Disciplines of Illinois Beef Producers

Table 3: Market orientation and subjective performance across value disciplines

Value Discipline	Market Orientation	Performance	N
Pure CI	0.7804^{A} (0.4210)	0.3122 (0.2915)	23
Pure OE	-2.3357^{ABD} (0.3616)	-0.5008^{E} (0.2005)	56
Hybrid OE/CI	-0.6538^{BC} (0.4719)	−0.2568 (0.2537)	32
Hybrid PL/OE	0.3031 (1.1208)	0.9250 (0.6570)	6
Hybrid CI/PL	1.5763^{C} (0.3245)	0.4340 (0.2203)	34
Middle	0.4691^{D} (0.1648)	0.0433^{E} (0.1063)	162

Note: Table displays scale mean (standard error in parentheses). No Pure PL strategy is analyzed as there was only one firm employing this strategy. Means sharing superscripts are significantly different from each other (Tukey-Kramer, $p < 0.05$).

istics have lower levels of market orientation than do firms without an operational excellence component. These results support hypothesis 1a. The low number of firms operating within a Pure PL value discipline does not allow us to answer hypothesis 1b. Results also show firms with a customer intimacy/product leadership value discipline have a significantly higher market orientation than firms utilizing an operational excellence value discipline. These results corroborate the findings of Menguc et al. (2007), who find a market orientation contributes to innovation or customer-based strategies, but does not lead to cost leadership strategies.

The results show firms within the operational excellence value discipline achieve significantly lower performance than firms operating in the middle of the value triangle. We are unable to observe any other statistically significant differences in subjective performance across value disciplines; therefore, we must reject hypotheses H3 and H4. Nevertheless, this is a surprising result given the theoretical arguments brought forward by Porter (1985) and Treacy and Wiersema (1993). However, when considering that firms within an operational excellence value discipline also have the lowest market orientation, the performance result is less surprising given the multitude of research studies linking market orientation and performance (Johnson et al., 2009; Narver and Slater, 1990).

While the above results do not show many significant differences in performance across value discipline strategies, we can observe a relationship between market orientation and performance. Our findings do show the value discipline choice with the lowest market orientation corresponds with the value discipline choice with the lowest level of performance. These levels are significantly different from other value discipline strategies. Operationally excellent firms have the lowest levels of performance and this is significantly different from those firms operating in the middle of the value triangle. Issues with the size of value discipline subsamples may have limited the significance of differences between OE firms with other value disciplines.

To attempt to provide some more clarity to these results, and to mitigate the issues with the small size of some of the sub-samples, we conducted a similar analysis using only four sub-samples of market orientation and value discipline choice. To give us larger subsamples, we split firms at the median level of market orientation and broadly on value discipline clarity. We classified those firms with market orientation scores above the median as having a high market orientation and those firms below the median as having a low market orientation. We characterized firms operating in the middle of the value triangle as having an unclear value discipline while we categorized all others as possessing a clear choice of value discipline. Theory would suggest firms having a low level of market orientation in combination with a lack of clarity on value discipline would have poor performance. Conversely, a high degree of market orientation in combination with a clearly defined value discipline should lead to superior performance. The question remains, however, does less market oriented firm with a clearly defined value discipline outperform a highly market oriented firm that has not clearly defined their

Table 4: Performance matrix between market orientation and value discipline clarity.[a]

Level of Value Discipline Clarity	Level of Market Orientation	
	Low	High
Low Clarity (Middle)	−**0.4371**[AC] (0.1743) N=70	**0.4088**[AB] (0.1194) N=92
High Clarity (Edge)	−**0.5626**[BD] (0.1631) N=87	**0.6450**[CD] (0.1365) N=65

[a] Values are means of performance factor scores. Standard errors are in parentheses.
[b] Means sharing superscripts are significantly different from each other (Tukey-Kramer, $p < 0.05$).

value discipline? Table 4 displays the means of performance factor scores across a matrix of market orientation and degree of value discipline clarity.

These results indicate that highly market-oriented firms outperform firms with an underdeveloped market orientation, irrespective of the degree of value discipline clarity. While self-identified performance differed between firms depending on their level of market orientation, our results show that performance is not significantly different across level of value discipline clarity. This is an interesting result as it is contrary to the suggestion by Treacy and Wiersema (1993) that firms with clearly articulated value disciplines will outperform those that are not able to define the specific means by which they provide value to the market.

6. Discussion

Treacy and Wiersema (1993) have suggested that when a firm chooses a value discipline they are simultaneously choosing their customers. It is for this reason that Treacy and Wiersema (1993) and Porter (1985) have posited that the ability to define ones value discipline could lead to superior performance. Consequently, firms are encouraged to search for opportunities to provide value for consumers in a manner that is congruent with both their value proposition and current capabilities. A market orientation may enable firms to develop innovative methods to provide products and services to meet the changing needs of heterogeneous consumers.

Understanding the means of providing superior value is important in order for firms to achieve increased performance. However, a clear idea of the firm's value discipline may provide other benefits as well. Porter (1985) posits that firms which are 'stuck in the middle' for an extended time may eventually go out of business as the product they offer evolves to one that is inconsistent with customer needs. However, our results from a cross-section of Illinois beef producers show performance is driven more by market orientation rather than the magnitude of value discipline clarity. Contradictory to previous theory, market oriented firms with no clear value discipline have performance measures that are not statistically significantly different from firms with a clearly articulated value discipline. Another interesting result is the lack of a statistically significant difference in performance across hybrid value disciplines, especially considering observed differences in market orientation across hybrid forms. Further analysis with larger datasets may help clarify these results.

While this research is not able to show evidence of a market orientation-clarity-performance link, it does show clarity alone does not lead to superior performance. There are several interesting implications of this result. First, our results corroborate previous research studies by showing market orientation to be an important driver of firm performance, even within the context of production agriculture. Second, these results show value discipline clarity is not a prerequisite for superior performance. Our results show that firms with a clearly defined value discipline and low level of market orientation had the worst performance, although not significantly different from other firms with a low market orientation. Firms that merely choose a value discipline (or choose one by default) may not be satisfied with their performance as the choice of market in and of itself provides few sustainable competitive advantages. Sustainable competitive advantages may only accrue to those firms that are able to leverage a clear value discipline with the organizational structure to develop and deliver products that provide value in a manner consistent with the chosen value discipline. Therefore, a necessary condition for improved performance may be the presence of a market orientation, which allows firms to more fully understand the fundamental drivers of the customer's value proposition.

One limitation of this paper is the cross-sectional nature of the study. As we use survey data from only one year to analyse value discipline choice and firm performance, we are not able to determine how changes in market orientation and value discipline clarity affect self-identified performance. Longitudinal data would be preferred as this would allow researchers to track the value discipline and the market orientation of the firm and determine if it was consistent through time. It may be that superior performance accrues to firms with a consistent value discipline (as measured year-to-year) and increased variability in both the choice of value discipline and level of market orientation contributes to poor performance. This could potentially explain how firms supposedly 'stuck in the middle' are more highly market oriented than those with an operational excellence value discipline, and how firms in the middle of the value triangle have similar performance to firms with a pure customer intimacy value discipline.

7. Conclusions and Implications

The goal of this paper was to analyse market orientation and performance across value disciplines. Previous research studies have suggested that firms who have a clearly defined value discipline are able to achieve superior performance. Surprisingly, there has been little research examining the relationship between value discipline clarity and firm performance. Using survey data, we measure the market orientation, subjective performance, and choice of value discipline of Illinois beef producers. We used Tukey-Kramer tests of differences in means to examine differences in market orientation and performance across value disciplines.

Our findings indicate that the average level of market orientation is lower for firms with an operational excellence value discipline (both pure and hybrid forms) relative to other value disciplines. Furthermore, our results show that firms with a hybrid product leadership value discipline have higher performance measures than firms using an operational excellence value discipline. While this paper lends some credence to the market orientation-performance relationship, it does not provide clear answers to the value discipline clarity-performance link. However, our results do show that firms with higher levels of market orientation report greater satisfaction with their performance than firms with lower levels of market orientation. Our results would suggest that firms should first work on improving their market orientation and then leverage their market awareness to develop a clearly defined value discipline.

Within the context of the Illinois beef industry, our findings show the magnitude of market orientation within firms is a more important determinant of firm performance than value discipline clarity. Future research will elucidate these results by conducting similar studies across a variety of industrial and cultural contexts. Additionally, future research could examine the market orientation-clarity-performance question in a longitudinal study to assess how consistency of market orientation and consistency of choice of value discipline contributes to firm performance.

About the authors

Eric Micheels leverages his farm background and professional experience to conduct research on issues facing agribusiness firms and farms. His research has been published in the International Food and Agribusiness Management Review, Agribusiness: an International Journal, and the Journal of Farm Managers and Rural Appraisers. Eric began as an Assistant Professor at the University of Saskatchewan on July 1, 2011.

Hamish R. Gow is a Professor at Massey University and serves as the Director of the Center for Agribusiness Policy and Strategy (CAPS) in the College of Business. Hamish is a globally recognized expert in the fields of agribusiness management, international marketing, value chain development, food systems governance, innovation and entrepreneurship, and international rural development.

Acknowledgements

The authors would like to thank Bill Brown along with the editor and two anonymous reviewers for suggestions to improve the manuscript. Any remaining errors are ours.

REFERENCES

Anderson, J.C., J.A. Narus and W. van Rossum, 2006. Customer Value Propositions in Business Markets. *Harvard Business Review*, 84(3), pp. 90–99.

Anderson, J.C. and J.A. Narus, 1998. Business Marketing: Understand what customers value. *Harvard Business Review*, 76(6), pp. 53–65.

Armstrong, J.S. and T.S. Overton, 1977. Estimating Nonresponse Bias in Mail Surveys. *Journal of Marketing Research,* 14(3), pp. 396–402.

Barbieri, C. and P.M. Mshenga, 2008. The Role of the Firm and Owner Characteristics on the Performance of Agritourism Farms. *Sociologia Ruralis*, 48(2), pp. 166–183.

Benson, G.A., 2008. Pasture-Based and Confinement Dairy Farming in the United States: An Assessment. *Journal of International Farm Management*, 4(2), pp. 1–16.

Bick, G., A.B. Brown and R. Abratt. 2004. Customer perceptions of the value delivered by retail banks in South Africa. *The International Journal of Bank Marketing*, 22(5), pp. 300–318.

Chen, M., 1996. Competitor Analysis and Interfirm Rivalry: Toward a Theoretical Integration. *Academy of Management Review,* 21(1), pp. 100–134.

Day, G., 1994. The Capabilities of Market-Driven Organizations. *Journal of Marketing,* 58(4), pp. 37–52.

Dess, G.G. and R.B. Robinson, Jr., 1984. Measuring Organizational Performance in the Absence of Objective Measures: The Case of the Privately-Held Firm and Conglomerate Business Unit. *Strategic Management Journal,* 5(3), pp. 265–273.

Drovers, 2008. *2008 Alliances*. March 16, 2008.

Farrell, M.A. and E. Oczkowski, 1997. An Analysis of the MKTOR and MARKOR Measures of Market Orientation: An Australian Perspective. *Marketing Bulletin*, 8(1), pp. 30–40

Ford, S.A. and J.S. Shonkwiler, 1994. The Effect of Managerial Ability on Farm Financial Success. *Agricultural and Resource Economics Review*, 23(2), pp. 150–157.

Gloy, B.A., J. Hyde and E.L. LaDue, 2002. Dairy Farm Management and Long-Term Farm Financial Performance. *Agricultural and Resource Economics Review*, 31(2), pp. 233–247.

Gow H.R., L.D. Oliver and N.G. Gow, 2003. Value Creation in Farmer-Driven Marketing Channels: The Case of Murrellen Pork. *Journal of Food Distribution Research*, 34(1), pp. 86–91.

Graham, D.J. and N.G. Midgley, 2000. Graphical Representation of Particle Shape Using Triangular Diagrams: An EXCEL Spreadsheet Method. *Earth Surface Processes and Landforms*, 25(13), pp. 1473–1477.

Grunert, K.G., L. Fruensgaard Jeppesen, K. Risom Jespersen, A.M. Sonne, K. Hansen, T. Trondsen and J.A. Young, 2005. Market orientation of value chains: A conceptual framework based on four case studies from the food industry. *European Journal of Marketing*, 39 (5/6), pp. 428–455.

Harrison, J.L., 2006. Financial Management and Dairy Farmer Satisfaction with Performance. *Journal of International Farm Management*, 3(4), pp. 1–18.

Hansson, H., 2007. Strategy factors as drivers and restraints on dairy farm performance: Evidence from Sweden. *Agricultural Systems*, 94(3), pp. 726–737

Homburg, C., H. Krohmer, and J.P. Workman, Jr., 2004. A Strategy Implementation Perspective of Market Orientation. *Journal of Business Research*, 57(12), pp. 1331–1340.

Ishmael, W., 2008. Market First. *Beef Magazine*, [online] Available at: <http://beefmagazine.com/genetics/breeding-systems/market_first/> [Accessed October 6, 2011].

Jaworski, B.J. and A.K. Kohli, 1993. Market Orientation: Antecedents and Consequences. *Journal of Marketing*, 57(3), pp. 53–70.

Johnson, A.J., C.C. Dibrell and E. Hansen, 2009. Market Orientation, Innovativeness, and Performance of Food Companies. *Journal of Agribusiness*, 27(1/2), pp. 85–106

Kim, W.C. and R. Mauborgne, 2005. Blue Ocean Strategy. Boston, MA. Harvard Business School Press.

Kirca, A.H., S. Jayachandran, and W.O. Bearden, 2005. Market Orientation: A Meta-Analytic Review and Assessment of Its Antecedents and Impact on Performance. *Journal of Marketing*, 69(2), pp. 24–41.

Lamb, R.L. and M. Beshear, 1998. From the Plains to the Plate: Can the Beef Industry Regain Market Share? *Economic Review.* Federal Reserve Bank of Kansas City. Third Quarter. Available at: http://www.kc.frb.org/publicat/ECONREV/PDF/4q98lamb.pdf.

Langemeier, M., 2010. Persistence in Financial Performance. *Journal of International Farm Management*, 5(2), pp. 1–15.

Menguc, B., S. Auh, and E. Shih, 2007. Transformational Leadership and Market Orientation: Implications for the Implementation of Competitive Strategies and Business Unit Performance. *Journal of Business Research*, 60(4), pp. 314–321.

Micheels, E.T. and H.R. Gow, 2009. Do Market Oriented Firms Demonstrate Clarity on Their Value Discipline: Evidence from Illinois Beef Producers. *International Food and Agribusiness Management Review*, 13(3), pp. 127–152.

Narver, J.C. and S.F. Slater, 1990. The Effect of a Market Orientation on Business Profitability. *Journal of Marketing*, 54(4), pp. 20–35.

Narver, J.C., S.F. Slater and B. Tietje, 1998. Creating a Market Orientation. *Journal of Market Focused Management*, 2(1), pp. 241–255.

Patrick, G.F. and L.M. Eisgruber, 1968. The Impact of Managerial Ability and Capital Structure on Growth of the Farm Firm. *American Journal of Agricultural Economics*, 50(3), pp. 491–506.

Porter, M.E., 1985. Competitive Advantage. New York: Free Press.

Purdy, B.M., M.R. Langemeier and A.M Featherstone, 1997. Financial Performance, Risk, and Specialization. *Journal of Agricultural and Applied Economics*, 29(1), pp. 149–161.

Ravald, A. and C. Gronroos, 1996. The value concept and relationship marketing. *European Journal of Marketing,* 30(2), pp. 19–30.

Schroeder, T.C. and J. Kovanda, 2003. Beef Alliances: Motivations, Extent, and Future Prospects. *Veterinary Clinics of North America Food Animal Practice*, 19(2), pp. 397–418.

Slater, S.F. and J.C. Narver, 1996. Competitive Strategy in the Market-Focused Business. *Journal of Market-Focused Management*, 1(2), pp. 159–174.

Smyth, P., A.M. Butler and T. Hennessy, 2009. Explaining the Variability in the Economic Performance of Irish Dairy Farmers 1998–2006. *Journal of International Farm Management*, 4(4), pp. 1–18.

Treacy, M. and F. Wiersema, 1993. Customer Intimacy and other Value Disciplines. *Harvard Business Review*, 71(1), pp. 84–93.

Venkatraman, N. and V. Ramanujam, 1987. Measurement of Business Economic Performance: An Examination of Method Convergence. *Journal of Management*, 13(1), pp. 109–122.

White, R.E., 1986. Generic Business Strategies, Organizational Context and Performance: An Empirical Investigation. *Strategic Management Journal*, 7(3), pp. 217–231.

Appendix: Value discipline scale

These questions relate to different strategies of your beef operation. Each item contains three descriptions of marketing strategies. Please distribute 100 points among the three descriptions depending on how similar the description is to your beef operation. There is no one right answer and please use all 100 points.	
Pricing	
We are able to set or negotiate above market prices for our cattle as we have established close relationships with our customers and fully understand their specific requirements.	
We are continuously developing or adopting new technology that provides us a short-term competitive market and price advantage.	
Due to being unable to influence current market prices, we strive to continually become more efficient in an effort to reduce costs.	
	100
Production	
We are continuously developing new and innovative technologies that provide our farm with product, production, or marketing advantages.	
We willingly modify production practices to meet our customers' specific product requirements, even if it increases our costs.	
We are seen as a leader in production efficiency by our neighbors and peers due to our continuous efforts to produce efficiency gains.	
	100
Relationship building	
We try to develop individual business relationships with each of our customers and attempt to produce products that meet each of their specific requirements.	
As producers and marketers of commodity beef through independent auctions, we are generally unaware of exactly who our customers and buyers are and see little value in establishing relationships with them.	
As we are recognized as a leader in innovation and early adoption of new beef production technologies, we are able to gain access to valuable customer markets and establish product differentiation.	
	100
Quality	
Through our close relationships with lead customers, we willingly adopt production practices, processes and certification systems to ensure our product meets customer specifications and supports their marketing brand.	
We only invest in meeting the minimum required level of certification and process control systems that are signaled through the pricing mechanism or mandated by regulatory agencies.	
Through the adoption and use of innovative technologies, we are able to screen and select animals while tracking them through the production process to ensure optimal final quality in the market.	
	100

CALL FOR PAPERS

International Journal of Agricultural Management (IJAM)

General

IJAM welcomes submission of articles of various types:

- Articles based on original research, submitted for peer-review (up to 6000 words);
- Reviews of 'state-of-the-art' of research in relevant arenas, again subject to peer-review (up to 6000 words);
- Reviews of 'state-of-the-art' in agricultural or related practice (up to 5000 words);
- Case Studies of innovative practice, including evaluation of results (up to 3000 words);
- 'Viewpoint' articles taking a particular standpoint on current issues, and encouraging response from readers (up to 1500 words);
- Professional updating pieces (e.g. in rural policy, market trends, managerial practice) (up to 3000 words);
- Book reviews (up to 1000 words).

Guidance for contributors can be found on the journal website at www.tinyurl.com/6cb3hmq

Themed issues

It is proposed to produce occasional special issues based on a particular theme relevant to agricultural management, the latter term including social, economic and environmental aspects of food production and rural development, but with a farm-level orientation. If you would be interested in being a Guest Editor for a themed issue of IJAM, please email the Editor at editor.ijam@gmail.com with an outline of your proposal. We would expect a Guest Editor to:

1. Identify potential authors who might be expected to write an article relevant to the theme, of the appropriate quality and rigour;
2. Invite those authors to contribute;
3. Identify reviewers with appropriate expertise for each paper;
4. Make judgements on inclusion of papers, in consultation with the IJAM editorial team.

The IJAM team would provide administrative support to minimise the workload on the Guest Editor. This might include, for instance, putting out a general call for contributions on the theme; communication with authors subsequent to submission, and with reviewers once identified.

Topic areas could include:

- business and commerce
- supply-chain management
- animal and crop husbandry
- farm diversification and pluriactivity
- governance, democracy, activism
- digital divides, alleviation of poverty
- internet-mediated co-operatives, joint ventures
- village and social enterprise
- crime
- health and rural services

Special Issue on Agricultural Marketing in a Globalized Economy

This issue will be edited by Dr. Sanzidur Rahman, a researcher in agricultural economics and development since the 1980s.

the term 'marketing' includes a wide range of issues and aspects related to market, such as:

- marketing channels
- marketing structures
- dimensions (e.g., wholesale, retail)
- futures markets
- spot markets
- export/import markets
- marketing efficiency
- price formation
- price discovery
- price transmission
- socio-economic as well as political issues/environment

Analytical procedures may encompass both quantitative and qualitative approaches depending on the requirement and justification provided for specific projects/papers.

Special Issue on internet and social media in agricultural management

This issue will be edited by Martyn Warren, a Board member of EFITA (The European Federation for Information Technology in Agriculture, Food and the Environment) and a researcher in this area since the 1990s.

The phrase 'internet and social media' is quite wide-ranging, including

- WWW, email, instant messaging
- Web 2.0
- social networking
- blogs
- mobile internet
- rural broadband
- interactive video games
- online television and radio
- voice-over-internet telephony
- virtual worlds
- interactive community radio
- converging technologies

Prospective authors are invited to submit an abstract to Dr Sanzidur Rahman or Martyn Warren via editor. ijam@gmail.com

CONFERENCE PAPER

Farm scale trials of variable rate irrigation to assess the benefits of modifying existing sprinkler systems for precision applicationr

CAROLYN HEDLEY[1], STU BRADBURY[2], ERIC WATSON[3], HEW DALRYMPLE[4] and JOHN WRIGHT[5]

ABSTRACT

Farm-scale trials are being conducted to assess the benefits of variable rate irrigation (VRI). Three farms have been selected where existing sprinkler irrigation systems have recently been modified to provide variable rate control of each individual sprinkler. Irrigation is being varied according to soil and crop differences, and is also being shut off over exclusion zones, such as drains and raceways, and for farm operations such as pasture renovation.

Under each VRI irrigator, soil variability has been quantitatively assessed using a mobile soil mapping system, which consists of an electromagnetic (EM) sensor pulled behind an all-terrain vehicle, with an on-board accurate RTK-GPS, datalogger and field computer. The EM sensor measures soil apparent electrical conductivity (EC), and the resulting soil EC maps were ground-truthed and used to define irrigation management zones. Soil moisture sensors have been installed into each zone to monitor real-time soil moisture status. This information is then used for variable rate irrigation scheduling.

Trial plots have been established in each zone at each site to compare a blanket uniform rate of irrigation to all zones with variable rates of irrigation fine-tuned to zone differences.

A goal of this research is to assess irrigation water use efficiency of a VRI system, as well as to develop a precision irrigation system with capability for full automation.

This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

KEYWORDS: variable rate; precision irrigation; soil water

1. Introduction

Irrigation plays an important role in agricultural productivity and is a major contributor to the New Zealand economy. In 2002/03, irrigation was estimated to contribute around $920 million net GDP "at the farm gate", over and above that which would have been produced from the same land without irrigation. Since then, the area of irrigated agriculture and horticulture has increased by about 25 percent, from 480 000 hectares to around 600 000 hectares. A further 1.9 million hectares of land is capable of being irrigated (New Zealand MAF, 2010). The New Zealand Land and Water Forum have recently developed a strategy for effective national water management, which includes acknowledgement of the need to improve water use efficiency of existing systems (New Zealand Land and Water Forum, 2010).

The modification of existing sprinkler systems for variable rate irrigation (VRI) (Hedley et al., 2010a, 2010b) provides opportunity for improved irrigation water use efficiency; and commercial uptake of VRI in New Zealand over the last two years has enabled research to be conducted to assess environmental and cost benefits of variable rate irrigation.

A soil moisture map is used to vary irrigation according to soil differences. Soils under the irrigator are mapped with an EM (electromagnetic) sensor, which measures apparent soil electrical conductivity (EC), and quantifies soil variability on a basis of texture and moisture differences (Sudduth et al 2005). The EM map is then used to target soil sampling positions for

[1] Landcare Research
[2] Precision Irrigation
[3] Rangitata Holdings
[4] Waitatapia Station
[5] Wainono

assessing soil available moisture holding capacity (AWC) and a zone map is produced based on soil AWC differences. Our research is using wireless soil moisture sensor networks which transmit soil moisture data to a website where it can be accessed by farm staff and researchers. Customised software is then used to produce irrigation plan maps which are uploaded to an automated VRI system.

This paper presents results to date from three farms where existing lateral and centre pivot sprinkler irrigation systems have been modified for variable rate irrigation.

2. Methods

Site selection

Farm 1: Ashburton: 111 ha linear move sprinkler with VRI modification. Soils range from deep Wakanui silt loams at one end of the irrigator to Rakaia very stony sandy loams at the other end. The land use is mixed cropping, and this season beans, wheat, pakchoi, and either buckwheat or corn salad crops have been irrigated simultaneously under this system.

Farm 2: Fairlie: 170 ha centre pivot with VRI modification. Soils range from very stony Eyre soils to deep clayey Ayreburn soils. The land use is dairy farming.

Farm 3: Manawatu: 75 ha centre pivot with VRI modification. Soils are sandy and are variably influenced by a high and fluctuating water table, so that some areas of the field remain wet in Spring, whereas other zones dry out very rapidly and require frequent irrigation. The most droughty zones are prone to hydrophobicity problems (i.e. once dry they do not wet up easily).

Variable rate modification of the sprinkler irrigation systems

The irrigators have been modified to provide individual sprinkler control using wireless nodes installed on the boom, each node controlling four sprinklers individually (Bradbury, 2010). The sprinklers have been modified with a solenoid valve which pulses the sprinkler on and off. The nodes act as wireless repeaters along the length of the boom, with a GPS node at the far end, and a central controller at the other end. Digital irrigation plan maps are uploaded into the central controller which controls the action of each sprinkler so that irrigation can be varied by time and place, with a resolution of less than 10 metres (Bradbury, 2010).

EM mapping and identification of irrigation management zones

A Geonics electromagnetic EM38 sensor was used with on-board datalogger, RTK-DGPS and Trimble field computer on an all-terrain vehicle (ATV), for simultaneous collection of positional and topographically located apparent electrical conductivity EC (mS/m) data. The method is termed "on-the-go EM mapping" (Adamchuk et al 2004). The map was then used to select at least nine soil sampling positions to investigate the full range of soil EC values. At each position, intact soil cores were collected from three soil depths (0–0.2 m, 0.2–0.4 m and 0.4–0.6 m) to assess available water holding capacity (AWC), (Hedley and Yule, 2008). The sampling depth was selected to reflect the majority of the root zone from which water is extracted by plants. The results were used to define irrigation management zones, based on soil AWC differences. Soil moisture is being monitored in each zone.

Irrigation scheduling

Trial plots have been established under each VRI system to assess the benefits of variable rate irrigation scheduling. We are comparing uniform rate irrigation (URI) scheduling with VRI scheduling. URI schedules a uniform irrigation event to all zones when the most droughty soil zone required irrigation. In contrast, VRI schedules different amounts of irrigation to different irrigation management zones, based on soil water status and crop requirement. Irrigation schedules and yield are being monitored in the trial plot areas this season.

3. Results and Discussion

EM values reflect major soil differences at all three farms (Table 1). Therefore the EM maps were used to define different irrigation management zones (e.g. Figure 1). Soil available water-holding capacity (AWC) for each zone was measured, and we found two to three-fold differences in soil AWC between zones at each site (Table 1). This has implications for irrigation scheduling because it suggests that some zones will dry out faster than others and require irrigation earlier.

Some examples of how irrigation is being varied under each system are given in Table 2, and described below.

At the Ashburton site, irrigation is being varied for soil and crop differences (beans, wheat, pakchoi, buckwheat, corn salad) (Table 2). Irrigation commenced on 8 October for the beans and wheat crops, with 15 mm applied to the very stony to stony soils (Zone 1 and 2), and 10 mm to the less stony soils (Zone 3). As the soils continued to dry out the amount of irrigation applied to Zone 3 was increased to 30 mm, as it has the ability to retain and supply this amount of water without leakage. However irrigation was reduced to 20mm and 25mm to the more stony soils. This provided a saving of 15% water for this period of irrigation. The finer soils in Zone 4 were used for shallower rooting seed crops and therefore required less irrigation.

At the Fairlie farm, irrigation commenced in October, when soils in Zones 1 and 2 required irrigation, although soils in Zone 3 and 4 did not (Table 2). Therefore only 115 hectares of the 174 ha pivot area were irrigated in the first two weeks of irrigation, giving a 34% water saving during this period. Irrigation was delayed to Zone 3 because these finer textured soils were able to store and supply more water to the pasture than Zones 1 and 2. Irrigation was also delayed to Zone 4 which has impeded drainage. By December all zones were receiving a uniform rate of irrigation. However, a 60 mm rainfall event in early January restored the soil zones to Field Capacity, so that irrigation could be

Table 1: Soil characteristics under the three VRI irrigators

Site	Size (ha)	Soil description	Soil electrical conductivity (mS/m)	Available Water-holding Capacity (mm/root zone)
Farm 1 – Ashburton mixed cropping (on Alluvial terrace soils)				
Zone 1	23	Well drained, very stony sandy loam	1–13	67 mm/m
Zone 2	50	Well drained, stony sandy loam	13–53	85 mm/m
Zone 3	22	Mixed sandy loam/ silt loam	53–79	115 mm/m
Zone 4	17	Imperfectly drained silt loam	79–132	163 mm/m
Farm 2 – Fairlie dairy pasture (on Alluvial Fans and Terraces)				
Zone 1	33	Well drained, very stony, shallow	4–13	39 mm/60cm
Zone 2	82	Well drained, stony, shallow	13–28	103 mm/60cm
Zone 3	39	Poorly drained, deep clayey soil	16–28	118 mm/60cm
Zone 4	20	Impeded drainage, peaty topsoil, stony, shallow	24–55	66 mm/60cm
Farm 3 – Manawatu maize (on Sand Plain soils)				
Zone 1	29	Excessively drained, sand	2–5	73 mm/m
Zone 2	36	Well drained, sand	5–8	87 mm/m
Zone 3	6	Imperfectly drained, loamy sand	8–11	160 mm/m

halted and then recommenced in a staggered fashion again with Zone 1 and 2 being irrigated before Zones 3 and 4, providing further water savings. Also at this farm the VRI system is being used to shut off and vary irrigation to paddocks when pastures are renovated.

At the Manawatu site, irrigation commenced in December with Zone 1 requiring irrigation earlier than Zones 2 and 3. VRI is enabling irrigation to be reduced to wet, low lying areas (Zone 3) and to be shut off over drains. Zone 3 and the drains occupy 14% of the 76 ha irrigated field.

Yield is also being assessed in each trial plot at each site, and these data will be used to estimate irrigation water use efficiency (IWUE) (kg dry matter production

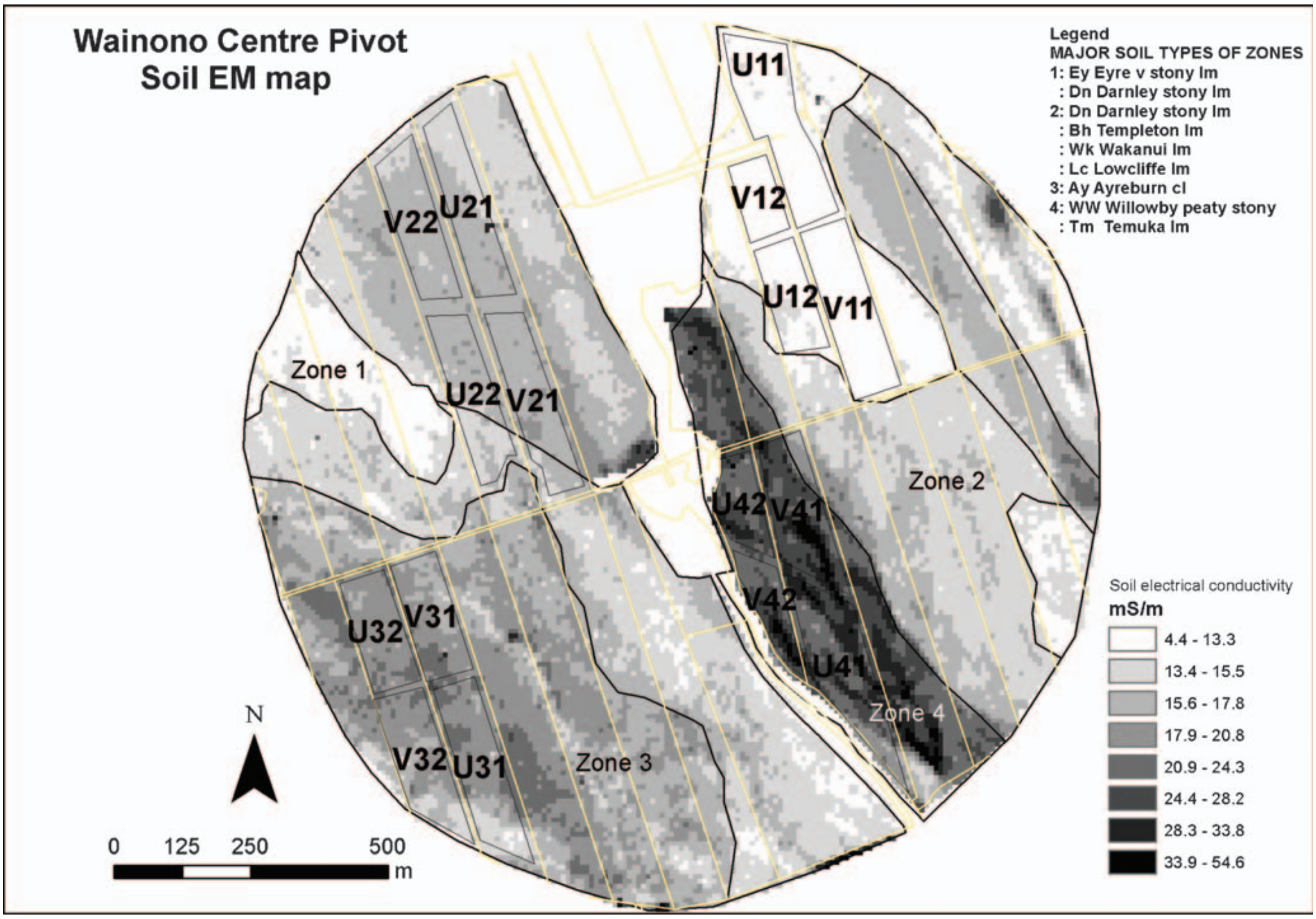

Figure 1: Figure to show trial plots and irrigation management zones overlaid onto the soil EM map for the Fairlie dairy farm centre pivot irrigation system

Table 2: Examples of how irrigation is being varied under each irrigation system this season

Site	Zone	Crop	Irrigation Schedule					
			8-Oct	10-Nov	20-Oct	31-Oct	22-Dec	19-Jan
Farm 1 Ashburton								
	1	Beans	15	20				
	2	Beans or wheat	15	25				
	3	Beans or wheat	10	30				
	4	Pakchoi	0	10				
Farm 2 Fairlie								
	1	Pasture			10	10		
	2	Pasture			10	10		
	3	Pasture			0	5		
	4	Pasture			0	5		
Farm 3 Manawatu								
	1	Maize					5	6
	2	Maize					2	6
	3	Maize					0	3

per mm of irrigation applied) under uniform rate irrigation (URI) compared with variable rate irrigation (VRI).

4. Summary

The VRI systems introduced onto these three farms are being used for:

- Varying irrigation according to soil differences, e.g.
  - Earlier irrigation of free draining very stony zones
  - Reduced amounts of irrigation to free draining very stony zones, to minimise risk of drainage and nutrient leaching
  - Delaying irrigation to soil zones with larger AWCs
- Varying irrigation according to crop differences
- Reducing irrigation into wet low-lying poorly drained areas
- Excluding irrigation from drains, gateways, lane-ways, water troughs, streams, pivot circle, and other areas such as irregular field boundaries
- Eliminating overlaps on the linear move irrigators
- Excluding irrigation to paddocks where pasture renovation is occurring
- Excluding irrigation to dairy paddocks the day before they are grazed

These farm management strategies are providing more efficient use of irrigation water.

About the authors

Carolyn Hedley

Carolyn (hedleyc@landcareresearch.co.nz) is a senior scientist with Landcare Research, and developed the concept of variable rate irrigation in her PhD "The development of proximal sensing methods for soil mapping and monitoring, and their application to precision irrigation" at Massey University, between 2006 and 2009. Carolyn now leads a 3-year MAF Sustainable Farming Fund project to assess variable rate irrigation at the farm-scale.

Stu Bradbury

General Manager of Precision Irrigation and Wheresmycows.com Farm Mapping.

Graduated from Massey University in 2005. Set up Wheresmycows.com farm mapping with George Ricketts in 2003, then Precision Irrigation in 2007. George and Stu developed the hardware and software for the world's first commercial Variable Rate Irrigation system that controls every sprinkler individually.

Precision Irrigation now has many Variable Rate Irrigation systems installed in New Zealand and Australia, and are just starting to export to other parts of the world.

Hew Dalrymple

Hew farms Waitatapia Station with his brother, Roger. The Station spreads over 2610 ha of coastal land in the Manawatu Sand Country, with soils ranging between alluvial silt loams to sandy soils. The farming is a mixture of arable farming with sheep and beef. A variable rate irrigation system has been installed on the farm so that water can be kept out of wet low-lying zones in the spring time when other areas are becoming droughty and need irrigation to avoid becoming hydrophobic.

Eric Watson

Eric & Maxine Watson farm 490 hectares on the Canterbury Plains, a fully arable operation which is 97% irrigated.

Average annual rainfall c 600mm, soils mostly silt and clay loams of water-holding capacity 97 – 115 mm in top 60cm, with some lighter river terraces of water-holding capacity in the range of 30 – 70 mm.

They grow a wide range of crops including cereals, perennial ryegrass and fescues, pulses, herbage seeds & vegetables (spinach, radish, pak choi, red beet, corn salad, edible chrysanthemum) for seed production, roughly 1/3 each year of cereals/grass/'other'.

There are 9 lateral irrigators on the property, 6 fitted out for VRI. Water is supplied from 3 wells (40, 40 & 87m) A renewed water right in 2005 placed quite a restriction on the annual and daily take - 1,183,500m^3 annual volume, 3.7 mm per hectare per day. This combined with over 5 hectares of overlaps made VRI a sensible and practical solution to their irrigation problems.

John Wright

Wainono Dairy Partnership Ltd farms a 700ha dairy farm of which 500ha is irrigated by pivots and rotorainers. There are three pivots all with precision irrigation equipment installed. We are milking 1800 cows through two rotary sheds producing 750,000kg/ms/year. The farm is located in the Fairlie basin with an additional 240ha run off 10km away. We have varying soil types and wet areas where the pivots go so precision irrigation is ideally suited for this farm to ensure the ground is not over saturated. Our water supply is not plentiful therefore we need to use our water allocation very efficiently. We have a 6ha water storage lake that holds 180,000m3 water which the pivots source water from. There are 9 fulltime equivalent staff employed by Wainono Dairy Partnership Ltd.

Acknowledgements

Foundation for Arable Research, DairyNZ and Ministry of Agriculture and Forestry Sustainable Farming Fund for financial assistance. Hydroservices, Streats Instruments and Boraman Consulting for soil moisture monitoring and telemetry. Waterforce for water metering. Ian Yule, Paul Whitehead and Michael Killick for EM mapping. Jagath Ekanayake for development and installation of wireless soil moisture sensor networks. Trevor Webb and Sam Carrick for soil characterisation. John Dando and Remi deClerq and Precision Irrigation personnel for technical assistance.

REFERENCES

Adamchuk, V.I.; Hummel, J.W.; Morgan, M.T.; Upadhyaya, S.K. (2004) On-the-go soil sensors for precision agriculture. *Computers and Electronics in Agriculture* 44: 71–91.

Bradbury S. (2010) *Variable rate irrigation for centre pivot and linear move irrigators*. Available at www.precisionirrigation.co.nz/index.php. Accessed 12 December 2010.

Hedley C.B., Yule I.J. (2008) Soil water status mapping and two variable-rate irrigation scenarios. *Journal of Precision Agriculture*, 10:342–355.

Hedley C.B., Bradbury S., Ekanayake J., Yule I.J., Carrick S. (2010a) Spatial irrigation scheduling for variable rate irrigation. In *Proceedings of the NZ Grasslands Association* 72: 97–102.

Hedley C.B., Yule I.J., Bradbury S. (2010b) Analysis of potential benefits of precision irrigation for variable soils at five pastoral and arable production sites in New Zealand. *19th World Soil Congress*, 1–6 August 2010, Brisbane, Australia. In Proceedings DVD, ISBN 978-0-646-53783-2.

New Zealand Ministry of Agriculture and Forestry (2010) Environment, *Water, Irrigation.* www.maf.govt.nz/environment-natural-resources/water/irrigation.aspx. Accessed January 2011.

New Zealand Land and Water Forum. (2010) *Report of the Land and Water Forum: A Fresh Start for Fresh Water*. Published in September, 2010 by the New Zealand Land and Water Forum. Report available on the Land and Water Forum website: http://www.landandwater.org.nz/ ISBN: 978-0-478-33296-4

Sudduth, K.A.; Kitchen, N.R.; Wiebold, W.J.; Batchelor, W.D.; Bollero, G.A.; Bullock, D.G.; Clay, D.E.; Palm, H.L.; Pierce, F.J.; Schuler, R.T. and others. (2005) Relating apparent electrical conductivity to soil properties across the north-central USA. *Computers and Electronics in Agriculture* 46: 263–283.

CONFERENCE PAPER

Disentangling farmers' preferences and cost allocation among inputs for food security in Vihiga District, Kenya

P.M. NYANGWESO[1], M.O. ODHIAMBO, P.O. ODUNGA, M.K. KORIR and D.C. OTIENO

ABSTRACT

Vihiga, one of the poorest and densely populated districts in Kenya, is perpetually in food deficit. Poor welfare and a low resource base continue to curtail efforts to circumvent food insecurity among households in the district. In their current financial status, what are their preferences when it comes to choosing inputs for food production? How do they allocate their scarce input expenditure among the various inputs required for food production? What are their major considerations when they are making such choices? Descriptive statistics were used to determine input preferences and cost distribution among the farm inputs. Cluster sampling was used with divisions forming the main clusters in the district. Using systematic random sampling, 50 households were selected from each cluster resulting in a sample of 300. Results show that labour cost pre-dominates farm input cost followed by fertilizers and seed maize. Out of the total labour cost, land preparation, weeding and shelling account for the largest part, the balance being accounted for by planting, harvesting, topdressing and transport activities. Similarly, inorganic fertilizer is the major contributor to soil amendment costs, and local seed is preferred due to its low acquisition costs, while hybrid H 614 is preferred to other hybrid seed due to its performance and other desirable properties like low postharvest losses during handling. Knowledge of farmers' input preferences and a deeper understanding of contributors to input cost are critical for proper planning of farmers production, especially when production is rain fed.

This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

KEYWORDS: Farmers' preferences; cost allocation; Food security; Vihiga; Kenya

1. Introduction

Despite having the potential to meet domestic food demand, Kenya continued to face persistent food deficits over the last two decades. Over the last decade annual demand for maize, the main staple food in the country rose from 29.5 million bags to 37.6 million bags (GOK, 2009). However, annual production ranged between 25 and 33 million bags in the same period thus necessitating importation of food to meet the deficit. To make matters worse, Kenya happens to fall in 'Sub-Saharan Africa which is off track on the hunger goal — and is the only region where child malnutrition is not declining' (World Bank, 2006).

Vihiga, one of the poorest and densely populated districts in Kenya is perpetually in food deficit (GOK, 2004). This has been attributed to limited land, high poverty levels, limited off-farm income, and non-adoption of recommended farm technologies. Over the last decade, the district maize demand outpaced local production worsening the already bad food deficit situation.

Food security describes a situation in which people do not live in hunger or fear of starvation. According to FAO (2005), food security exists when all people, at all times, have access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Food security can therefore be assured by tackling both demand side and supply side constraints. Addressing demand side constraints encompasses measures that attempt to improve access to food by improving purchasing power of individuals through putting money in people's pockets. Addressing supply side constraints entails empowering individuals or households to access and utilize inputs optimally to maximize output while keeping the cost of production as low as possible.

As poverty levels rise, household food insecurity in the district worsens. Families with the financial resources to escape extreme poverty rarely suffer from chronic hunger; while poor families not only suffer the most from chronic hunger, but are also the segment of the population most at risk during food shortages and

[1] Economics and Agricultural Resource Management, Moi University, P.O. Box 1125, Eldoret, Kenya. philoe2000@yahoo.com

famine (FAO, 2005). Vihiga district has unfavorable poverty indicators as measured by food poverty, absolute poverty and hard-core poverty. About 57.6 percent of the population in Vihiga district lives below the absolute poverty line, which is set at US$ 34.39[2] and US$ 16.08 per month for urban and rural areas respectively (GOK, 2004). Similarly, more than half of the households in Vihiga, which is one of the worst hit districts in Kenya, fell below the absolute poverty line. Poverty has a twin impact on household food security. It not only reduces the capacity of households to access farm inputs due to capital limitations thus hindering expanded food production, but also prevents households from accessing food due to their low or non-existent purchasing power. Poor welfare indicators and resource base continue to curtail efforts to circumvent food insecurity among households in the district raising a number of questions. In their current financial status, what are their preferences when it comes to choosing inputs for food production? How do they allocate their scarce input expenditure among the various inputs required for food production? What are their major considerations when they are making such choices? The paper examines farmers' preferences and cost allocation among inputs for food production in Vihiga district, Kenya. The paper is subdivided into four sections. In section one, an introductory exposition of the problem is presented. In section two, materials and methods are presented with key considerations being the review of the theoretical framework and various methodologies used. In sections three and four, results and discussions followed by conclusions of the study are presented.

2. Materials and Methods

In Vihiga district, Kenya most farmers are entirely subsistence and therefore are not driven by the profit motive. This study, therefore, did not duel on the intricacies of stochastic modeling of farmers' cost behavior, but evaluated farmers' preferences for certain category of inputs and how their input cost was allocated among the various inputs.

Methodologies

The study targeted all farm households in Vihiga district. Cluster sampling was adopted on the basis of the six divisions. Using systematic random sampling procedure, 50 households were selected from each cluster generating a sample of 300 respondents. Both primary and secondary data was used. Types of data collected encompassed resource endowments at household levels, area allocated to maize in acres, farm input quantities and prices for fertilizer, seed, farm yard manure, labor, machinery and transportation. Primary data was collected through a survey while secondary data was acquired through perusal of annual agricultural reports, economic surveys, statistical abstracts and development plans. Both interviews and questionnaires were used as instruments for data collection. To validate survey instruments, 10 questionnaires were pre-tested in one of the divisions, revised and forwarded to enumerators. Trained enumerators were used to administer the questionnaires. Focused group discussion was used to elicit information from key informants who included the district agricultural officer, district development officer, heads of district non-governmental organizations, divisional agricultural extension officers, field extension workers and local administration. Observation was used to countercheck some of the findings. Descriptive statistics especially measures of central tendency and bar charts were used to isolate the unique characteristics of household in Vihiga district using SPSS.

3. Results and Discussion

Socio-economic Profile of respondents

Table 1 shows a summary of socio-economic characteristics of respondents surveyed.

While the total members of the households ranged between 1 and 26, household size averaged around 6 people (Table 1). A few households which were extremely large were reported to be polygamist. On the contrary, while the number of adults per household ranged between 1 and 16, the household adult number averaged around 4 people. The results also show that an average household in Vihiga district is likely to own 2 head of cattle and 6 poultry. However, while some households neither own cattle nor poultry, there were households reported to own as many as 19 cattle and 60 poultry animals respectively. Incidentally, about 79 percent (Figure 1) of the households own less than the average number of cattle estimated at 2, while 21 percent own more than the average figure.

Similarly, about 68 percent (Figure 1) of the households own less than the average number of poultry animals estimated at 6, while 32 percent own more than the average figure. Results on land area under food production (Figure 2) do not paint a different picture. Over 64 percent of respondents managed to put less than the average size of land estimated at 0.71 hectares under food production, while only 36 percent achieved more than average acreage. This explains how the majority of the poor residents of Vihiga district have a very poor asset base compounding their inability to utilize their limited resources.

Table 2 shows highest level of education attainment among households in Vihiga district. While 53 percent of the respondents did not go beyond primary school, 26 percent attained a maximum of secondary education and the remaining 21 percent underwent vocational, college or university training. The large percentage of primary level households could explain the difficulties faced by extension agents in trying to convince farmers to adopt new technologies.

The picture painted by employment among the surveyed respondents is glum. About 73 percent (Table 3) of respondents were not in formal employment, while only 27 percent were in formal employment. This indicates that livelihoods of the majority of the Vihiga residents were either dependent on their small pieces of land or on transfers from their working relatives in urban centers.

[2] At mid-October 2011, $1 (US) was equivalent to about £0.63 and €0.7

ISSN 2047-3710

Table 1: Indicators of Household Socio-economic Profile in Vihiga district

Indicator	N	Minimum	Maximum	Mean	Std. Dev.
Number of household members	300	1	26	6	2.9
Number of adults	300	1	16	4	2
No. of cattle	290	0	19	2	1.7
No. of poultry	288	0	60	6	6.6
Size of land under food production(Ha)	297	0	7	0.71	0.82

Source: Authors compilation, 2006.

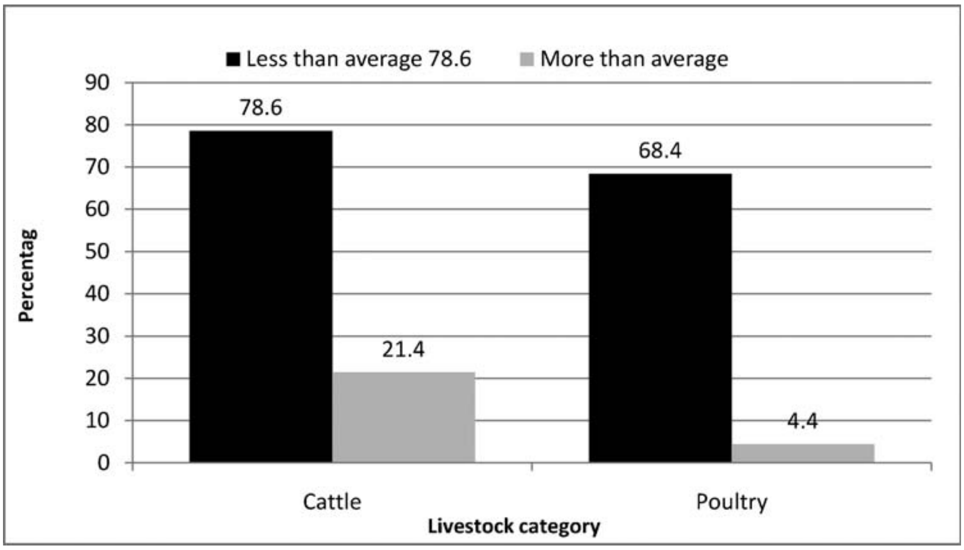

Figure 1: Livestock ownership across households by percentage
Source: Derived from authors' survey, 2006

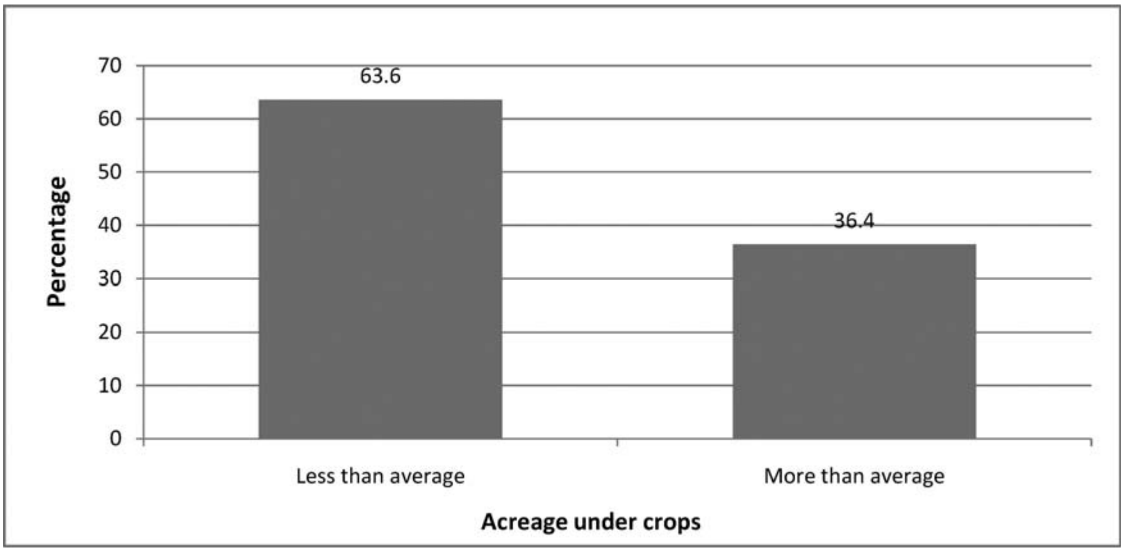

Figure 2: Acreage under food crops across households by percentage
Source: Derived from authors' survey, 2006

Cost allocation among farm inputs

Results show that labor is the single most predominant farm input followed by fertilizers and seed maize with cost shares of 64.2 percent, 20.5 percent and 8.7percent respectively (Figure 3).Out of the total labor cost, land preparation, weeding and shelling contribute 73 percent (Figure 4) with the balance being accounted for by planting, harvesting, topdressing and transport activities.

However, of the total soil amendments and pest control costs diamonium phosphate (DAP), calcium ammonium nitrate (CAN) and farm yard manure (FYM) account for 44.18, 30.5 and 24.8 percent respectively(Figure 5) indicating that chemical fertilizers

Table 2: Highest education level

Education level	Frequency	Percent	Cumulative Percent
Pre-primary	27	9.4	9.4
Primary	125	43.6	53
Secondary	75	26.1	79.1
Vocational training	18	6.3	85.4
College/University	42	14.6	100
Total	**287**	**100**	

Source: Compiled from authors' survey, 2006

Table 3: Employment status across households in Vihiga district

Status	Frequency	Percent
Unemployed	220	73.3
Employed	80	26.7
Total	**300**	**100**

Source: Compiled from authors' survey, 2006

are the most predominant contributor to the soil amendment costs.

Results further show that hybrid (H614), local variety and hybrid (H512) account for 40.1, 42.3 and 12.8 percent respectively of the total seed cost (Figure 6).

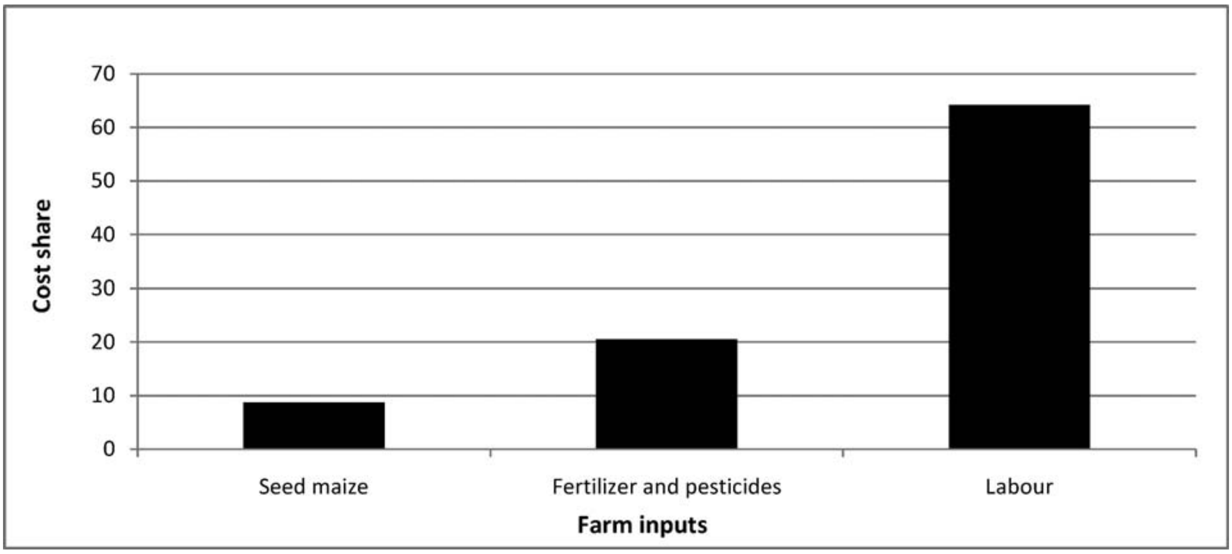

Figure 3: Average household cost share across farm inputs
Source: Derived from author's survey data, 2006

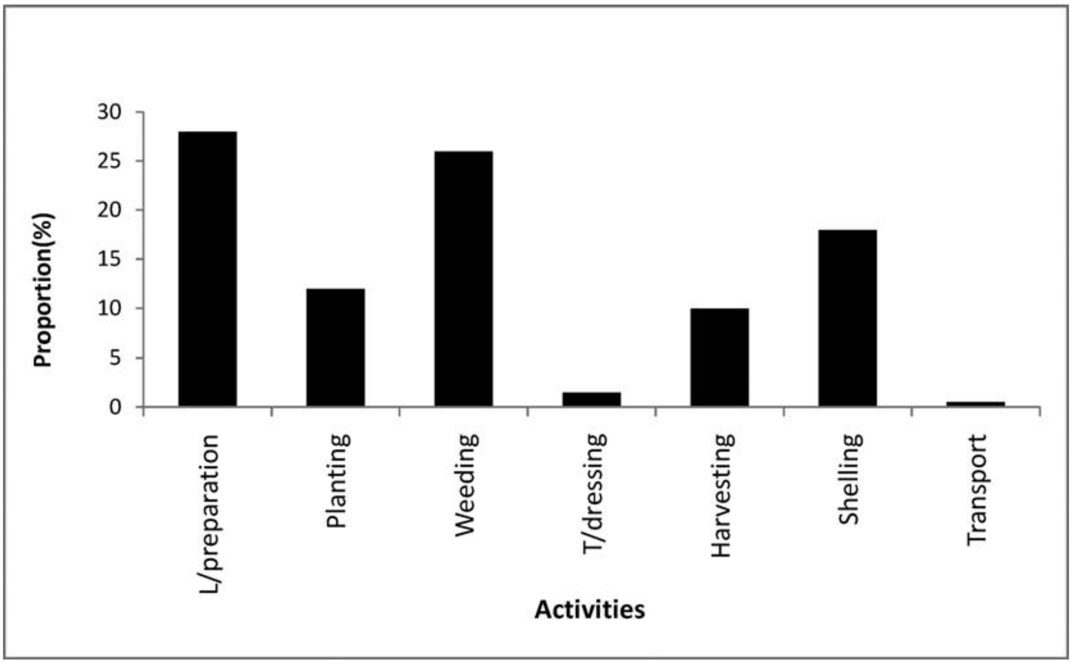

Figure 4: Contribution to labour cost of production
Source: Derived from author's survey data, 2006

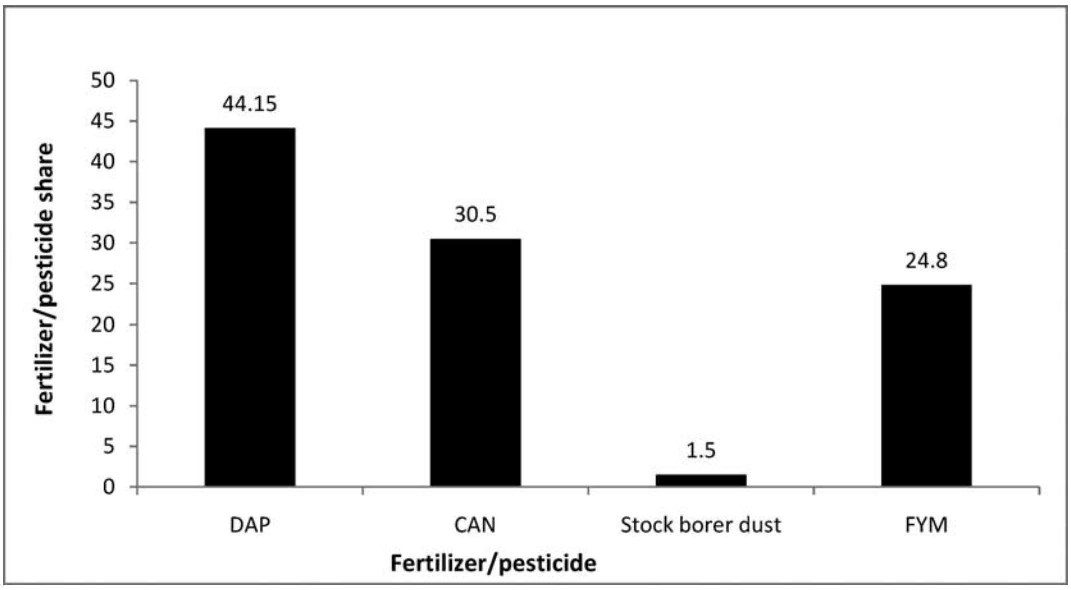

Figure 5: Contributor to fertilizer/pesticide cost
Source: Derived from author's survey data, 2006

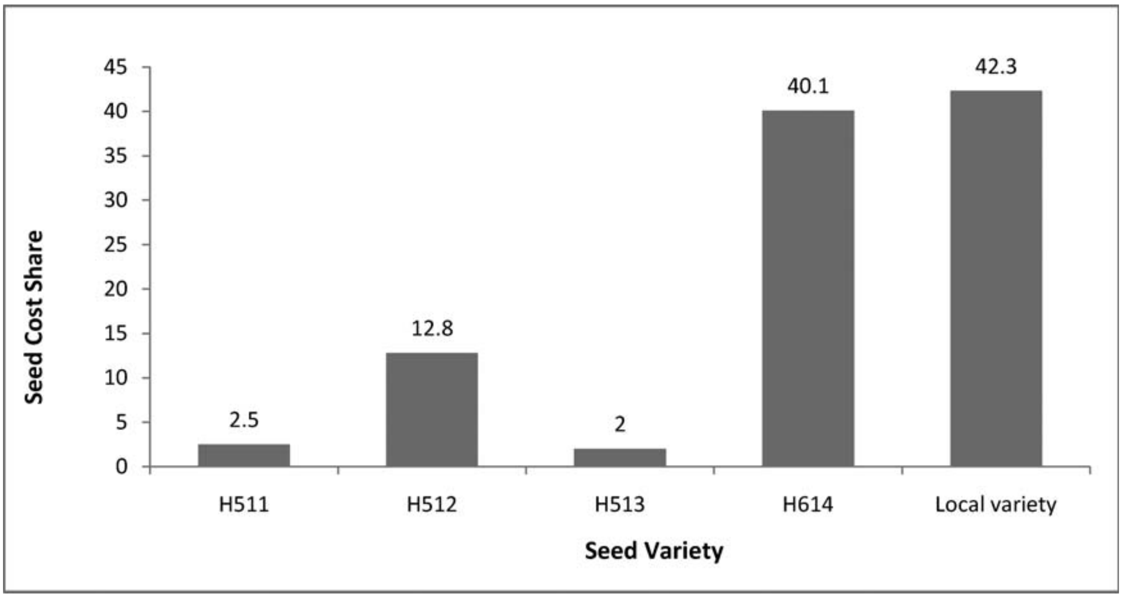

Figure 6: Predominant seed varieties
Source: Derived from author's survey data, 2006

Thus by implication Vihiga farmers who are not growing the local variety are likely to be growing H614. Incidentally H614 which is a high altitude variety seems to be more popular in Vihiga district than the low altitude maize varieties such as H511, H512, and H513. This shows that among the hybrid seed varieties many farmers prefer H614 to other seed varieties. However, when you consider all the seed varieties many farmers prefer local variety to hybrid.

4. Conclusions

Vihiga, one of the poorest and densely populated districts in Kenya is perpetually food deficit. Poor welfare and resource base curtail efforts to circumvent food insecurity among households in the district. In their current financial status, what are their preferences when it comes to choosing inputs for food production? How do they allocate their scarce input expenditure among the various inputs required for food production? What are their major considerations when they are making such choices? Descriptive statistics were used to determine input preferences and cost distribution among the farm inputs. Cluster sampling was used with divisions forming the main clusters in the district. Using systematic random sampling, 50 households were selected from each cluster resulting in a sample of 300.

Results show that labour cost pre-dominates farm input cost followed by fertilizers and seed maize. Out of the total labor cost, land preparation, weeding and shelling account for the largest chunk of labor cost the balance being accounted for by planting, harvesting, topdressing and transport activities. Similarly, inorganic fertilizers are the major contributor to soil amendment costs.

Results further show a higher preference by farmers for local seed variety when all seed are considered due to its low acquisition costs. However, when only hybrid seed varieties are considered farmers show preference of H 614 over the remaining hybrid seed varieties due to its performance and other desirable properties like low postharvest losses during handling.

It is concluded that preference of farmers and a deeper understanding of major contributors to input cost is critical for proper planning of farmers 'production. This will facilitate timely acquisition of production inputs which is a pre-requisite for successful agricultural production considering that a large chunk of the agricultural preproduction is rain fed.

The principal author

Dr. Philip M. Nyangweso (philoe2000@yahoo.com) is the Regional Representative for the East and Central Africa Regional in the African Association of Agricultural Economists. He is the current Chair of the Department of Economics and Agricultural Resource Management, Moi University, Kenya. He is a senior lecturer in the Department of Economics and Agricultural Resource Management, Moi University, Kenya. He has published more than 26 articles in international refereed publications. He joined the University in March 2004 after serving in various capacities and stations in the Ministry of Agriculture. Prior to joining the University, Dr. Nyangweso worked as a Senior Agricultural Officer in the Ministry of Agriculture where he executed government advisory services on various community development projects with special focus on Agricultural Marketing and Extension. Apart from teaching and supervision of both undergraduate and graduate students, his research interests are: Agriculture and Food Policy, Agricultural Marketing, International Trade and Household Food Security, Microeconomic and Macroeconomic Modeling. Dr Nyangweso is also currently undertaking three research projects sorghum and maize, tobacco and module development in agricultural market and price analysis. He was recently consulted as an expert on Agriculture and Food Policy by the Southern Africa Development Community which is in the process of formulating a Regional Agriculture and Food Policy.

Acknowledgements

I would like to acknowledge IFMA secretariat for organizing this conference and giving me the opportunity to present the paper. Special thanks go to Prof. Mark Odhiambo, Dr. Pius Odunga and other colleagues for their constructive comments. I also appreciate the role played by Moi University who facilitated the research and other logistics to enable me to attend this conference.

REFERENCES

Dejanvry S. and A. Dejanvry (1995). Profit function Approach to Supply and Factor Demand. *Quantitative Development Policy Analysis*. The John Hopkins University Press.

FAO (2005). *Nutrition: A guide to data collection, analysis, interpretation and use.* Food Security Analysis Unit for Somalia. Food and Agriculture Organisation of the United Nations. Nairobi

Government of Kenya (2009). National Population Census Ministry of Planning and National Development. Government Printer, Nairobi.

Government of Kenya (2004). Economic Survey. Ministry of Planning and National Development. Government Printer, Nairobi.

Jehle GA and Reny PJ (1998). *Advanced Microeconomic Theory.* Addison Wesley Longman. New York. Mas-colell A. Whinston M.D and Green, JR (1995). *Microeconomic Theory*. Oxford University Press, New York.

Varian HR (1992). *Microeconomic Analysis.* 3rd Ed. W.W. Norton & Company, New York.

Wayne LW (1991). *Operations Research: Applications and Algorithms*. 2nd Ed. PWS-KENT Publishing Company Boston.

World Bank (2006). Repositioning Nutrition as Central to Development. A strategy for Large Scale Action. *Directions in Development*. International Bank for Reconstruction and Development/The World Bank, Washington DC, USA.

Identifying and reporting the value-added from training in four New Zealand industries

JEREMY D. NEILD[1] and DENNIS J. RADFORD[1]

ABSTRACT
The ability to estimate and report the value add of industry vocational training interventions in New Zealand can make a significant contribution to both industry and to the training providers and institutions. Understanding the value of investment in training is important for industry to underpin their commitment to training and the development of their workforce to improve the productivity and performance of their business. For training providers and institutions, the understanding of what and how training adds value to industry is important to the development and delivery of industry training.

These studies, the first of their kind in New Zealand, describe a methodology and the results achieved for four discrete sectors important to the New Zealand economy.

This paper was originally given at the 18th International Farm Management Association Congress, *Thriving In A Global World – Innovation, Co-Operation And Leadership*, at Methven, Canterbury, New Zealand, 20 – 25 March 2011, and is reproduced by kind permission of the conference organisers.

KEYWORDS: Reporting Value Added (RVA); Industry Training Organisation (ITO); vocational training; productivity; skill; management systems

1. Background

In March 2005, the Agriculture Industry Training Organisation[2] began a research project to develop a model and quantify the benefits of vocational training in ways that would be valued by key stakeholders.

The final report (McLeish *et al* 2007) reported the findings of the two year research project:

- Agricultural vocational training provides both quantitative and qualitative value to trainees, their employers, the wider industry and the economy.
- The total value to the dairy farm business from training was $8,332[3] per trained employee. The total cost of training, including trainee salary cost while training, was $2,452/trainee. Therefore the net return from training spent was $2.40 per $1.00 spent.
- The total value to the sheep and beef cattle business from training was $17,400/trainee and the cost was $3,505 per trainee giving a net return of $3.96 per $1.00 spent on training.
- There were also less tangible but important benefits from training that were identified by farmer employers – more positive attitudes, better understanding of farming systems, better communication through common understanding and shared terminology and better transfer of knowledge and technology. Trained staff also stayed in the industry, if not the farm business, for longer. Employers want employees who "can do" rather than "know how to do".
- The value derived from training was largely dependent upon the employer.

Some work in another study indicated training improves trainee earning power and improves career advancement by seven years earlier than a non-trained worker would achieve.

The RVA project was informed by the high impact learning work of Professor Robert Brinkerhoff (Brinkerhoff, R.O. and Dressler 2003) of the University of Western Michigan. These two pieces of work have and are continuing to influence the way that the Agriculture ITO structures its qualifications and delivers training to its industries (Hardy 2008).

2. The project brief

The Industry Training Federation developed a brief to undertake a project with the following objectives in four primary sector industries, including the food services industry.

[1] Agriculture Services Ltd, New Zealand
[2] Industry Training Organisations (ITOs) are not-for-profit entities owned by industry as part of a New Zealand government/industry partnership. ITOs sit at the interface between industry and tertiary education. They are recognised under the Industry Training Act 1992.
[3] The currency used here is the New Zealand dollar. At mid-October 2011 this was equivalent to about £0.50, €0.58, and US$0.80

Objectives

- Test the applicability of the model used in agriculture for identifying and reporting value added from training in other industries.

Key Outcomes

- To enable Industry Training Organisations (ITOs) and wider tertiary groups, industries and firms to gain a greater understanding of how they can identify and report value add by industry training.
- To enable better targeted investments in education and training.
- To be able to design and select better education and training activities.
- To get improvements in follow-up and support for the implementation of skills gained from education and training activities.
- To improve the connection between skill, productivity, profits and pay.

3. Methodology

The Reporting Value Added (RVA) methodology has seven steps in the process:

Step 1: To identify what training will be measured
There are two dimensions:

(*a*) Identify the key activities, tasks, etc, where the employee can have the most significant impact upon the performance of the business.
(*b*) Identify the topics of the most frequently used Unit Standards[4] that are completed in the workplace. This determines where the training effort is going.
If (a) and (b) are markedly different, then a number of useful questions can be asked about why the difference.

Step 2: Identify the financial benefits of improving performance across the training selected for evaluation

(*a*) Describe the observable behaviour of employee for each key task at each level of performance: *Entry, Basic Competence, Average/Good Operator Level, Best Practice Operator*
(*b*) Describe the impact of each level of performance in terms of the business, eg quality and quantity of output, change in risk, change in level of supervision required, rework required, downgrade of product, etc.
(*c*) Calculate the impact in financial terms.

Step 3: Gather data on costs

- Government costs (paid to tertiary training provider)
- Contribution by industry body (if any)
- Employer paid cost – direct costs
- Opportunity cost
  - Trainee time
  - In-house trainer time
  - Coaching/mentoring time by supervisor until the trainee is able to work unsupervised

Step 4: Gather data from direct supervisors on how a trainee changes in performance after training. A rating scale can be used.
Step 5: Using data from Steps (2), (3) and (4), calculate financial model and benefit/cost ratio
Step 6: Collect non-financial and other information from employees/supervisors
Step 7: Collect data from employees who have experienced the training

Steps 6 and 7 provide a qualitative dimension to the study.

4. Results

4.1 Extractives Industry

(a) Employee Training at Quarry Operator Level
In terms of vocational training in quarries, managers identified four key areas where operator performance had a significant impact on quarry performance.

1. Understanding the quarrying process, the operation of the crusher and their impacts on aggregate quality.
2. Operating mobile plant and machinery effectively and efficiently.
3. Operating within company environmental policies and standard operating procedures to avoid a breach of environmental regulations and consents.
4. Operating within company's health and safety policies and standard operating procedure.

Benefit/Cost Ratios
Task 1: Understanding the quarrying process, the operation of the processing plant and the impact on aggregate quality.
Issues:

- The task is very complex, has huge impact on the quarrying profitability and takes several years to acquire the skill and requires considerable supervision.
- Takes two years to get to average competence and four years to get almost to best practice.

Table 1 indicates a range of benefit/cost ratios for training a competent processing plant operator.

Table 1: Benefit/cost Ratios for Training a Competent Processing Plant Operator

After 1 year	2:1
After year 4 (fully trained)	24:1

Task 2: Benefit/cost ratio for the training of a competent operator of movable plant in the quarry.
This task is less complex but still significant. It takes a year to get to an acceptable standard and two years to get to best practice (on the range of movable plant).
Table 2 indicates the range of benefit cost ratio of training movable plant operators.

[4] A unit standard describes the skills and knowledge needed to complete a unit of work and the standard of performance to be reached. All unit standards are registered on the National Qualifications Framework, assigned a level and a credit value, and may contribute to the award of a National Certificate or Diploma.

Table 2: Benefit/cost Ratio for Training Movable Plant Operators

After 1 year After 2 years	6.6:1 10:1

There was insufficient data to confidently provide benefit/cost ratios for the value of training in health and safety or environmental management compliance.

Interviews with quarry managers identified a number of themes:

- A well-trained operator can make a huge difference to quarry performance in the order of 30–40% and initial training can lift productivity 10–20% with further gains with experience.
- It is difficult to separate the benefits of formal ITO facilitated training, informal non-ITO facilitated training and on-the-job training by peers. It all works together to create high performance.
- Training and assessment by itself is not enough to assure competence. Ongoing practice under good coaching/mentoring is required to meet a competence in terms of a commercial operation. It can take six months to two years from the training event.
- Compliance training has made a noticeable difference in behaviour to improve health and safety outcomes.
- Front-line supervision has a major impact on training outcomes and needs more support and training for this role.

(b) National Diploma in Extractive Industries (Management)

The Level 5 301 credit National Diploma is a large qualification that is strongly supported by some companies and not supported by others.

Determining a single value add financial indicator for the Diploma qualification was not achievable. It was evident from the survey work undertaken that significant value can be added by applying the learning provided within this qualification. However, this is very dependent on the scope available to the learner within their management role. It was not considered that aggregation of this data would provide meaningful information.

Sixty one recent graduates and current trainees were surveyed and 33 usable replies were received.

- All interviewees really valued the Diploma in making a difference in managing a quarry. The high value modules were around people, finances, health & safety (managing older staff and getting them to comply with good practice) and enabling trainee managers to better understand and meet their KPIs.

Table 4: Benefit/cost ratios for horticulture

Fruit	Benefit/cost ratio
Pipfruit	10:1.
Kiwifruit: Orchard Hand Supervisor/Leading Hand	 4:1 for 2.9 ha 15:1 for 25 ha
Viticulture	5.7:1

- Even the units with less value were worthwhile in providing background understanding but the interviewees suggested that they went into too much detail.
- Case studies reported 2–5% productivity gains per year while other individual cases reported annual savings of $200,000 per annum in one case, a one-off saving of $300,000 in another and a gain in profitability of 20% per annum.

4.2 Horticulture (Pipfruit, Kiwifruit, Viticulture) Industry

Employee training at orchard operational level

The work in the kiwifruit industry demonstrates the impact of the value of the final crop has on the return – Gold kiwifruit has twice the value in terms of return because of its market value.

Supervision training has a higher benefit/cost ratio because of the orchard area over which the training is effective.

Interviews with Employers

Staff Turnover: Forty five percent of viticulture employees thought that training resulted in higher staff turnover but only 16% of kiwifruit employers thought this. Conversely, 58% of kiwifruit employers and 36% of viticulture employers thought training resulted in improved staff retention. The difference may reflect differences in industry maturity. The kiwifruit industry is mature while the viticulture industry had been in a state of rapid expansion and trained staff were in short supply. Trained staff were often "head hunted" by other employers or staff could advance their careers more rapidly by changing employers.

The critical factors to achieve great results from training are:

- Motivation of the trainee.
- The support of the manager to coach, mentor and supervise.
- Effective leadership and workplace culture.

Table 3: Key Tasks, horticulture

Pipfruit	Kiwifruit	Viticulture
Crop thinning Pruning Harvesting Pest and disease management	Crop load management Canopy management/thinning Harvesting Pest and disease management Supervision	Canopy management Pruning Hand harvesting Machine harvesting Pest and disease management

4.3 Seafood Industry

Employee training for seafood processing

In terms of vocational training in seafood processing, senior managers were asked to identify three to four key areas where processing staff performance had a significant impact on significant impact on the performance of the company.

The areas identified were:

1. Hygiene and Sanitation
2. Health & Safety Compliance
3. Production/Productivity

Economic Value of Training in Seafood Processing

There are particular challenges to developing an economic value for training in the seafood industry because of the diversity of product and market value of that product. Hoki at $7,000/tonne to $60,000/tonne for rock lobster creates quite different economic loss if product is downgraded because of poor practice due to inadequate training. For this reason, we have calculated a number of economic benefits from data provided that give insight into the wide range of returns from training.

Seafood example 1: Pre-season training for "green" processing team at sea

Pre-season training was estimated to improve output in the first three weeks at sea by 27% and improve quality 1–2%. It was expected that the balance of the trip would be similar for the teams regardless of the pre-season training. The benefits were calculated from less time at sea to fill the boat and less quota fish downgraded to fish mince.

The benefit/cost ratio was estimated at 4.67:1 – i.e. a net $3.67 return on each $1.00 spent.

Seafood example 2: shore-based processing

A shore based factory estimates that it takes 160 hours of supervision and training over the first six months to take a new entry person up to a satisfactory level of performance and to offset risks. The production level of a new entry person will be about one third of a competent employee. In addition, 20% of their processing will go to waste compared to 1–2% of the competent employee (see Table 5).

Manager Perspectives

- Training is not always aligned to business goals but is often more compliance driven.
- The current qualifications tend to be too long and consequently had low completion rates. Shorter qualifications aligned to KPIs for specific roles would be more useful.

Table 5: Benefit/cost ratios for training in on-shore processing

Estimated value of training on annualised basis	$133,262
Estimated cost of training including supervisor and employee time	$8,400
Benefit Cost Ratio (i.e. for every $1 spent, there is a net return of $14.80)	**15.8:1**

Employee Perspectives

The three most highly rated benefits of training:

- Training helps me do the job better.
- It makes the job more interesting.
- I can do a wider range of jobs in the processing plant.

Employees believed that training made a difference in improving their productivity, with over half of those surveyed suggesting that it resulted in improved output by 10–20%.

If there was a gap identified in available training, employees thought that supervisor training in communication and team building would make a significant difference.

4.4 Hospitality Industry

The work done in the hospitality industry was done on behalf of four service industries working together as the Service Industries Training Alliance so the focus was on front-of-house service rather than on cookery.

(a) Employee training at front-of-house

In terms of vocational training in the hospitality industry, managers identified four key areas where operator performance had a significant impact on the hospitality outlet performance. Each area was associated with three-four key activities.

Key Tasks

Task 1: Providing customer service
Task 2: Product knowledge
Task 3: Working as part of a team to provide service

Benefit/Cost Ratios

While many employers/managers were able to describe the observable behaviours on the job by untrained, competent and best practice employees, they struggled to describe the impact of that on their business and, in particular, were unable to estimate the likely financial consequences of those differences.

Some examples were developed with individual outlets and one national quick service restaurant chain.

Hospitality industry example 1: Buffet style family restaurant

A shift towards a strong commitment to training with a new manager over the last six years has resulted in:

1. A reduction in staff numbers lifting productivity (customers served/staff member) by 12%. The ratio of part-time: full-time staff has changed from two thirds part-time to one third part-time.
2. A reduction in staff turnover from 150% per annum to 35% per year.

The manager claims her focus on training is a critical component of that improvement.

The estimated benefit from these changes is $39,248 per full-time staff equivalent.

The benefit:cost ratio was estimated at approximately 6:1.

Hospitality industry example 2: A service club operating a restaurant, bar, function centre, coffee bar and gambling facilities
The service club has invested significantly in training as a key to accomplish specific business goals.

- Improved service to members.
- More flexibility through multi-skilling staff.
- Improved productivity.
- Providing consistency of experience.

Results include:

- Improved operating surplus in restaurant.
- Cost savings through multi-tasking and reduced staff numbers on duty.
- Improved sales through upselling.
- Reduction in customer complaints.
- Improved mystery shopping "scores".
- Improved workplace culture.
- Better focused staff recruitment.

A benefit/cost ratio of at least 2:1 has been identified with many benefits unquantified.

Hospitality industry example 3: Quick service restaurants
The main quantifiable financial benefits have been from:

- Upselling.
- Reduction in complaints.
- Speed of service.

Other benefits in terms of food safety, health and safety, working as a team are important but difficult to quantify in dollar terms. The benefit:cost ratio was estimated at 3.5:1.

Interviews with managers/employers across different establishments in the hospitality industry identified some common themes:

- "Front-of-house" staff turnover is quite high and the job is frequently not treated as a career option.
- The part-time nature of front-of-house work influenced the investment in training by employers.
- Higher-end restaurants invested more heavily in training systems to differentiate their businesses.
- Smaller businesses struggled to find time for staff training. Finding time for assessment was often seen as a barrier.
- Use of suppliers for "free" training was common, eg wine supplier for wine awareness, coffee supplier for barista training.
- The larger businesses that invested in training and manage it well saw good benefits, although measurement of this was generally weak.

5. Conclusion

The Applicability of the RVA Methodology for Identifying and Reporting Value Added from Training

The RVA methodology is relatively straight forward to use in industries where employee effort can be measured in terms of output volume and quality which can be directly measured in financial terms. Secondly, its use is also more relevant where the industry output is relatively homogenous in value.

Consequently, benefit cost ratios were established for the quarrying industry (within the extractives industry) and the pipfruit, kiwifruit and viticulture industries (within the wider horticulture sector).

The wide range in seafood product prices from \$7,000/tonne for Hoki to \$60,000/tonne for rock lobster creates quite variable benefit cost ratios for training in areas such as improving product recovery. Consequently, developing a benefit-cost ratio for training in seafood processing was challenging. This would be true for other industries with a heterogenous product with a wide range in market values.

Even within industries where benefit cost ratios were able to be established, it was not possible to apply the methodology to training in activities such as compliance with health and safety, fishing quota, food safety and environmental regulations.

In theory, it would be possible to do this using sufficient subjective risk assessments by experienced industry personnel. However, the authors found that there was insufficient experience and/or willingness to make estimates about the change in risk from compliance training and the possible savings in product rejection, fines and other costs associated with non-compliance. Given the amount of compliance training carried out in the ITO sector, this is an important area for future research.

The methodology was also difficult to apply in the hospitality industry, which was not unexpected given the nature of the industry.

While hospitality employers could describe the observable differences in practice by employees with different levels of skill, they struggled with quantifying the impact this had on their business and providing estimates for the financial consequences that this produced for the business.

It is the "clear line-of-sight approach" between Key Performance Indicators (KPIs) for the business, employee contribution to the KPIs through the application of skills and the training delivered to lift those skills that are central to the added-value approach. When managers say that they do not understand what half or a third of the qualification is about, or that it has no relevance for their business, then there is scope for an added-value approach to be taken by an ITO when reviewing Unit Standards or qualifications.

Training and Management Systems
The studies identified that training is just one factor among many that impact on the performance of staff. Critical factors include:

- The opportunity for the trainee to apply the new skill and knowledge.
- The calibre of management.
- The quality of recruitment and the commitment of staff.
- Alignment of training objectives and company strategic direction.
- Clear company operating policies and procedures.

The return on investment from training is influenced by these non-training factors. The Valued Added Approach measures the impact from all these factors.

When considering the value added of training in the workplace, there is a need to think beyond the training event and the acquisition of discrete skills and knowledge, to alignment with business goals, integration of training with performance and operating systems, and supportive management systems.

Brinkerhoff and Dressler (2002) criticised Return on Investment (ROI) methods of evaluating the impact of training. "In evaluating the transfer of skills and knowledge into the workplace from training, we are measuring the management and performance systems rather than training alone. The training function assumes questions about instructional quality and the design of the training programme to meet training needs and how well it is integrated with the business performance system. The management function looks at how learning is applied, identifies obstacles and facilitating factors and considers how effective performance is."

Training for Managers and Supervisors

While the objectives of this project were not specifically focused on the value of training supervisors and managers, there were a number of case studies completed.

The case studies for the extractives, services and seafood industries indicated strong gains in productivity where the individual supervisor/manager trainee was able to implement the learning gained. The kiwifruit study showed a benefit/cost ratio of 15 for the training of leading hands/supervisors compared to 4 for "orchard hands".

In particular, a number of supervisor trainees commented on the value gained from learning and applying skills in training staff, assessing competence and to identify training needs with a "line of sight" to business goals and KPIs and to implement training activities and coaching to enable staff to meet the required level of performance.

While supervisor/first-line management training was identified as important to all four sectors in our study, a comment from one restaurant owner reminded the authors that the training of supervisors was not a substitute for not training all employees. The restaurant owner identified employees who could work unsupervised as adding real value to their business. Customer service is the culture of the business and requires attention to detail – service, personal engagement and sensing of customer need. This cannot be delivered through closely supervised but poorly trained staff.

6. Themes

Four themes emerged from the studies completed.

Theme 1

Training must be linked into management systems and have strong management support to get high returns.

Industry Training Organisations need to:

- Connect well with management – both at senior and at operational level
- Understand company Standard Operating Procedures/Key Performance Indicators (SOPs/KPIs) and performance systems and how training supports these and improves performance
- Be part of firm's HR/manpower planning in identifying training needs and solutions

Theme 2

For the SME market, Industry Training Organisations need to consider provision of additional HR support system for many managers and businesses. This could include:

- Training-needs analysis
- Performance management system to measure the results of training
- On-the-job training/assessment skills for managers and supervisors
- Developing workplace culture/organisation for high performance

Theme 3

On-job task based assessment systems seem to be preferred by employers but simpler, less bureaucratic systems are required with good Recognition of Current Competence/Recognition of Prior Learning (RCC/RPL) attributes, and job specific/company SOP application.

Theme 4

There appears to be a significant market for improved training for supervisors/managers and particularly:

- How to get value from training
- How to train on the job
- How to assess competence/performance
- How to manage staff
- How to identify/satisfy training needs with line of sight to business goals and KPIs

REFERENCES

Brinkerhoff, R.O. and Dressler, D.E. (2002) Using Evaluation to Build Organisational Performance and Learning Capability: A Strategy and a Method. *Performance Improvement*. Volume 41. Number 6.

Brinkerhoff, R.O. and Dressler, D.E. (2003). *Using the Success Case Impact Evaluation Method to Enhance Training Value and Impact*. The Learning Alliance, Portage, MI, USA.

Hardy, F. (2008). *The Agriculture ITO's Implementation of Learnings from the Reporting Value Added Project (RVA)*. An internal paper prepared for AgITO, Wellington, New Zealand.

McLeish, P., Gardner, B. and Waters, W. (July 2007). *Reporting Value Added by Agricultural Training, Final Report*. An Internal Report prepared for AgITO, Wellington, NZ.

BOOK REVIEW

Farm Business Management: Analysis of Farming Systems

Peter L. Nuthall

Published September 2011 by Publisher: CABI, Wallingford, UK. Hardback. ISBN: 978 1 84593 839 0. Price: £115/$220/€160. (Special price for all three books in the *Farm Business Management Series* £208/ US$395/€290). Length: 464 pages.

This book itself is a masterful achievement, but as the third in a Farm Business Management series, all published in 2010 and 2011 by this author, it represents the culmination of a wide-ranging comprehensive and thorough treatment of this field of human endeavour. It completes an impressive statement of the knowledge, skills and insights that the author has accumulated over his academic career. The companion volumes are *Farm Business Management: the Core Skills* (CABI2010) and *Farm Business Management: the Human Factor* (CABI 2010). Brief mention of these two texts is warranted, as background to the volume being reviewed.

Farm Business Management: the Core Skills deals with the core important skills required by successful farm managers. Based on research within farming communities, it covers broad topics including observation, anticipation and risk management, with thorough developments of each of these, and a concluding section devoted to assessing and improving managerial ability. It is therefore a book about what things farm managers do, which of these are important, and how execution can be improved. The second title, *Farm Business Management: the Human Factor* addresses in an accessible format the individual psychological aspects that underlie human behaviour and the expression of farm management skills in managerial ability. Both books provide a valuable resource for students of agriculture or agribusiness, farm managers, consultants, researchers and other agribusiness professionals to better understand the complexity of what makes each individual unique.

With that background established in the first two books, this third volume is designed to focus on the science of management – the identification and exposition of the techniques and skills needed to analyse and improve farm systems. There are 16 chapters. The introduction sets out the main premises of the book – that farm management is essentially about seeking to optimise a farm system, that optimising requires identification of problems, and that there are 6 essential steps in the optimising process: formulating the problem; constructing a model to represent the problem situation; testing the model; deriving a solution; testing the modelled solution; and fully implementing the solution. This framework provides the structure for the chapters that follow.

As observed in Chapter 1, much of the material that follows is quantitative in nature, seeking mathematically optimal solutions. Consequently, the book contains much of the material common to management science and management economics texts. It has strong underpinnings of economic principles, and takes the reader clearly and logically through many of the topics and techniques developed for framing, constructing and executing problem analyses. However, there is acknowledgement that in some situations, problems cannot be addressed quantitatively, because of lack of information, and that qualitative approaches may be usefully employed in these situations. Useful advice is provided for such situations.

Chapter topics move in a somewhat unconventional sequence, for a management science text – but this is not just a management science text, and the sequence has sound internal logic. In Chapters 2 and 3, fundamental economic principles are established, such as decision making under uncertainty, probability, utility and so on. This continues in Chapter 4 (description of cost-benefit analyses techniques) and Chapter 5 (more on decision making and utility). Chapter 6 departs from this theme to provide a comprehensive overview of approaches to gathering farm survey data that can be used with validity for developing farm system models.

The remaining chapters then provide cogent coverage of the conceptual issues, tools and techniques required to use data to construct useful farm system models, whether complete or partial, for a range of optimising purposes. Topics of budgeting, linear programming, dynamic programming, systems simulation, and part-of-farm analyses follow in sequence. In addition to text material there are four appendices providing supporting information on production economics, farm analyses outputs, and different aspects of linear programming.

Farm Business Management: Analysis of Farming Systems focuses clearly on the farm business, and offers coverage of a wide range of analytic techniques that have potential for providing guidance to managers and other on ways in which outcomes may be improved or optimised. This reviewer was impressed with not only the mastery of topics but also the succinct effective coverage of the material. This book will have wide appeal to many different readers. As a text for undergraduate and postgraduate coursework students it will provide an excellent reference for one or several themed courses on farm business management. It will provide a comprehensive resource for research students, not only for the clear exposition of analytical techniques but also on important issues of survey design for a wide range of data acquisition purposes. It will be of much value to practising farm managers and agribusiness consultants, and also for policy makers. It is a very good book.

Reviewed by Donald Cameron[1]

[1] Senior Lecturer and Research Postgraduate Coordinator, University of Queensland, Australia

EDITORIAL

My biggest worry, in setting up this new journal in 2011, was whether we would be able to attract authors in sufficient numbers to be able to provide both volume and quality consistently in each issue. As it has turned out, my main concern now – and it is a good one to have – is how to cope with the quantity of material submitted. Thanks to the efforts of both authors and reviewers, we have been able to make up some time on each issue and to soften the impact of the prolonged set-up time of the Journal's systems last summer and autumn. Keep them coming!

As for the reader, we can't hope to please everyone all the time – but we will keep trying. In this issue we have a rich mixture of articles of different types. Professor Sir John Marsh, in his acceptance speech to the Royal Agricultural Society of England for his National Agricultural Award 2011, examines the issue of maintaining food security in the face of population growth and pressure on natural resources. Always readable, always thought-provoking, Sir John is clear that increasing productivity by application of new technology is critical to the task, requiring greater commitment of governments to funding applied science, and a more relaxed attitude in society to change and its potential consequences.

Four peer-reviewed papers follow. Thia Hennessy, Doris Läpple, Laurence Shalloo and Michael Wallace examine the economic efficiency of the Irish milk quota exchange scheme using an optimisation framework, finding evidence of a 'wedge' between estimated economic value of milk quota and its traded price. While the system under study is specific to Ireland, the authors' method of analysis may well have applications to conditions in other parts of the European Union, or further afield.

Nicola Shadbolt is well-known to readers of IJAM's progenitors, the *Journal of Farm Management* and *The Journal of International Farm Management.* In this article, developed from a paper to the 2011 International Farm Management Congress, she takes a comparative look at five different dairy systems through the medium of the DuPont model. Particularly interesting to me, and I am sure to managers and consultants, is that this approach works in terms of business financial measures rather than using a complex econometric model (the weapon of choice for many academic analysts). While this may appear to have less explanatory power than the latter, it does mean that the results are couched in terms that are immediately and directly applicable to the farm business. As with Hennessy *et al*, it would be good to see this approach being adopted outside the specific contexts of New Zealand and dairy farming.

In a world that is increasingly subject to uncertainty, whether arising from climate change and other natural events or from human activities as reflected in political, social and economic disturbance, all farmers are having to pay more attention to risk. As in rich countries, so in poor, but in the latter the consequences of mismanaging risk are so much greater, leading to hunger, misery and often death for many. Those of us from the Western world have much to learn from reading the article by Maggie Kisaka-Lwayo and Ajuruchukwu Obi, concerning a study of risk management behaviour of smallholders in South Africa: an essential precursor to design and implementation of agricultural and food policy.

The topic that is usually most popular in farmers' online chat rooms and forums is that of machinery, so I hope that the article by Swiss authors Markus Lips and Frank Burose will have a wide readership amongst practitioners. A popular conclusion will be that 'high annual utilisation coupled with a short length of service life is beneficial', which I read as giving licence to farmers to buy new tractors more often. Flippancy aside, this is a thorough and analytical investigation which makes a valuable addition to the literature on machinery costs and their estimation.

One of the highlights of this year's Oxford Farming Conference was a paper by Martin Harper and Ellie Crane of the UK's Royal Society for the Protection of Birds, on the hot topic of reconciling the needs of agriculture and conservation. This is a thoughtful and well-balanced analysis, and I am very happy that the Conference has given its permission for us to present it here. In this area of debate, those at the extreme on both 'sides' make the most noise, and are easily taken to be representative, leading to caricatures of the rabidly productivist, nature-hating farmer and the deep-green environmentalist longing for a return to some pre-industrial utopia. In my experience, there is often precious little distinction between one camp and the other, and I hope that this honest and constructive paper will play a role in finding mutually agreeable and beneficial ways of operating.

Finally, Philip Nyangweso reviews a book edited by Herman D. van Schalkwyk, Gavin C.G. Fraser, Ajuruchukwu Obi and Aad van Tilburg, addressing the various constraints on market development for smallholders in South Africa, and ways in which those constraints can be addressed. As the reviewer points out, the theoretical underpinning of this book and the illustrative case studies make it of value throughout Africa and other emerging markets where sectors of the farmer population are excluded from full and free participation in economic activity.

Martyn Warren

Know More or Eat Less

PROFESSOR SIR JOHN MARSH

ABSTRACT

We face a truly challenging task to achieve an acceptable level of food security in the future. Food supplies have kept pace with, and at times and in places, outstripped an increase in population from 3 billion to 6 billion in fifty years. Not only has the amount of food kept pace but the quality of the diet has improved. Greater labour productivity on the farm has been possible because jobs that were once done within the farm boundary are now the business of external suppliers. Globally the most productive land is already in use and increased area, where it is possible, will not lead to proportionate increases in output. The food chain is a major user of fossil fuels and water. Contemporary farming can also damage water, soil, biodiversity and is a significant contributor to global warming. The CAP is still needed if non-market public goods are to be authentically taken into account as markets become open to competition but there is little sign of new thinking in the latest proposals. Globally policy failure exacerbates problems rather than relieves them. There is no reason to believe that we have reached the end of productivity increasing technology. If we are to benefit from investment in research we need applied scientists as well as those engaged in more fundamental, pure research. We also need means of bringing new technology into action. Our ability to capture and apply new science depends on society accepting changes that may be uncomfortable and to some seem potentially threatening. New technologies involve risks, some known and others not yet recognized, but less readily recognized are the risks involved in not taking action. Pressure groups, who claim to speak for the public, occupy an important place in assessing and interpreting new technology but they also have agendas of their own.

This is the transcript of the National Agricultural Lecture, given on the occasion of the Royal Agricultural Society of England President's Seminar and Awards Ceremony, held in London on 28th February 2012 (http://www.rase.org.uk/events/conferences/presidents-seminar/index.asp). Sir John received the National Agricultural Award for his services to agriculture at the ceremony. We are very grateful to the RASE for permission to reproduce this paper.

1. Introduction

When I went to University in 1952 food was rationed. We were accustomed to handing over the necessary coupons or a ration book that entitled us, or others on our behalf, to buy the food to which we were entitled. Shortly afterwards rationing came to an end. The initial response was not universal joy but a worry that governments were being irresponsible and we might no longer be assured of the essentials of life. Food security was not just a future issue or one for other people; it was a present practical concern.

When I retired in 1997 agricultural policy sought to limit EU production of cereals by set aside and of milk and sugar by quota. In addition to regulatory restraints on production we spent substantial sums on intervention and export subsidies. It seemed that unrestrained the industry would flood its markets, induce either a catastrophic price collapse or unsupportable budgetary cost.

Today public concern has turned full circle. In real terms food prices have risen, after a half-century of decline. Not long ago Defra minister's speeches highlighted 'sustainability'. Today this has been qualified by 'food security'. The focus is not just sustainable methods of production but increasingly the need for food and farming systems that will provide sustainable and adequate levels of consumption.

This lecture starts with a brief reminder of the extraordinary increase in agricultural productivity that has taken place in the past half-century. That appears to provide good reason to be optimistic about the future. The paper then outlines the multiple reasons for current anxieties. Finally, the paper argues that to enjoy a secure, sufficient and sustainable food supply, the global community must encourage scientific discovery and make careful use of existing and new technologies throughout the food chain; from the farm to the fork.

2. Past successes

The past half-century has witnessed an increase in the supply of food that has often exceeded the growth in demand leading to lower real prices. Food supplies have kept pace with, and at times and in places, outstripped an increase in population from 3 billion to 6 billion in fifty years. In Europe, where consumption per head is already more than needed to sustain health, both supply and demand have levelled off. In the most vulnerable developing countries demand has continued to increase.

Not only has the amount of food kept pace but the quality of the diet has improved. In the poorer countries the consumption of animal products per head has continued to rise although it remains far below that of Europe. Here, the share of livestock and livestock

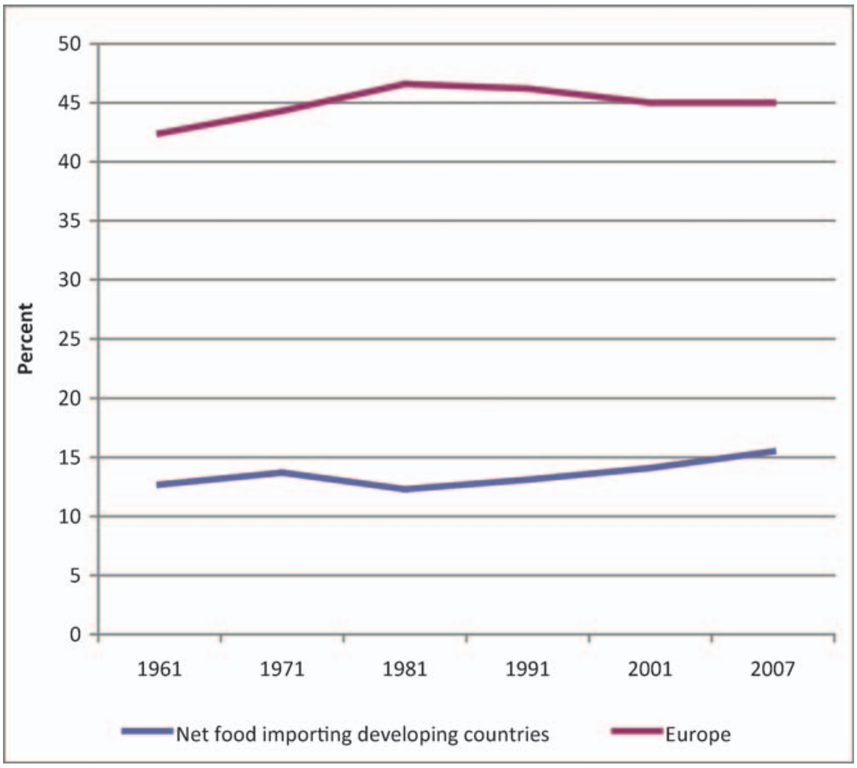

Figure 1: Percentage of Kg/capita/day from animal products
Source: FAO Production Yearbooks

products in total consumption has tended to level off at around 45 kg/cap/day.

Not only has production increased but, resources have been released from farming. A broad indication of the effect of this greater productivity is given by comparing the area of the UK that would have needed to have been planted to deliver the 2009 volume of output if we had only 1946/47 yields.

In the UK and most of the developed world this increase in production has been achieved despite a substantial decline in farm employment.

In the UK the hired labour force has fallen by some 80%. The number of full time farmers has also dropped and an increasing proportion of farms are now part time.

Greater labour productivity on the farm has been possible because jobs that were once done within the farm boundary are now the business of external suppliers. Farmers make use of machinery, fertilisers, purchased feed, pharmaceuticals and improved breeds of plants and animals that are the output of other specialist suppliers. Farm produce, when it leaves the farm gate, is increasingly processed into a diversity of food and other products and reaches consumers, for the most part, through large multiple supermarkets. To make sense of what happens on the farm we have to see it within the context of this larger food chain.

On a global scale, data for land use suggests that there is still a large share of the land area not used for farming. However the most productive land is already in

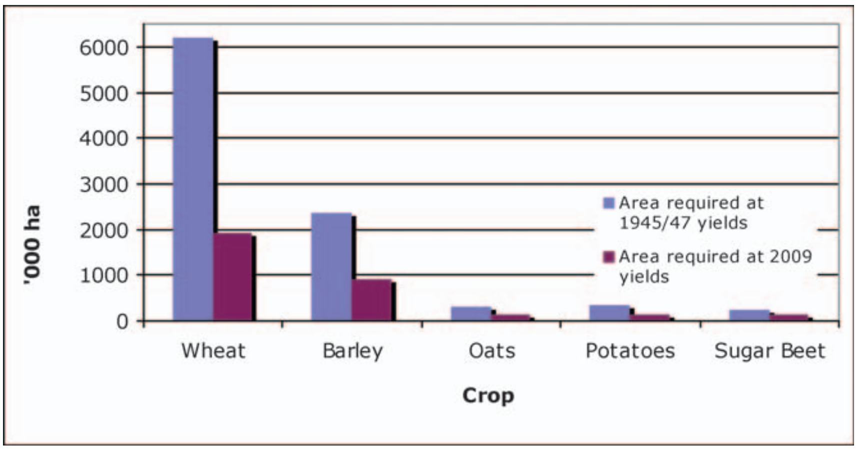

Figure 2: Area required to deliver 2009 levels of output at 1945/7 yields, UK.
Source: Author's calculations based on Annual Cereal Production Survey, Department for Environment, Food and Rural Affairs, UK.

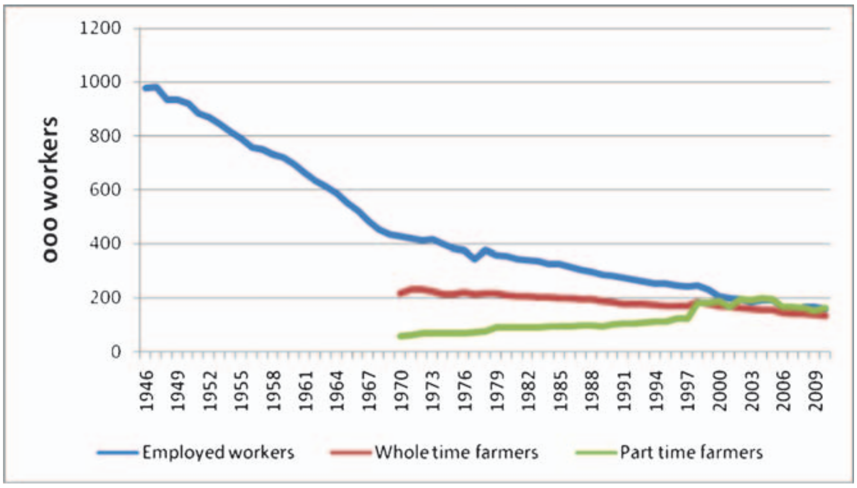

Figure 3: Decline in farm employment, United Kingdom
Source: Agriculture in the United Kingdom, Department for Environment, Food and Rural Affairs.

use and increased area, where it is possible, will not lead to proportionate increases in output. If unfarmed land is brought into cultivation, the environmental cost, in terms of lost forest area, lost habitat and managed water tables is substantial. Still relatively little of the land area recorded forest or grazed rough pasture is suited to more intensive use.

3. Nature's alarm signals

The size of the resource base

The function of farming is to give preference to plants and animals that are of greatest value. In recent decades the volume and value of output from a given area of land has grown through applying new science in a variety of technologies. These include genetic improvement and the use of fertiliser and animal feed. Competing species have been controlled by pesticides and herbicides. The productive potential of the industry has been enhanced by innovations outside agriculture including improved transport infrastructures and the use of IT, what is produced can be more tailored to a diversity of markets and delivered in good condition.

Such high levels of productivity depend upon resources that are non-renewable. The food chain is a major user of energy, mainly from fossil fuels. Growing demand for water for domestic and industrial purposes as well as to supply farm requirements, has already led to some streams running dry and aquifers being depleted at rates that exceed natural replenishment. Increasing production using present production systems will accelerate the decline in reserves of these non-renewable inputs. In resource terms the way we farm now is not sustainable.

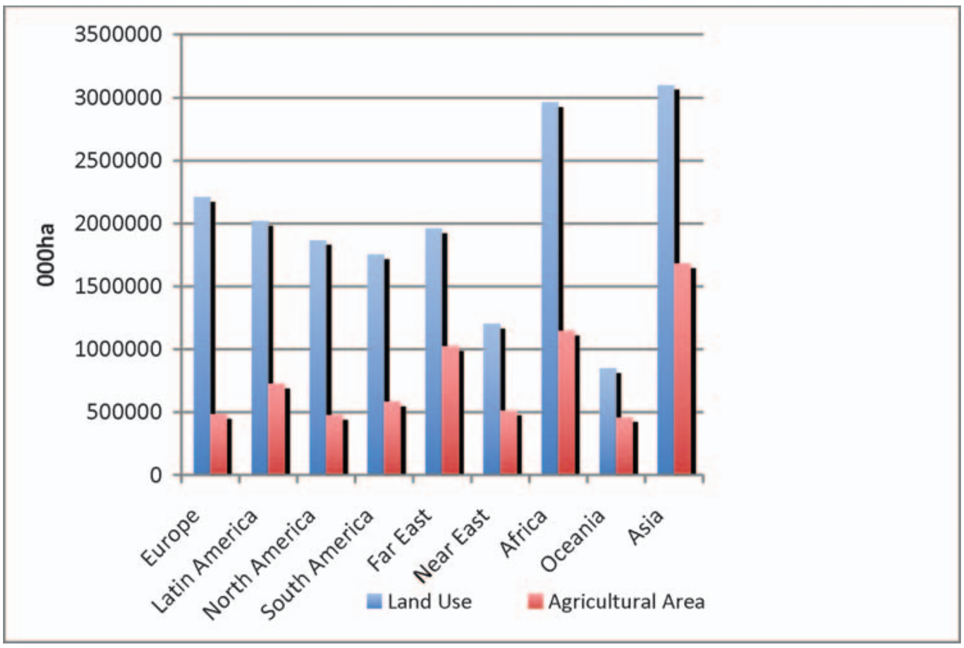

Figure 4: Percentage of land used for agriculture
Source: FAO Production Yearbooks

Damaged resources
Contemporary farming can also damage resources that it is not currently using. Water pollution from run-off fertiliser or animal waste damages aquatic life and imposes heavy clean-up costs on water companies. Inappropriate cultivation leads to soil loss and damages soil quality reducing productive potential. In extreme situations erosion can turn productive land into deserts.

Lost biodiversity
The success of farmers in giving preference to plants and animals that have economic value necessarily changes the underlying ecology of the farmed countryside. Giving preference to 'economic' plants implies lost biodiversity, competing species, both wild and cultivated, may decline below levels critical for survival of the species. Radical changes in habitat destabilise productive systems that traditionally renewed themselves over time. Changes in the balance of soil structure, insect life, plant nutrients and bacterial populations may not only reduce the interest of the farmed landscape but also undermine parts of the natural process upon which farm crops themselves depend.

Climate change
The consensus understanding is that temperatures, which have risen at unprecedented rates in recent years, will continue to rise. In part at least this is attributed to the release of greenhouse gases into the atmosphere as a result of human activity. Such changes will limit food production capacity in some of the major agricultural areas of the world. Agriculture is affected through higher temperatures and major changes in the amount and distribution of rainfall. It is itself a significant contributor to global warming. Attempts to mitigate climate change by limiting the emission of greenhouse gas have to include agriculture. Dairy and beef production are a major source of methane. The ploughing up of previously uncultivated land releases carbon into the atmosphere.

As well as being part of the problem agriculture can also be part of the solution. Plants, especially trees can remove carbon from the atmosphere and biofuels that replace fossil sources of energy help to restrict releases of CO_2.

Policies designed to minimise the release of greenhouse gases and to promote biofuels will condition the economic environment for farming during the coming decades. The impact on food production varies by region but at a global level it will make it more difficult to ensure that food production keeps pace with demand.

4. Social alarm signals

Population growth
Population, some 6 Billion at the turn of the century, is already 7 billion and expected to reach 9 billion by 2050. The increase is likely to be greatest in the poor countries of Africa and Asia where there is already no security of food supply for many people.

In richer countries growth stems more from increased life expectancy than from high levels of reproduction. Not only does a larger population have to be fed but it includes a greatly increased proportion of old people. Such people are vulnerable. They generally cannot generate income from continuing economic activity they impose increasing costs on the public sector for health, pension and welfare.

The impact of rising real incomes
The world's population is not only expected to grow but to become richer. Each generation looks forward to being better off than its predecessors. All governments are expected to foster 'economic growth'. Indeed when the rate of growth falters unemployment and regional inequities threaten social cohesion. Growth can facilitate new, more resource-conserving technologies and it has the capacity to uncover and develop new resources. Without new technology growth that stems from using existing systems more intensely will intensify the problems of resource scarcity.

Rising personal incomes also change the demand for food. Low incomes force people to rely on the cheapest forms of nutrition, mainly vegetable in origin. As incomes grow diet includes more meat and animal products. In terms of nutritional value, animal foods are much more resource intensive. Rising incomes, accommodated by developing technologies have accustomed consumers in rich countries to upgrade their diet by eating more meat. They expect all types of food to be available throughout the year. Processing and distribution systems use resources that simpler systems, where food consumption was more seasonal and local, did not. Whilst such changes may be regarded as 'improvements' in diet they increase the call on resources to feed a given population.

Richer communities also demand more land for activities other than food production. More is needed for housing and the infrastructure of roads and services. Often the land most suitable for development is also amongst the better cropping land. A more affluent and urban population also seeks to impose its views on how the land should be farmed. Farm production is increasingly constrained by a growing array of regulation.

Planning impacts on the freedom of action of farmers
In Sites of Special Scientific Interest, National Parks and Areas of Outstanding Natural Beauty farmers face more detailed requirements and the cost of infringing them may be considerable.

Public goods and private decisions
Traditionally the relationship between farmers and the community has been focused on the price of food and has been regarded as a contest between producers and consumers. Today that is no longer adequate. A richer and more mobile community is not prepared to leave the way in which food is produced to farmers. In addition to food the community benefits from a variety of public goods that are affected by the way land is farmed. These

include accessibility for leisure activities, landscape and the impact of land use on the control of flooding and water storage.

Concerns about food safety

These have led to greater interest in the provenance of food. Supermarket chains need to be sure that the food sold is safe. They seek products that conform to a tight specification, delivered to an agreed timetable and at low cost. They seek to serve market niches such as organic food, locally produced food and ethnic food. They reflect consumers' concerns about animal welfare and the environmental impact. Their purchasing policies substantially determine the shape of the market farmers face.

Apart from market pressures farming is also subject to legislation greatly influenced by concerns of non-farmers. Issues such as wildlife habitat, hunting, animal welfare and battery cages have been highlighted by pressure groups, most of whose members live in towns. Many farmers and country folk share the same concerns but are also aware of the impact of restrictions on farming practice on the viability of many farm businesses. Policies that add to costs but are not applied to competitors may diminish market share, and yet, because products are sourced from farmers in other countries, may simply export the problems they seek to resolve rather than remove them.

Landscapes especially in some of the more mountainous areas are seen as precious and vulnerable. They represent a recreational asset and provide a basis for rural tourism. They depend upon systems of hill cattle and sheep farming that offer low levels of reward to the producer. In response to market forces, younger members of farm families tend to move away and the system that generated the upland landscapes is imperilled. The survival of such systems depends upon income from other sources than the market for food.

5. Political Impotence

The textbook rationale of economic policy is that it exists to correct market failure. Market failure can arise because markets do not effectively relate demand to production. Markets fail where the accumulation of monopoly enables some part of the supply chain to increase profits by shutting out competitors. Where structural characteristics of the industry impede changes in response to new technology or changed markets there is a loss of real income to society as a whole. Market failure arises in agriculture for all these reasons but the most pressing, in recent discussion, has been the failure to value satisfactorily public goods and costs. They provide an orthodox and compelling justification for an agricultural policy that seeks to influence production decisions at each level of the food chain in terms of the entire costs and benefits that are involved.

The Common Agricultural Policy (CAP)

In practice we have the CAP; almost entirely a policy that has become the property of its clients. The economic benefit of the single market, which is the core achievement of the EU, is to allow competition to work. Since the initial member countries had different and generally highly protective agricultural policies the process of creating a single market needed to be phased in, if crises were to be avoided. A CAP is still needed if non-market public goods are to be authentically taken into account as markets become open to competition.

The initial policy resulted in a distribution of benefits between consumers and producers and among member countries that has become entrenched so that change was resisted even when the evidence that a new approach was needed was overwhelming. Throughout the life of the CAP economic growth, technological advance and the opening of world markets demanded sustained structural change if agriculture was to play its full part within the economy of the Union. In fact the policy has continued to support high cost, small scale farming under the label of the 'European Model of Agriculture'. The inability of the CAP to serve the common interest in Europe and to facilitate more internal and external competitiveness has been costly to the rest of the economy but has not removed poverty among farmers and farm workers in substantial areas of Europe.

There is little sign of new thinking in the latest proposals for 2014–20. The proposal to cap benefits to larger producers is yet another way of impeding the adaptation of more competitive systems. The whole business of attaching conditionality to single farm payments reeks of the costly dirigisme that keeps bureaucrats employed at considerable cost to the rest of us. The policy betrays the capacity of pressure groups that have no actual responsibility for running a farm, to influence the terms on which EU farmers operate in a negative manner.

The international dimension

Many of the threats to the world's ability to feed itself can only be credibly tackled on a global basis, not least the issues of energy; its supply, use and generation and the complex problems of living with and seeking to mitigate global warming. The record is not reassuring.

The Doha world trade talks seem to have run into the sand, despite the clear evidence that opening up markets has been one of the primary drivers in achieving real economic growth. Tangles of conflict between national interests and pressure group positions seem to have overwhelmed the important benefits that further moves towards freer trade can still offer.

Similarly international conferences on climate change are more powerful in their rhetoric than in their achievements. There is a deep asymmetry between the commitments made and the progress achieved. This may reflect the sheer magnitude of any effective attempt to reduce emissions in terms of its overall economic impact.

Again conceptually policy intervention seems to be the right way to cope with market failure but in practice, if effective action is not taken by all countries, policy failure may exacerbate problems rather than relieve them.

6. Knowing more

In the years following the Second World War government policy focused on increasing output by the development and application of new productivity increasing technology. In addition to public support for research, resources were deployed to encourage its uptake on farms, in part by subsidies on inputs and prices and in part by advisory services. Much of that machinery has now disappeared but the need to achieve its goals, through appropriate but different mechanisms, is equally pressing.

Reasons for hope

There is no reason to believe that we have reached the end of productivity increasing technology or that we have yet fully applied all we know. In many ways the potential seems greater now than it has ever done before. Today innovation results less from the efforts of extension agencies and much more in the course of trade. Seed breeding companies push forward varieties that perform better. Major developments in the genetic potential of farm animals are the product of specialist companies. Developments emerging from IT and the machinery world make possible precision farming. It is the retail sector that identifies and develops characteristics of products that consumers prefer and makes these preferences effective through linkages with farmers and farming groups.

Innovation on this scale can change the face of farming very rapidly. It is likely to give only secondary consideration to the impact on non-market values. This has become an important responsibility of government. Policy needs to ensure that considerations such as environmental impact and social consequences shape the decision framework within which commercial decisions are taken.

Applying known technology and adopting new methods demands of both government and industry a profound understanding of the processes and their impact on the natural and social environment. Sustaining the scientific capacity of both the industry and government becomes ever more important as the power of new methods to transform landscapes, habitats and the shape of the food and farming industries increases.

As scientific understanding grows it opens up fresh areas in which further research can lead to greater ability to manage the resources we have. At this level there are solid grounds for optimism. In several fields we stand at the threshold of new radical developments.

Developments in genetics have already enabled us to understand how inherited characteristics affect the health, growth and conformation of plants and animals. In doing so it not only enables us to recognise and cope with emerging problems but to breed resistant varieties. Using genetic markers we can be much more precise in securing the target characteristics we value. Using genetic modification we can tailor plants to cope with situations where traditional varieties would be unable to survive.

The development of nano-materials is at an early stage but offers potential for the more effective use of the resources we have in combatting disease and developing more efficient ways of using finite resources.

The development of IT has already changed the way we communicate, the systems we use to control processes and our ability to handle rapidly vast quantities of data. Scientific discovery in this area continues apace and its application into the things we use and the way we behave in our daily lives occurs at a pace many people find disconcerting.

Making use of scientific discovery demands an awareness both of the progress of science and of the world in which it is to be applied. In effect this translates science into technology. If we are to benefit from investment in research we need applied scientists as well as those engaged in more fundamental, pure research. We also need means of bringing new technology into action.

Much new technology becomes effective in agriculture in the form of new, improved inputs, whether of machines, seed or more productive breeding stock. Its application can sometimes take place within existing farming systems and requires no major changes in farming practice. However, much new technology can only be fully exploited by changes in the current structure. We have seen this in the changes in the farm labour force, the consistent move towards larger scale enterprises and the more tightly linked relationships between farmers and their suppliers and customers.

Such changes have impacts on society. In rural communities the pattern of employment has changed. The impact of large-scale arable farming has changed the face of the countryside in major producing areas. New crops appear with major impact on the seasonal appearance of the farmed landscape. New farming methods raise ethical questions about how we treat animals and the exclusion of non-competitive plants and animals. New science and the emergence of large scale animal production raise issues about the safety of food and raise concerns about the loss of variety in the diet as well as biodiversity in the countryside.

In practice our ability to capture and apply new science depends not only on the work of discovery and application to production but on society accepting changes that may be uncomfortable and to some seem potentially threatening. In understanding how such values develop and become powerful we need not only natural science but social science as well.

Facing up to risk

New technologies involve risks, some known and others not yet recognised. We can seek to understand the significance of known risks by calculations of probability. This may give an objective valuation but it may not lead to acceptance. Some risks may be very remote but their potential raises dread to such a level that a new technology will be rejected.

Less readily recognised but potentially of equal concern are the risks involved in not taking action. Reluctance to tolerate risk can waste opportunities to use resources more efficiently. It may also result in benefiting companies in other countries where the risks are accepted.

In such a situation it is important that there should be a monitor whom people trust. In the USA the Food and

Drug Administration seems to possess such authority. In the UK the Food Standards Agency should possess such a role but its advice is often contested by pressure groups that exercise substantial public credibility.

Putting new science into practice

The time span between committing resources to research varies but is often to be measured in decades rather than years. Thus under financial pressure cutting research is attractive – it appears to have little negative impact and makes the accounts look better. In the private sector competition can encourage research when business is good but lead to its abandonment in hard times. Maintaining continuing research, especially more fundamental research, depends heavily on public funding and on funding by private charities. Governments find it hard to fund research where the immediate benefit may be seen in larger profits of private companies. However if a gap is allowed to develop between discovery and application the substantial initial commitment may not deliver the benefits to which it can give rise.

Progress in science that leads to new technology also has to pass the test of public acceptability. It is reassuring that the research community now devotes substantial resources to communication. Pressure groups, who claim to speak for the public, occupy an important place in assessing and interpreting new technology but they also have agendas of their own. Fear is a powerful salesman used by both the media and pressure groups. Stories that all is well or that the risks are negligible are boring. Stories that discredit opposing views catch headlines and influence public judgements. Recent experience relating to climate change has shown how damaging it can be if scientists even appear to cover up information inconsistent with the view it is seeking to explain.

7. Making it happen

The purpose of this lecture has been to recognise that despite past achievements we face a truly challenging task to achieve an acceptable level of food security in the future. It is equally to suggest that there are solid reasons why, if we are prepared to invest in and apply new technology we should not achieve a secure supply of food during the coming century. To make it happen implies a readiness to change that affects every part of society. The discovery and application of new technology involves the whole food chain and the policy community.

Fundamental research makes radically new approaches that may solve old problems possible. The benefits will only be realised if its relevance is recognised. They become effective as they enter into the economic and environmental of business and government. One of the attractions of Agricultural Economics for me and many colleagues was that it was possible both to work in a university and be engaged with the actual issues of management and policy. We were not only concerned with elegant models but with helping government and business to make better decisions. The decline of state advisory systems and the impact of the Research Assessment process in universities have weakened this link. It is reassuring that the Research Councils have taken on board this need. It will however take time in many areas of science for applied science to be equally highly regarded with more fundamental studies.

Society derives benefit from discoveries that can make food production more sustainable only when they are implemented by industry. The market can reward farmers for innovation but this is only part of the benefit or the cost of change to society. This means that new methods often have to face a regulatory hurdle and may only be adopted if they pass the test of both commercial profitability and public acceptability. Attempting to make the social costs and benefits of industrial activity figure in private decisions is complex and controversial. To do so by legislation that reaches the stage of micromanagement of an industry is likely to be clumsy and prove costly. More may be achieved if in the process of disseminating new systems investors recognise the importance of such considerations and incorporate them into their plans.

The media play a major role in the public understanding and acceptance of new technology. It is a misfortune that recent history has been scarred by phrases such as 'Frankenstein foods' and promises of 'miracle drugs'. Such hyperbole sells newspapers and attracts viewers but is deeply damaging to our society. The distortion of the debate that ensues delays and makes more costly technological improvements that may be vital for sustaining a secure food supply. It is good to be able to recognise many excellent science based television programmes that share not just 'facts' but convey the excitement and interest scientific endeavour.

In the formation of policy agricultural and food industries pressure groups play a vital role. The most effective engage in science as well as expressing views about science done elsewhere. Necessarily they exist to promote a particular view or interest. That will not matter if they operate within a science environment in which their views are robustly challenged. Part of the need for public investment in science is to enable government to take a balanced view of proposed innovation. If this is missing powerful pressure groups may exercise undue influence over the policy process.

The government has both to recognise the limits of what can be achieved by policy and to provide leadership in thinking about what policy can achieve. Freedom of action is increased where there is a common understanding of the issues. The recent publication on the Future of Food and Farming may not have offered new prescriptions but by focusing minds on the long-term significance current decisions it has enriched the debate on decisions that have to be made today.

From its birth the Royal Agricultural Society of England has had 'Practice with Science' as its major purpose. That has never been more needed than now. It is my privilege in this lecture to be able to emphasise its relevance and its contribution not just to the welfare of agriculture but for the whole of our global community.

About the author

Professor Sir John Marsh (john.marsh27@ntlworld.com), winner of the 2011 National Agricultural Award

of the Royal Agricultural Society of England, is an Emeritus Professor of the University of Reading. He was appointed a Research Economist in 1956 and became successively Lecturer and Reader in Agricultural Economics at the University of Reading. In the 1977 he was appointed Professor of Agricultural Economics in the University of Aberdeen and Chairman of the North of Scotland College Economics Group. Between 1984 and 1997 he was Professor of Agricultural Economics; Dean of the Faculty of Agriculture and Food 1986–1989, Head of the Agricultural Economics and Management Department 1985–1991 and Director of the Centre for Agricultural Strategy 1990–1997.

From 1969–1984 he was Secretary to the Agricultural Economics Society and its President in 1985–1986. He is an Honorary Fellow of the Royal Agricultural Society and a Fellow of the Institute of Biology. He is Chairman of the Council of RURAL, (the Society for the Responsible Use of Resources in Agriculture and on the Land), he is Chairman of the Board of the Centre for Dairy Information; a former governor of the Royal Agricultural College, Cirencester, and of the Scottish Crop Research Institute. He is the immediate past President of the British Institute of Agricultural Consultants (BIAC). He was Deputy Chairman of Defra's Science Advisory Council and has acted as specialist adviser to several parliamentary select committees. His academic interests include agricultural and food policy, the development of the common agricultural policy, and the role of research in economic development. He was awarded the CBE in June 1993 and Knighted in the Queen's Birthday Honours List in 1999.

An economic analysis of the Irish milk quota exchange scheme

THIA HENNESSY[1], DORIS LÄPPLE[1], LAURENCE SHALLOO[2] and MICHAEL WALLACE[3]

ABSTRACT

In Ireland, the trade of milk quota is subject to regional restrictions and a large variation in quota prices between regions has caused some controversy. This article investigates this issue by analysing the functioning of the Irish milk quota exchange market. For this purpose, the economic value of milk quota is estimated using an optimisation framework. The estimated values are then compared to milk quota prices paid at the exchange market. The analysis reveals that quota is undervalued in the border, midlands and west and south-west regions, while milk quota is overvalued in the east and south regions. This implies that farmers in certain regions overpay for additional quota, while other farmers secure good value for their quota investments. The paper concludes by discussing that the identified regional differences are only partly explained by economic and production factors.

KEYWORDS: Milk quota trade; optimisation modelling; dairy production

1. Introduction

It is well understood and supported by many economic studies that quotas introduce inefficiency in a sector but that this inefficiency can be reduced if the quota is traded freely between producers (e.g. Colman, 2000; Hennessy et al., 2009). Despite this, few Member States of the European Union (EU) permit open trade in milk quotas. Quota trade restrictions come in the form of regional restrictions, quota price cooling mechanisms, taxes on transfers and so forth (e.g. Bogetoft et al., 2003; Colman, 2000). These restrictions are mostly motivated by social goals but they have economic consequences that affect the efficiency of the dairy sector, the functioning of the quota market, the price at which quota is traded and ultimately farmers' welfare.

The EU dairy sector has been restricted by milk quotas since 1984 in order to limit public expenditure on the dairy sector, to control dairy production, and to stabilize milk prices and the incomes of dairy farmers (EC, 2009). The abolition of milk quotas in 2015 was first stipulated at the Luxembourg Agreement of the Mid Term Review of the Common Agricultural Policy (CAP) in 2003, and the abolition of milk quotas has been confirmed at the subsequent Health Check of the CAP (EC, 2009). In order to prepare the sector for the imminent removal of milk quotas, national milk quotas increase by 1% annually from 2009 to 2013.

The removal of milk quotas is expected to have large implications for the dairy sector, as for the first time in over 25 years, dairy farmers will be able to expand milk production without restrictions. However, still being subject to quota restrictions, dairy farmers face difficult decisions whether and when to expand milk production. Increasing milk production by acquiring additional quota on the milk quota market is a difficult decision for dairy farmers, since the economic consequences of this decision depend on the future profitability of dairy farming (Hanson, 2009).

In this analysis we study the Irish milk quota market. The exchange of milk quota in Ireland has been allowed since the beginning of 2007, but the ring-fencing of quota in general, and the large variation in milk quota prices in particular, has been the subject of considerable controversy in Ireland. Many theories have been postulated as to why the large variation in quota prices exist, however there has been no empirical analysis of this issue to date. On the one hand the economics of milk production in the various regions may justify the price differential; however there may also be an element of farmer behaviour or regional idiosyncrasies at play.

The objective of this paper is to investigate the functioning of the Irish milk quota trading scheme by comparing the estimated economic value of milk quota to actual trade prices observed at the milk quota trading scheme. The purpose of this analysis is to identify whether quota is over- or undervalued in certain regions. The results of this analysis are relevant to policy makers as they allow suggestions as to where milk production is likely to move after the abolition of quota. Further, the findings are also of relevance for farmers wishing to expand milk production. The results can serve as a decision tool whether to invest in quota or to wait until quotas are abolished.

Following the introduction, the Irish milk quota trading scheme is outlined. Next, the details of an empirical model that is developed to estimate the economic value of milk quota are presented. In section

[1] Rural Economy and Development Programme, Teagasc, Athenry, Co. Galway, Ireland
[2] Moorepark Research Centre, Teagasc, Cork, Ireland
[3] School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Ireland.

4 the data are described. The subsequent section presents the results, followed by some final conclusions.

2. Background

In Ireland, the transfer of quota between farmers has been permitted since the late 1980s but such transfers were highly regulated and mostly attached to land. In 2007, a new milk quota allocation scheme has been introduced allowing farmers to make permanent quota transfers separate from land. The quota allocation scheme can be divided into three schemes: the milk quota trading scheme, the temporary leasing scheme and the reallocation of unused quota. Since the milk quota trading scheme is the main scheme by which quota can be allocated to different producers, the focus of this study is on the milk quota trading scheme.

The milk quota trading scheme is operated on a biannual basis and takes place at the beginning and in autumn of each year. Each of the approximately 30 dairy processors (co-operatives) operates a ring-fenced quota exchange, i.e. quota cannot be moved from one exchange to another. Farmers give a single-bid, stating price and quantity that they are willing to sell or to buy. The equilibrium price at which quota is traded is subject to some intervention and market cooling mechanism. For example, 30% of the milk offered for sale is transferred to a priority pool sold at a fixed price to successors, new entrants or lost leases. This implies that the scheme consists of a priority pool and a market exchange. All offers to buy and to sell are entered into the exchange and the initial equilibrium price is calculated as follows: only 70% of the quantity offered will be considered for the equilibrium price calculation as 30% of the quantity offered goes directly into the priority pool. Next, all offers and demands are ordered on the price quoted. Offers are added up from the lowest price, while demands are added up the opposite way. The initial equilibrium price is either the price at which the quantity offered equals the quantity demanded or, if that price does not exist, the price with the least difference between the two quantities where demand exceeds supply (DAFF, 2011a). After the initial equilibrium price is calculated, all bids that exceed the calculated price by 40% or more will be removed and the price is calculated again without those offers. This is the final market clearing price at which milk quota is sold. All offers to sell quota at or below this price will be sold at the market clearing price and similarly all bids to buy quota at or above the market clearing price will be accepted. The remaining offers and bids will be rejected (DAFF, 2011a). The market clearing prices differ significantly between the co-operatives, as can be seen in Figure 1.

Buyers and sellers face certain rules when participating in the milk quota trading scheme. For example, if all or parts of the milk quota are sold, the farmer is not allowed to purchase, lease or receive any milk quota for a period of three years. Further, the milk allocated to the priority pool will not be returned to the farmer, even if the offered quota fails to sell. Buyers are subject to quantitative restrictions. The maximum quantity that can be purchased in each milk quota trading scheme is limited to 100,000 litres since 2010, which increased from 80,000 litres in 2008.

While the milk quota trading scheme is operated in advance of the relevant milk quota year, Irish farmers also have the option to avail quota during the milk quota year with the temporary leasing scheme. Producers have the opportunity to lease the part of their quota which they will not use during the current milk quota year into their co-operative pool. In turn, producers who require additional quota can apply to lease quota from the pool (DAFF, 2011b).

Finally, there is also the possibility to receive quota at the end of the milk quota year through the reallocation of unused quota. This scheme is designed for the event of a production level that exceeds national quota, and unused quota is then reallocated to eligible over-quota producers.

3. Empirical Approach

A cross-sectional farm level dataset is used in an optimisation framework to estimate the economic value of quota. Hennessy et al. (2009) used Irish National Farm Survey (NFS) data and FAPRI-Ireland price projections to estimate the economic value of milk quota in Ireland. Here a similar methodology is applied but the model is re-specified to simulate as closely as possible the conditions of the milk quota trading scheme as it is operated in Ireland.

The model structure is as follows. The objective function of an individual farmer, denoted by subscript i, is expressed as:

$$\underset{Q_i}{Max}\,\Pi_i = \sum_{t=0}^{T} \frac{1}{(1+r_i)^t}[\pi(M_{it}) - P_t Q_{it} - C(Q_{it})] \qquad (1)$$

where Π_i represents the net margin of farmer i, r is a discount factor, π denotes the gross output from milk quota (M_{it}) in period t, Q_{it} denotes the quantity of quota farmer i decides to purchase or sell in period t, and P_t and C are the associated price and quantity.[4] This implies that the second component in the square brackets in equation (1) is the quota investment in period t which is simply the price of quota in that period times the quantity of quota purchased and the final component represents adjustment costs to the farmer. The farmer chooses a quantity Q_{it} of quota to purchase (or sell) in each period (year) that maximises a discounted stream of annual net margins between the current period $t=0$ and the period when quota is abolished, $t=T$. The solution to equation (1) represents the demand or supply of milk quota by farmer i in each time period associated with expansion of milk production by amount Q_{it}. Adjustment costs include for example, additional housing, land, labour, etc. In the case where a farmer sells quota, the cost of quota includes the margin foregone due to the reduction in milk production less the net margin gained from reallocating resources to the best alternative enterprise.

Since it is assumed that milk deliveries M_{it} are equal to the farm's milk quota in period t, then:

[4] To avoid notational clutter the profit function displays only milk quota (M_{it}) in its argument. It also comprises a vector of other factor inputs as well as cost and revenue coefficients.

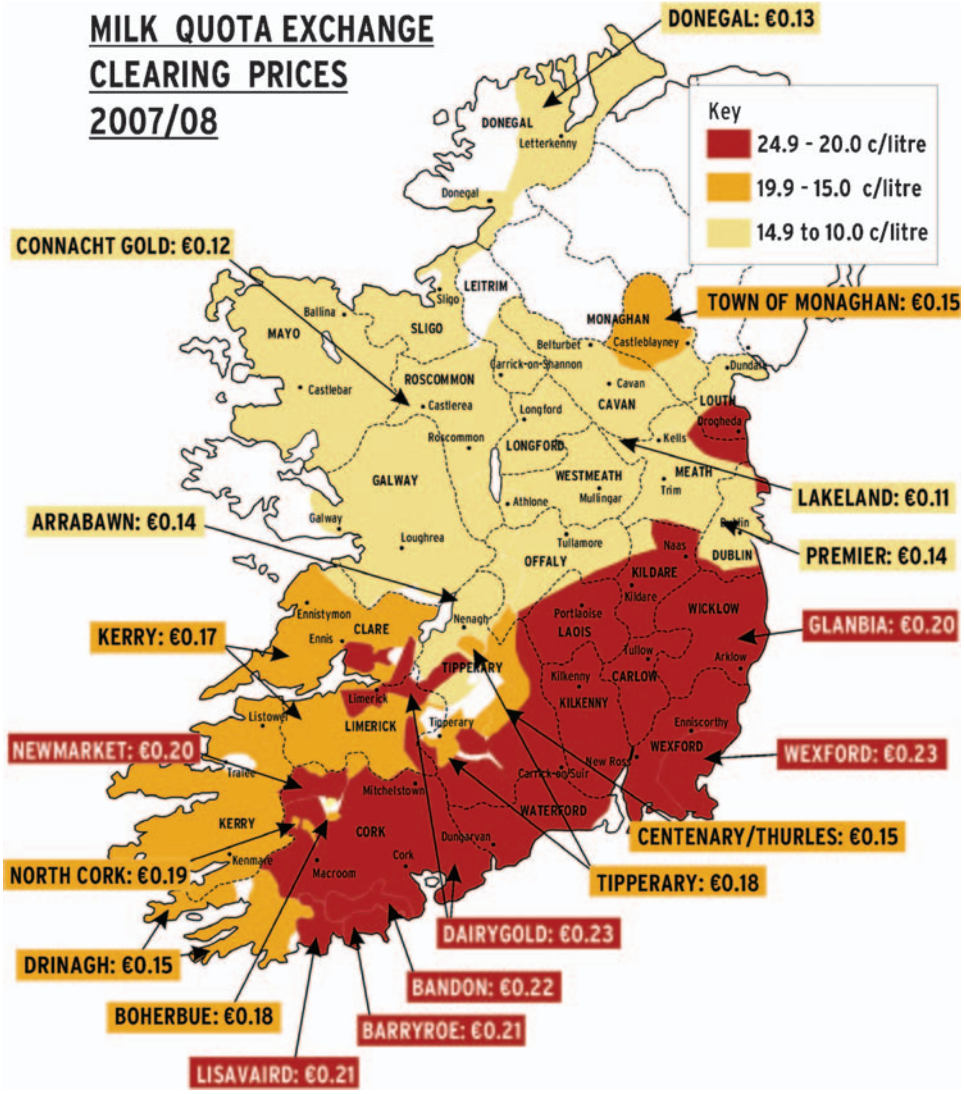

Figure 1: Milk Quota Exchange Clearing Prices

$$M_{it} = M_{it-1} + Q_{it.} \tag{2}$$

Thus milk deliveries in period t are equal to milk deliveries in period $t-1$ plus quota purchased (or less quota sold) in period t. Equation (2) therefore defines the quota constraint that limits the farmer's optimisation problem. The Lagrangian for farm i's maximisation problem is:

$$L_i = \sum_{t=0}^{T} \frac{1}{(1+r_i)^t}[\pi(M_{it}) - P_t.Q_{it} - C(Q_{it})] + \sum_{t=0}^{T} \lambda_{it}(M_{it-1} + Q_{it} - M_{it}). \tag{3}$$

Here λ_{it} represents the marginal value to farmer i from relaxing the milk quota constraint by one unit - the shadow price of milk quota - specifying the marginal effect of an increase in M_{it} on the value of the farm's discounted net margins between $t=0$ and $t=T$ discounted to time 0. The economic value of quota is derived based on the aggregated effect, as explained in the following paragraphs.

The constrained optimisation problem defined by equations (1) and (2) is solved using estimates of farm level adjustment costs, price and cost projections coming from the FAPRI-Ireland model (Binfield et al., 2008) and NFS (Connolly et al., 2007) data for Ireland. Estimates of the marginal revenue product (economic value) of milk quota are derived for a sample of dairy farms for the period up to 2015. In this analysis it is assumed that the national milk quota remains binding up to 2015 and therefore the quota produces a profit up to and including the year 2014. Aggregation of these results generates an empirical estimate of the aggregate demand for milk quota, while the distribution of farm reservation demands against existing holdings of quota indicates the trades of quota between farms. Within the model each farmer's purchase is limited to 80,000 litres to reflect the constraints imposed on quota purchase in the 2008 milk quota exchange.[5]

In this analysis it is assumed that farmers increase milk production on a phased or incremental basis. They begin by increasing the dairy specialisation of the farm, by removing all male animals from the farm and

[5] Please note that our analysis refers to the milk quota market in 2008, and the limit to buy quota was 80,000 litres in 2008. Our analysis is based on 2008 as milk prices in 2009 were at an unusual low level, thus unlikely to provide a representative analysis of the quota market.

retaining only dairy cows and replacements. This is considered the low cost stage of expansion. Once this stage of expansion has been exhausted, farmers will move beyond their own resource base and rent more land and acquire additional resources. This is considered the high cost stage of expansion. The extent to which farmers can expand at the different stages is estimated for each farmer in the NFS on the basis of their livestock numbers and land area. The costs associated with the two stages of expansion are taken from Shalloo and Dillon (2006). The full details of costs associated with each stage of expansion are outlined in Appendix A. It should be noted that the analysis does not factor in the possibility of expanding milk production by changing the production system, i.e. moving to a more intensive production system or a higher genetic merit cow.

The demand and supply price of milk quota is estimated for each farmer in the NFS. The 2008 economic value is estimated, this estimate is based on the net margins earned from each unit of quota in every year from 2009 to 2014 inclusive. Farms are grouped according to their geographic location and individual farm demand and supply prices are summed using the NFS weights to arrive at aggregate supply and demand curves for milk quota in various regions. The intersection of regional supply and demand curves are interpreted as the economic value of quota.

4. Data

In the analysis of economic value of quota, data on all manufacturing milk dairy herds in the NFS[6] dataset are used; this consists of 343 farms that are weighted to represent the national population of 19,600 dairy farms (Connolly et al., 2007). The NFS collect enterprise specific variable costs but fixed costs are recorded on a whole farm basis. For this analysis total costs are considered, although excluding the cost of owned resources such as land or family labour. Fixed costs are allocated to the dairy enterprise on the basis of gross output share. All technical coefficients, as recorded by the NFS, are assumed to remain static over the period.

To simulate the milk quota exchange scheme as closely as possible the sample of dairy farms are disaggregated by region. While it would be desirable to represent all exchange schemes, the dataset is neither sufficiently large nor geographically representative to enable such an analysis. Instead, the dataset is disaggregated into four regions: border, midlands and western (BMW), the south-west (SW), the east and the south.[7] Each of the four regions has unique characteristics regarding dairy production. While the south and the south-west are mainly dairy production regions on good soils, the BMW region is characterized by lower stocking density based on poorer soils and higher rainfall areas.

[6] The NFS is a member of the Farm Accountancy Data Network of Europe. A stratified nationally representative random sample of approximately 1,200 farms is surveyed annually.

[7] BMW region = Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan, Galway, Mayo, Roscommon, Longford, Offaly, Meath, Westmeath and Dublin. South-west region = Kerry, Clare, Limerick and Tipperary. East region = Kildare, Wicklow, Laois, Carlow, Kilkenny and Wexford. South region = Waterford and Cork.

Table 1 presents some summary statistics for the four regions. For comparative purposes direct costs, gross and net margins are presented in a per litre figure. Direct costs represent the dairy production costs, such as feeding stuffs, fertilisers and veterinarian costs. Gross margins are defined as gross output minus direct costs, with gross output being total milk sales less purchased livestock. Net margins are calculated as gross margins minus overhead costs of production and include for example depreciation of machinery, buildings and land.

With a total quota size of 1,382 million litres, over a third of the national quota is located in the south region. Farms in the BMW region are characterized by smaller herds and smaller milk quota sizes per farm in comparison to the remaining regions.

On a gross margin basis, the east region has the highest profitability, with a gross margin of 17.3 cent per litre; however when overhead costs are factored in and net margin is considered the south-west is the most profitable region with an average net margin of 7.4 cent per litre. The east has the largest expansion capacity on existing resources with the average farm having capacity for 24 additional cows. The expansion capacity is based on the assumption that half of the cattle herd is replaced by dairy cows, while also considering replacement of the current dairy herd.

In terms of milk prices, it is evident from Table 1 that farmers receive different milk prices in Ireland[8]. This is due to different prices paid by the various co-operatives. For example, farmers in the south region generally receive higher milk prices than farmers in the remaining regions. Further, farmers in the BMW region get paid less for their milk than farmers in the south-west and east region.

Figure 2 presents the milk price projections under a baseline policy scenario; this assumes that milk quotas remain in place and binding until 2015. Data for 2006 to 2010 are actual average national farm level milk prices (Donnellan and Hennessy, 2011). Prices from 2010 to 2014 are projections produced by Binfield et al. (2008) using the FAPRI-Ireland model.

5. Results

Development of Quota Prices

Before presenting the estimates of the economic value of milk quota, the development of milk quota exchange prices is explored. Individual data on quota trade prices are available for the main co-operatives, see Table 2. For the purposes of this analysis the co-operatives are grouped into four regions as described in section 4. The average quota price for each region is calculated as the quota price weighted by the volume of milk sold in each co-operative.

As is evident from Table 2, there is a large variation in market quota clearing prices between the regions. For example, in the fourth exchange market quota clearing prices ranged from 17 cent per litre in the BMW region to 41 cent per litre in the south region. Further, there is a noticeable tendency toward decreasing quota prices over time, which is explained by the approach of the abolition of milk quotas. The development of the

[8] In late February 2012 €1 was approximately equivalent to £0.85 or U$1.35 (www.xe.com)

Table 1: Regional Variability – Summary Statistics

Summary Statistics	BMW *N*=65	South-West *N*=76	East *N*=80	South *N*=122
Weighted population	4,893	5,961	2,796	5,949
Percentage of national quota (%)	22	29	15	34
Total Quota (millions of litres)	894	1,175	610	1,382
Quota size (litres)	182,000	197,000	218,000	232,000
Deliveries per cow (litres)	4,740	4,330	4,570	4,700
Number of dairy cows	35.4	44.0	45.7	46.4
Milk price received (€)	0.261	0.263	0.263	0.265
Direct cost per litre (€)	0.112	0.102	0.102	0.110
Gross margin per litre (€)	0.169	0.166	0.173	0.156
Net margin per litre (€)	0.062	0.074	0.068	0.061
Expansion capacity (cow numbers)	11	15	24	16

Source: National Farm Survey (2007)

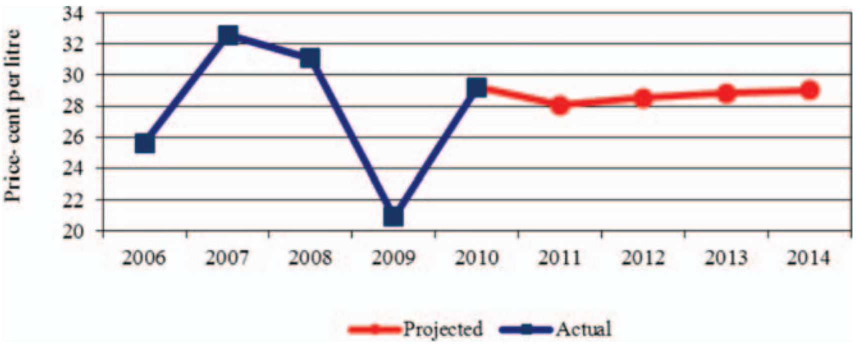

Figure 2: FAPRI-Ireland Farm-Level Milk Price Projections for Ireland

various prices is depicted in Figure 3. This figure presents the average market quota clearing price for each region and the national average milk price that prevailed at the time of each milk quota exchange.[9]

The milk quota prices follow the development of milk prices quite closely, although to a lesser extent in the BMW region. Overall, quota prices peaked at the fourth exchange which took place at the beginning of 2008. In 2007, the national average farm level milk price was over 30 cent per litre and remained at this level in early 2008. However, a significant drop in milk prices occurred in the latter half of 2008 and milk prices decreased to an average of 20.9 cent per litre in 2009. As can be seen, quota prices collapsed in the fifth exchange, autumn 2008, following the milk price decline.

Economic Value of Milk Quota

Figures 4a and b present the estimated milk quota supply and demand curves for trade occurring at the end of 2007 for the four regional quota markets, i.e. 2008 is the first year the quota provides a return and seven years of return are produced from 2008 to 2014 inclusive. These figures are derived from the previously explained optimization model (see section 3) and show the estimated overall quantity traded in the region (x-axis, volume litres) and the estimated milk quota price (y-axis). The intersection of the estimated demand and supply curve is interpreted as the economic value of milk quota for the specific region.

[9] The three months average milk price preceding the quota exchange scheme is used.

The results show that the estimated equilibrium economic value for milk quota in the BMW region is approximately 21 cent per litre compared to a milk quota price of 26 cent per litre in the east. The results from the optimization model also show that the markets in the south-west and south have a higher quantity of milk quota traded and the equilibrium values are also estimated to be higher. Our model predicts the highest milk quota equilibrium price in the south-west region with 35 cent per litre. The corresponding milk quota equilibrium price in the south is 29 cent per litre.

The variation in the estimated economic values of quota in the different regions is driven by the profitability of milk production in the region and the farm structure. More specifically, the supply price for milk quota is derived from net margins, which implies that farmers in regions with more profitable milk production are also looking for higher prices when intending to sell milk quota. Clearly, profitability of milk production is highly dependent on milk prices. The milk quota market is also influenced by the expansion capacity of farms, which indicates that farmers with lower expansion costs are also able to offer higher prices for additional quota. Further, the quantities demanded and supplied in the different regions also impact on the estimated economic values of milk quota.

In line with the actual milk quota exchange prices (see Table 2), our optimization model results also show considerable variation between the regions. The south-west region, for example, has the highest equilibrium price with 35 cents per litre (see Figure 4b), which is driven by the highest net margins of the four regions

Table 2: Milk Quota Exchange Clearing Prices for Selected Co-operatives

	2007/08		2008/09		2009/10		2010/11
Exchange Closing date for bids	1st 10/06	2nd 01/07	3rd 10/07	4th 01/08	5th 10/08	6th 01/09	7th 10/09
Co-operative							
Border, midlands and western							
Arrabawn	14	16	24	29	21	13	0
Connacht Gold	12	10	12	14	13	10	5
Donegal	13	12	13	14	10	0	7
Lakelands	11	11	13	14	14	10	5
Town of Monaghan	15	16	20	20	14	10	0
Average price	**13**	**14**	**15**	**17**	**16**	**11**	**5**
East							
Wexford	23	28	29	36	37	10	11
Glanbia	20	21	31	37	32	18	12
Average price	**20**	**21**	**31**	**37**	**32**	**17**	**12**
South-west							
Kerry	17	16	20	27	20	11	5
Dairygold	23	26	45	45	40	16	12
Tipperary	18	18	25	30	29	25	16
Average price	**20**	**21**	**28**	**38**	**30**	**15**	**10**
South							
Dairygold	23	26	45	45	40	16	12
Glanbia	20	21	31	37	32	18	12
Bandon	22	24	36	42	0	24	17
North Cork	19	20	30	29	19	0	0
Average price	**22**	**23**	**37**	**41**	**35**	**17**	**12**

All prices are milk quota prices expressed in cent per litre.
Source: Irish Department of Agriculture, Fisheries and Food

and, in addition, almost 30% of milk quota is located in this region (see Table 1). The south region, with an economic value for milk quota of 29 cent per litre, has the second highest value for milk quota (see Figure 4b), which is explained by the fact that this relatively small region holds over a third of the national quota. Further,

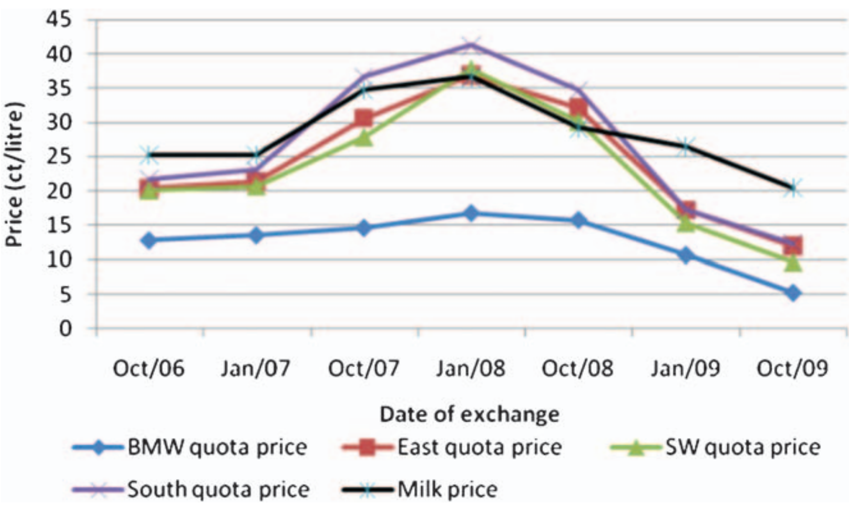

Figure 3: Development of Prices by Region

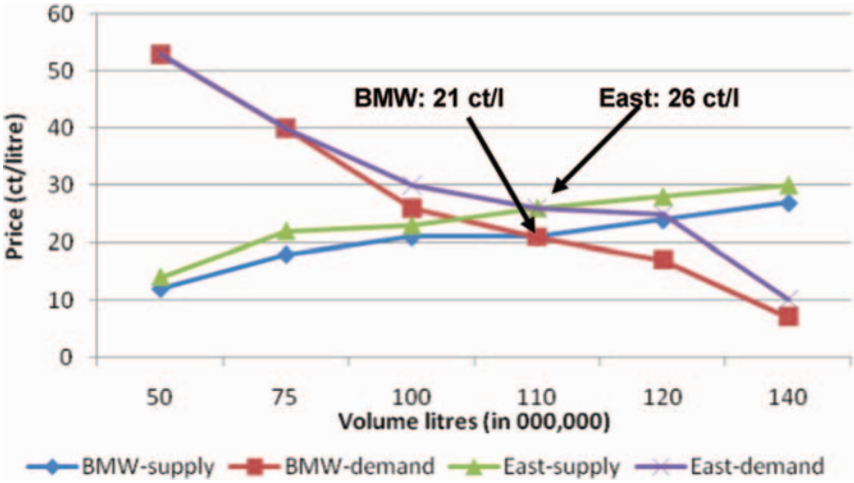

Figure 4a: Regional Milk Quota Market – BMW and East Region

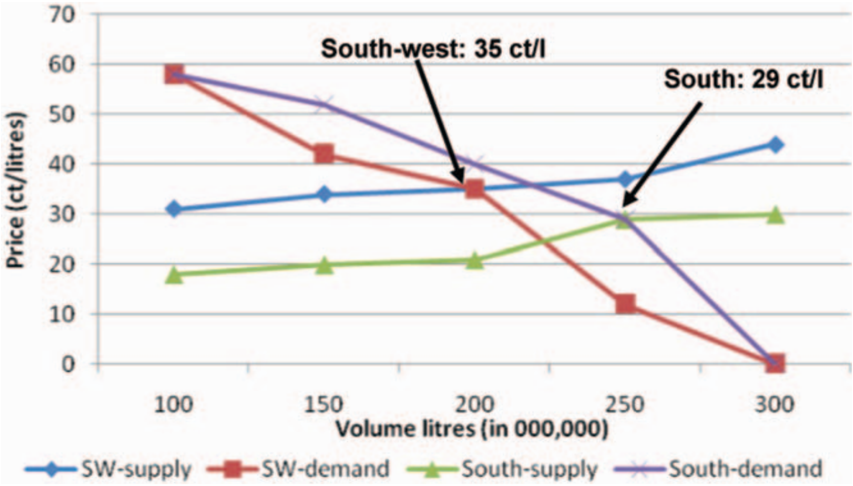

Figure 4b: Regional Milk Quota Market – South-west and South Region

milk prices received in this region are higher than in the remaining regions. In the east region (see Figure 4a), the estimated economic value of milk quota of 26 cent per litre is explained by the high expansion capacity (see Table 1). A high expansion capacity implies that farms can expand dairy farming at low costs, meaning that these farmers are able to pay more for additional quota due to lower expansion costs, i.e. a large number of male cattle that can be disposed and replaced with cows. Finally, the BMW region has the lowest estimated value of milk quota at 21 cent per litre (see Figure 4a), which is in line with the lowest milk price received and the highest direct costs in comparison to the remaining regions (see Table 1).

By comparing the estimates of economic value to the actual quota exchange prices recorded in the respective milk quota exchanges, some interesting findings emerge. Table 3 presents a comparison between the estimated economic value of milk quota and the average milk quota exchange price in each region for the end of 2007.

Based on our estimations of the economic value, farmers could afford to pay more for quota in the BMW and south-west region, suggesting that quota is undervalued in those regions. The average exchange price exceeds the estimated economic value of quota in the east and south of the country, indicating that quota is overvalued in those regions.

Close inspection of Table 3, reveals significant differences between the regions. For example, farmers in the BMW and the south-west region could afford to pay more for milk quota (based on the estimated economic value of milk quota) than the milk quota exchange price. This indicates that it could be profitable for farmers to acquire additional milk quota while the quota scheme is still in place when intending to expand milk production in the future. In contrast, our estima-

Table 3: Regional Economic Value of Milk Quota and Average Milk Quota Exchange Price per Region

Region	Economic value 2007	3rd Exchange price	Difference
		Cent per litre	
BMW	21	14	+7
East	26	31	−5
South-west	35	28	+7
South	29	37	−8

The respective co-operatives for each region are shown in Table 2.

tions also reveal that farmers in the remaining two regions overpay for quota. This is most significant for the south region, where farmers pay eight cents per litre more for additional quota than they could afford to pay based on our model estimations. Given the high milk quota exchange prices, farmers in these regions would be better off waiting to expand production until milk quotas are abolished or quota prices drop.

6. Conclusions

This paper presented a review of the development of milk quota exchange prices in Ireland and showed regional estimations of economic values of milk quota. By comparing actual milk quota exchange prices to the estimated economic values of milk quota, improved insight into the functioning of the milk quota market in Ireland is gained. The result provide insight as to where milk production is likely to move after milk quota expires and the results can also assist farmers in the decision whether and when to invest in additional milk quota. This is of particular relevance since the abolition of milk quotas in 2015 in the EU brings significant changes for dairy farmers, most importantly the possibility to expand production without restrictions.

This study showed that there has been a large variation in milk quota exchange prices between regions and also over the years. While the variation in milk quota prices over the years mainly followed fluctuations in milk prices, differences between the regions can partly be explained by profitability and characteristics of milk production in the particular region. Indeed, the results of our optimization model confirm this finding and consequently the estimated economic values for milk quota in the four regions differ considerably. For example, the estimated economic values of milk quota vary from 35 cent per litre in the south-west region to 21 cent per litre in the BMW region, which mirror the different levels of profitability and costs of production in those regions. When comparing the estimated economic values of milk quota to the actual milk quota exchange prices, differences between the regions are even more pronounced. More specifically, we find that farmers in the south and east regions overpay for quota, while farmers in the BMW region and south-west regions secure good value when investing in additional milk quota. Based on our model findings, farmers in the south and east region would be advised to postpone milk quota investment until prices drop or quotas are abolished. In contrast, farmers in the BMW and south-west region secure good value for additional milk quota and could thus afford to invest in additional quota while the scheme is still in place.

The high milk quota exchange price in the south region indicates strong demand for milk quota, which could be an indicator that farmers are eager to expand milk production in this region. Further, high milk quota exchange prices in the east in combination with high estimated expansion capacity, could also be a sign of potential expansion of milk production in this region. Further, evidence from co-operative supplier numbers suggests that farm-level structural change differed in Ireland. Structural change has been more rapid in the border and west of Ireland whereas it has been more sluggish in the south and east over the past decade. This may imply that farmers wishing to expand in the south and east regions have pent-up demand. Indeed, anecdotal evidence indicates that farmers in these regions are eager to get additional quota (Hennessy et al., 2009).

Overall, the findings of this study indicate the presence of a wedge between milk quota value, i.e. estimated economic value, and its traded price. Interestingly, the analysis also revealed that the difference between the economic value of quota and the milk quota exchange price is not in the same direction for all regions. Thus, the imposition of a regional restriction on milk quota trade is controversial because it inevitably leads to different trade prices in different regions. While these regional differences may be partly explained by the economics of production, other factors such as the influence of short-term market development and farmers' behaviour also seem to play an important role.

About the authors

Thia Hennessy (Thia.Hennessy@teagasc.ie) is a principal research officer and Doris Läpple is a research officer at the Rural Economy and Development Programme, Teagasc. Laurence Shalloo is a senior researcher at the Moorepark Research Centre, Teagasc. Michael Wallace is a Lecturer in the School of Agriculture, Food Science and Veterinary Medicine, University College Dublin.

REFERENCES

Bogetoft, P., P. Nielsen, and H.B. Olesen, 2003. *The single-bid restriction on milk quota exchanges*. European Review of Agricultural Economics 30:193–215.

Binfield, J., T. Donnellan, K. Hanrahan and P. Westhoff, 2008. *FAPRI-Ireland baseline 2008: outlook for EU and Irish agriculture FAPRI-Ireland partnership*. Teagasc, Carlow, Ireland.

Colman, D. 2000. *Inefficiencies in the UK milk quota system*. Food Policy 25:1–16.

Connolly, L., A. Kinsella, G. Quinlan and B. Moran, 2007. *National Farm Survey*, Teagasc, Rural Economy Research Centre, Athenry, Ireland.

Department of Agriculture, Fisheries and Food (DAFF) 2011a. *Milk quota trading schemes*. Available at: http://www.agriculture.gov.ie/farmingsectors/dairy/milkquotas/milkquotatrading scheme, last accessed June 2011.

Department of Agriculture, Fisheries and Food (DAFF) 2011b. *Milk quotas – an overview*. Available at: http://www.agriculture.gov.ie/farmingsectors/milkquotas/milkquotas-anoverview, last accessed June 2011.

Donnellan, T. and T. Hennessy, 2011. *Situation and outlook for dairying.* In: proceedings of the Teagasc Outlook 2011 conference, January 2011, Portlaoise, Ireland, pp. 17–45.

European Commission (EC) 2009. *Economic impact of the abolition of milk quota regime: regional analysis of the milk production in the EU*. Available at http://ec.europa.eu/agriculture/analysis/external/milkquota/full_report_en.pdf, last accessed June 2011.

Hanson, B.G. 2009. *Economic consequences of milk quota purchase and renting of milk quota on farm level*. Journal of International Farm Management 5:1–15.

Hennessy, T., S. Shrestha, L. Shalloo and M. Wallace, 2009. *The inefficiencies of regionalised trade of milk quota*. Journal of Agricultural Economics 60:334–347.

Shalloo, L. and P. Dillon, 2006. *Is milk quota worthless? New vision for the Irish dairy industry.* In: Proceedings of Irish National Dairy Conference. November, Limerick, Ireland, pp. 9–16.

Appendix A: Details of Adjustment Costs

The first stage of expansion up to the threshold level X_i involves increasing cow numbers by disposing of non-dairy livestock (ND) – typically beef cattle.[10] To allow for replacements each non-dairy livestock unit is equal to one dairy cow less the farm's herd replacement rate (RP_i). The quantity of extra milk then depends on the yield record on farm i in period t ($Yield_{it}$). Hence, the extent of this expansion differs with each farmer's resource base and technical efficiency; this is expressed as follows:

$$X_i = 0.5ND_i(1 - RP_i) \times (Yield_{it}) \quad (4)$$

The incremental adjustment cost per litre (C_{ix}) for farm i associated with this stage of expansion are derived from:

- Replacing a beef livestock unit with dairy results in a net increase in labour of 23 hours per cow. The cost of extra labour ($Wage_t$) is assumed to be €12 per hour, increasing over subsequent time periods according to projected wage rate inflation.
- Infrastructure costs in the first expansion stage ($InfraX$) comprise the conversion of existing non-dairy accommodation (estimated cost of €300 per cow) plus upgrading of dairy facilities (estimated cost of €406 per cow).
- Infrastructure costs are fully written-down over a 10-year period on a straight-line basis. The investment is financed using a 10-year term loan at an interest rate of 6 per cent. Interest in each year for the amortized loan is computed by applying the appropriate period compound interest factor ($IntFac_t$) to the sum invested.
- The cost of retaining additional replacement heifers.
- The foregone profit per livestock unit on Non-Dairy livestock ($NDProf$), excluding the decoupled payment, is estimated from NFS data. In 2006, the average profit per beef livestock unit was €103.

Thus the adjustment cost per litre of quota investment in this stage would be:

$$C_{ix} = \frac{23(Wage_t) + (0.1 + IntFac_t)(InfraX) + NDprof_{it}(1 + RP_i)}{(Yield_{it})} \quad (5)$$

The second stage of expansion which occurs after threshold X_i is more costly as it involves acquiring additional land and increasing overall livestock numbers. The costs are as follows:

- Land rental costs are estimated to be €268 per year hectare ($Rent$). The additional land required is dependent on the stocking rate of the farm (SR_i).
- Full labour costs are assumed in this expansion stage involving annual input of 35 hours per cow. The wage rate ($Wage_t$) is €12 per hour in the first time period and increases in subsequent time periods.
- Infrastructure costs ($InfraY$) in the second stage involve expansion of milking facilities and construction of new housing at a combined cost of €1,633 per additional cow.
- Infrastructure costs are fully written-down over a 20-year period on a straight-line basis. The investment is financed using a 20-year term loan at an interest rate of 6 per cent. Interest in each year for the amortized loan is computed by applying the appropriate period compound interest factor ($IntFac_t$) to the sum invested.
- Additional cows are purchased for an average price of €1,320 ($CowCost$) and the interest rate (Int_t) on capital invested in the extra cows is assumed to be 6%.

Therefore, the incremental adjustment cost per litre of quota investment in this stage can be written as:

$$C_{iy} = \frac{\left(Rent/SR_i\right) + 35(Wage_t) + (0.1 + IntFac_t)(InfraY) + (1 + Int_t)(CowCost)}{(Yield_{it})}. \quad (6)$$

[10] As data on land fragmentation is not available, it is assumed that only half of the non-dairy stock can be replaced with dairy cows.

Competitive strategy analysis of NZ pastoral dairy farming systems

NICOLA M. SHADBOLT[1]

ABSTRACT

The purpose of this paper is to examine the financial performance of five pastoral dairy farming systems through the use of financial ratio analysis in the form of the Du Pont model and to determine any differences in the drivers of financial success between systems. The differing level and allocation of resources, or organisational structure, that each farm system adopts was the basis for a test to determine superior competitive advantage. This test was on the premise that if a farm system has a competitive advantage it would exhibit above average performance. While the on-farm competitive strategy, cost leadership, is the same for all systems the organisational design and the resource configuration differ between farms. There are low-input farms which achieve low cost production through cost control (the numerator effect) and high-input farms which achieve it through improved outputs (the denominator effect). There has been significant debate in New Zealand as to which system is better with discussion focusing often on misleading metrics. The focus on competitive advantage and the rigour provided by the Du Pont model analysis enables a more balanced assessment of the benefits, or not, of intensification on New Zealand farms. The results highlight how misleading commonly used metrics can be. Despite differences in production and operating profit per hectare there is very little difference between return on assets and return on equity between the systems. Of particular interest is the consistency in operating profit margin between systems indicating no loss in operating efficiency as systems intensify. The only exception to this was the more intensive systems in 08/09 when input and output market price relativity was extremely unfavourable. Further research is required to determine if farms switch between systems as input and output market prices change and to explore those farms that are more resilient to such changes.

KEYWORDS: pastoral dairy farm systems; competitive advantage; Du Pont analysis; cost of production; Return on Equity

1. Introduction

Strategy-structure-performance relationships

Business literature is awash with debate around the vexed question of whether structure follows strategy, or vice versa, with respect to establishing competitive advantage. Contingency theory researchers (Chandler, 1962, Porter, 1985) have concluded that optimal organizational design is contingent on strategy. Porter (1985), when distinguishing between two key types of competitive advantage – low cost and differentiation - surmised that the significance of any strength or weakness is ultimately a function of its impact on relative cost or differentiation. Essentially the premise is that it is the external environment and strategic decisions that influence structure.

An alternate view is that the internal resources or organizational structure of a firm are in fact a key source of competitive advantage rather than just being part of the implementation of strategy (Barney, 1991, Barney & Clark, 2007). It is proposed that this resource-based view (RBV) may explain the sources of competitive advantage better than an externally focused orientation (Pertusa-Ortega et al, 2010).

The connection to performance is also the subject of debate. To suggest a firm has a competitive advantage would suggest that it, over time, would out perform its competitors and exhibit above average performance. Pertusa-Ortega et al (2010) identify that while organizational structure can influence competitive strategy it will not directly influence performance. They reference a number of studies that all confirm that strategy influences performance most as it directly influences costs and revenues. In an attempt to define a causal relationship between sustainable competitive advantage and sustainable performance Tang & Liou (2009) suggest that the presence or absence of competitive advantage may be reflected in the causal relationship between resource configuration, dynamic capability and observable financial performance. The relationship between performance and managerial ability or some other resource advantage is also noted by Langemeier (2010) who notes the importance of identifying unique resource advantages. Hansen et al (2005) similarly identifies from the literature the frequency at which farm management is found to be the crucial factor in determining farm production and financial performance.

[1] Professor in Farm Business Management, Massey University, New Zealand. N.M.Shadbolt@massey.ac.nz

Measuring Performance

The Du Pont model has been used consistently by business analysts to provide a better understanding of a firm's superior performance (Little et al, 2009, Langemeier, 2010). In the farm management literature its use in farm business analysis is more common in North American research. Its ratios are included in the sixteen measures recommended by the Farm Financial Standards Council (FFSC) in 1995. The Du Pont model is discussed in detail by Boehlje (1994) and Shadbolt & Martin (2005), was the basis for a farm business diagnostic and evaluation system (DES) developed by Barnard and Boehlje in 1999 and has been fully developed since 1995 in various editions of the Barry et al (2000) textbook. It is used to evaluate the drivers of both Return on Assets (RoA) and Return on Equity (RoE).

In the business literature the Du Pont model commonly provides the metrics in the analysis of strategy-structure-performance relationships. For example Palepu & Healy (2008) evaluated execution of competitive strategy and Little et al (2009) evaluated alternative strategies - cost leadership/differentiation - with modified versions of the Du Pont model. Little et al (2009) concluded that the Du Pont model enabled them to determine that for a firm to be successful with cost leadership it was through generating asset turnover while success with differentiation was through generating profit margins.

Tang and Liou (2009) applied the Du Pont approach to three structures or ''resource bundles'' and found that return on invested capital discriminated the groups more effectively than any other indicator. However, when comparing the sustainable competitive advantage of companies with different resource configurations they concluded it is made up of not one measure but an amalgamation of measures. Through quite complex analysis they concluded that superior financial performance arises from a firm's unique resource configuration and management capability.

The use of the Du Pont model to statistically analyse strategy/structure/performance relationships between farm systems is not as common. While various of the Du Pont ratios have been used to assess farm performance (Thorne & Fingleton,2006, Langemeier, 2010, Hansen et al, 2005, Smyth et al,2009)) the connection between that performance and the farm's strategy or resource allocation and configuration has not been subject to analysis using the Du Pont model. Barnard and Boehlje (1999) identify how the Du Pont model can be used to assess alterative management systems, how production, financing and marketing decisions impact the return on assets and return on equity ratios, but little work has been done using the model to assess, from historical data, the impact of such strategic decisions.

NZ Dairy Farm Strategies

Apart from a few exceptions, such as organic milk production, the on-farm strategy followed by the majority of NZ dairy farmers is low cost. With over 95% of their milk exported the price they receive for their milk is strongly influenced by the world price of milk ingredients/commodities. While membership of cooperatives provides vertical integration for most of these farmers, and therefore an opportunity to benefit from differentiation along the supply chain, this is reflected in the return they receive for their cooperative investment and is, for the Fonterra Cooperative at least, clearly distinguished from the price received for the milk alone.

So the external environment is the same for all producers and the on-farm competitive strategy is the same. Yet organisational design, the resource configuration, differs between farms. There are low-input farms who achieve low cost production through cost control (the numerator effect) and high-input farms who achieve it through improved outputs (the denominator effect). There is significant debate in the industry over which system is right and which is wrong, with much of the debate fuelled by conflicting opinion and misleading metrics (Roche and Reid, 2002, Shadbolt et al, 2005). A frequently reported concern is that New Zealand's low cost advantage is being eroded by more intensive production systems, requiring greater use of purchased supplements (maize and grass silage, palm kernel extract) and significant investment in depreciating assets (feed pads, feed wagons).

Little et al (2009) state that conventional wisdom is that companies devise successful competitive strategies around either profit margin or asset turnover. All farm systems are operating under the same competitive strategy of cost leadership. Under this strategy firms typically generate a low profit margin but balance that against a high asset turnover. Is this the case for New Zealand low and high-input dairy farming systems or are the differing resource configurations creating different relationships between the key drivers of the Du Pont model and RoE? Does performance differ between systems and which drivers have the most influence?

Volatility of market prices – both inputs and outputs – has increased in recent years and this has led to further debate around which system is the more able to cope in such conditions. When a farm moves from a low-input system to a high-input system it mitigates one source of risk and creates another. In pastoral farming, climate uncertainty has a big impact on production. In particular, rainfall dictates whether pasture grows or not through the critical summer months. In a low-input system, if pasture stops growing cows are dried off and production reduces or stops altogether. In a high-input system, feed supplement reserves are utilised, and more are purchased if it is cost effective to do so. Climate uncertainty is therefore replaced by market uncertainty. Lactation lengths are improved with high-input systems making better use of available resources, but at a cost. Farmers use a variety of methods to manage the variability of those feed costs but the costs tend to be inversely correlated to rainfall reflecting a greater demand for them when pasture growth is limiting. The high-input system therefore does not totally mitigate climate uncertainty.

Hedley and Kolver (2006) suggested that while the higher input systems can provide more consistent production they may be more complex to manage. They state risk in these systems may be higher if variability in feed prices is not controlled, as profitability is very sensitive to milk and feed price fluctuations. Overseas observations, concluding US confinement farms with higher levels of milk production had inferior financial performance to pasture based farms (Benson, 2008), and that it is the difference between milk price and feed costs, not the price or costs per se, that is crucial to profitability (Hansen et al, 2005), add fuel to the debate on system choice.

Which system is the more resilient? This paper reports on an initial exploration into the evaluation of the various systems. It is part of a larger research project funded by DairyNZ in which resilience *per se* is explored in greater depth and risk management strategies better understood and developed.

2. Methodology

This research extracted performance of individual dairy farmers from DairyBase (www.dairybase.co.nz), a database used by farmers and professional advisors in New Zealand to analyse farm results and benchmark them with their peers. The data set included physical and financial data for three consecutive seasons, 2006/7, 2007/8 and 2008/9. The total number of farmers analysed varied by season and by system (Table 1) and included farms from both the North Island and South Island. Each season was analysed separately so no attempt was made to track trends between years or exclude farms that did not have data in all three years. Owner-operator data was extracted from the DairyBase database and grouped by farm system. Farms with missing data or extreme values were eliminated.

There are five production systems defined by DairyNZ based on the quantity and time of year that imported feed is used, they progress from the 'low input' of system one to the 'high input' of system five. Pastoral dairy farming systems in New Zealand are typified by a 'milking platform', the effective milking area of the farm, on which the cows are grazed; it surrounds and is in walking distance from the milking shed. As seasonal production systems the aim is to match feed demand as closely as possible with the pasture feed supply curve, to turn as much of that pasture feed into milk as possible. Imported feed for the system includes feed brought onto the milking platform to supplement the pasture, as well as feed provided as grazing or supplement for cows removed from the milking platform. All systems assume that young stock, cow replacements, are grazed off the milking platform. The non-milking area that grazes dry cows and replacements is commonly termed the 'run-off'.

The systems are as follows:

System 1. *Self contained – no imported feed*
No supplement fed, except supplement harvested off the effective milking area and no grazing off the effective milking area by dry cows

System 2. *4 – 14% of total feed imported*
Feed imported, either as supplements to milking cows or grazing and supplements for dry cows

System 3. *10 – 20% of total feed imported*
Feed imported, both as supplements to extend lactation (typically autumn feed) and grazing and supplements for dry cows

System 4. *20 – 30% of total feed imported*
Feed imported, both as supplements used at both ends of lactation and grazing and supplements for dry cows

System 5. *More than 30% total feed imported*
Feed imported for use all year, both supplements used throughout lactation and grazing and supplements for dry cows. Split calving is common in this system

The analysis was performed between groups for each of the three seasons to identify differences between systems.

The next step in the research process was then to run ANOVA statistics on the farms in the relative system groups to test if there was a statistically significant difference in production, cost of production and profitability in the different systems each year.

The Du Pont model was used first to analyse the drivers of Return on Assets (RoA), the operating profit margin (OPM) and asset turnover (ATR) as follows:

$$\text{RoA} = \text{OPM} \times \text{ATR} \tag{1}$$

where OPM=operating profit / gross farm revenue
ART=gross farm revenue / opening assets

A farm with a relatively high OPM and ATR will yield a relatively high RoA and vice versa. However, as Langemeier (2010) concludes farms with high ATRs are not necessarily those with high OPMs so farms with the same RoA could have a quite different ATR and OPM. The interpretation of the results from these drivers is, however, complicated by farms that lease land. In particular, as noted by Langemeier (2010), the ATR will be lower for those farms that own a high percentage of their land; the more land that is leased the higher the ATR. Conversely, if the rental cost is deducted from the operating profit before calculating the OPM (as it is by the FFSC (1995) and in the Langemeier, 2010 analysis) the OPM will be lower for those farms with a higher proportion of lease land.

While this analysis cannot remove the impact of lease land on the ATR, it has removed it from the OPM by not deducting the rental costs in the OPM calculation. The OPM used is therefore an accurate measure of the efficiency with which the operating profit is generated from the revenue irrespective of how the business is owned or funded. This provides greater clarity on operational efficiency but it should be understood that the RoA calculated as per equation 1 above will differ from that calculated with rental costs deducted from operating profit as outlined in Equation 2 below.

Table 1: Number of owner-operator farms in each farm system for the years 06/07, 07/08 and 08/09 in DairyBase

	System 1	System 2	System 3	System 4	System 5	Total
2006/07	79	235	186	85	25	610
2007/08	68	185	206	121	29	609
2008/09	46	130	194	89	28	487

RoA and RoE calculations used by DairyBase and for this analysis are as follows:

$$\text{Return on Assets (RoA)} = (\text{operating profit} - \text{rent}) / \text{opening assets} \quad (2)$$

$$\text{Return on Equity(RoE)} = (\text{operating profit} - (\text{interest rent})) / \text{opening equity} \quad (3)$$

The RoA, RoE, OPM and ATR all feature as recommended ratios by the FFSC (1995) and Barry et al (1995) and have been used frequently by farm management analysts.

The cost of production per kilogramme of milksolid (CoP) is the sum of the operating expenses (OE) and the cost of funds (CF) divided by the milksolids production as follows:

$$\text{CoP} = (\text{OE} + \text{CF}) / \text{kilogrammes of milksolids} \quad (4)$$

Both OE and CoP are relevant indicators for this analysis; as explained by Thorne & Fingleton (2006) the OE is a useful measure of the short to medium term competitiveness of a business while the CoP is a measure of future competitiveness as it includes the opportunity cost of owned resources.

Further details of these equations including the definitions of the inputs to each equation are provided in Appendix A.

3. Results and Discussion

Production

As farm systems adapt from low input to high input there is a noticeable increase in stocking rate and production per hectare. This is apparent in all three years of the analysis (Figure 1). Apart from the increase in production per hectare difference between system 2 and system 1 in 2008/09 and the increase in stocking rate between system 2 and 1 in 2006/07 and 2008/09 all other differences between systems for both production per hectare and stocking rate are significant.

Profitability

Operating Profit /hectare

The relationship between production and operating profit per hectare is not as consistent (Table 2). If the P-value is less than 0.05 then there is a significant difference between some or all of the systems. In 2006/07 the significant difference between systems was between system 4 and system 1 and system 4 and system 2, otherwise no systems differed significantly. In 2007/08 the increase in operating profit per hectare from system 1 to 5 was significant in all cases apart from between system 2 and system 1 and system 5 and system 4.

Only when milk prices were high was there a significant increase between systems 1 to 3. System 4 outperformed systems 1 and 2 in 06/07, in 07/08 both system 4 and system 5 outperformed systems 1, 2 and 3.

In 2008/09 there was no significant difference between the operating profit per hectare of the five systems. In 2008/09 milk price decreased but many input prices did not. This was partly because the forecast milk price decrease did not happen until part way through the season and farmers were committed to contracts for feed that had been based on the higher milk price, but also because input prices such as fertiliser had not come off the peak attained in 2007/08.

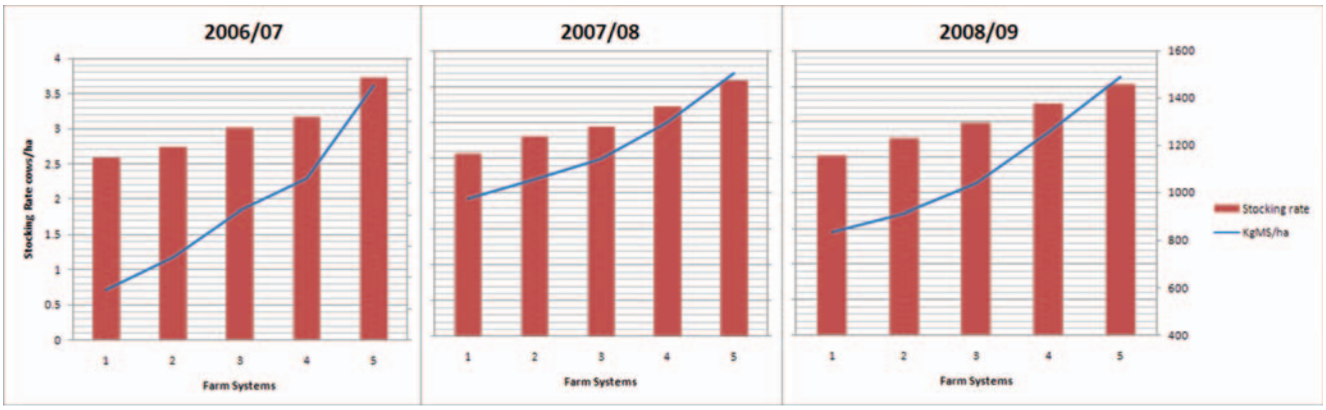

Figure 1: Stocking rate (cows/ha) and production (kilograms milksolids (MS)/ha) for the three years of 06/07, 07/08 and 08/09 by farming system

Table 2: Operating Profit $/ha for the three years of 06/07, 07/08 and 08/09 by farming system

Operating Profit $/ha	2006/07	2007/08	2008/09
System 1	997	2559	974
System 2	1040	2770	865
System 3	1111	3067	823
System 4	1300	3837	619
System 5	1334	4401	428
P value (0.05)	0.010916	2.15E-14	0.072899

Table 3: Return on Equity % for the three years of 06/07, 07/08 and 08/09 by farming system

Return on equity %	2006/07	2007/08	2008/09
System 1	0.7%	6.7%	-1.9%
System 2	−0.1%	7.7%	-2.1%
System 3	−0.6%	10.1%	-3.9%
System 4	−0.8%	9.6%	-5.1%
System 5	−2.9%	8.2%	-6.6%
P value (0.05)	0.343481	0.076249	0.011223

When, in 2007/08, milk price increased significantly this was reflected in the operating profit per hectare. For system 2 farms, for example, the operating profit increased from \$1040/ha[2] in 06/07 to \$2770/ha in 07/08. This increase was all the more notable as input prices also increased significantly in that year and most farms experienced extreme drought conditions.

It is not surprising that operating profit per hectare is used so frequently by NZ media and commentators and is touted by some as the most relevant measure of profitability (Roche and Newman, 2008). It is relatively easy to calculate and is well understood. In 2006/07 and 2007/08 this metric would have led to the conclusion that intensification is the profitable alternative for NZ farmers. Even in 2008/09 it could be concluded from this metric that intensification was a good strategy as the difference was statistically insignificant.

But as pointed out by Shadbolt (1997), operating profit per hectare is a misleading metric. When comparing farms within a production system it cannot reflect the fact that not all hectares are of equal quality and therefore are not of equal value. When comparing between systems it does not reflect the additional capital invested as farms intensify - the extra cows as stocking rate increases, extra cooperative shares as production per hectare increases and the machinery, building and infrastructure changes required to manage more intensively.

As described in the Du Pont model and many management texts, the measure of profit most relevant to business owners is the return on their equity (RoE) as this determines how effectively they have employed their capital. It also provides awareness of where change might be required.

Return on Equity and Return on Assets

In 2006/07 and 2007/08 there was no significant difference between the RoE for the five farm systems (Table 3). No one system performed better than another. Any conclusions that system 4 or 5 was better, based on operating profit per hectare, were negated when return on equity was compared. So the additional capital invested as systems intensify, while enabling the farms to produce more milk, delivered an equal, not a greater return on equity. There was also no significant difference between the three years in the debt servicing capacity of the farm systems. The level of commitments (interest and rent) does not differ. This is contrary to popular belief that suggests the intensive farmers carry more commitments.

Similarly, in 2006/07 and 2007/08 there was no significant difference between the RoA for the five farm systems (Figure 2); in other words the additional capital required to achieve the higher production delivered a consistent return per unit of capital.

However, in 2008/09, the inability to produce a higher operating profit per hectare coupled with the additional assets required per hectare resulted in a significantly worse outcome under intensification. For the RoE both system 4 and system 5 performed significantly worse than systems 1 and 2. For the RoA systems 3, 4 and 5 all performed significantly worse than system 1 (Figure 2).

The impact of the unfavourable milk price/ input cost relativity in 08/09 was therefore felt most strongly by the high input farms. These farms, while able to continue to produce at higher levels (Figure 1), mitigating climate risk, are more affected by market risk – both input costs and output prices. Even though production per hectare and operating profit per hectare increased, the combination of unfavourable milk price/input cost relativity and the additional capital required to generate that production and profit was unfavourable in the higher input systems.

Return on Assets Drivers

Given the similarity in RoA in 06/07 and 07/08 and the difference between systems in 08/09 is there any difference in the ATR, the efficiency with which the assets are used to generate revenue, and the OPM, the efficiency with which that revenue is turned into profit?

In 06/07, apart from a significant difference between asset turnover in systems 1 and 3, there were no significant differences between systems in either asset turnover or operating profit margin. Despite the increase in milk production per hectare the increase in revenue it generated was matched by an increase in the resources required to achieve that production, hence no change in asset turnover. No difference in operating profit margin indicates no deterioration in operating efficiency as systems intensify.

In 2007/08 system 3 had a significantly greater asset turnover than systems 1 and 2 but otherwise there were no significant differences between asset turnover and operating profit margin between systems. Once again

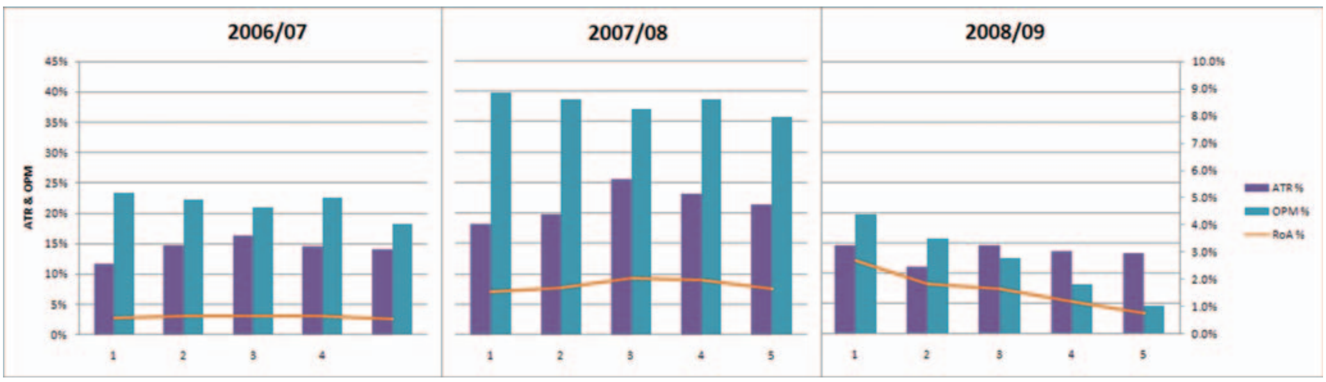

Figure 2: Return on Assets (RoA), AssetTurnover (ATR) and Operating Profit Margin (OPM) for the three years of 06/07, 07/08 and 08/09 by farming systems (1,2,3,4+).

there was no significant difference between the operating profit margins indicating the efficiency of production (costs spent per income generated) is maintained as farms intensify. This asset turnover driven performance is commensurate with firms pursuing cost leadership strategies (Little et al, 2009).

In 08/09 the drivers of RoA presented a different picture. System 2 delivered a significantly lower asset turnover than system 1 and systems 3 and 4 delivered a significantly higher asset turnover than system 2. While asset turnover differences were inconclusive there was significant deterioration in operating efficiency as systems intensified. System 4 and system 5 were significantly less than systems 1 and 2 and system 3 is significantly less than systems 1. Differences in RoA in 08/09 can be explained by operating profit margin and not asset turnover. As operating efficiency declined so also did return on assets. Achieving the higher production and asset turnover with intensification came at an unacceptable price.

Cost Leadership

So, if all farm systems are operating under the same competitive strategy of cost leadership, was there any difference in their cost of production? Both farm working expenses and operating expense per kilogram of milksolids are frequently used by NZ media and commentators as the most relevant measures of cost of production. However they, like operating profit per hectare, can be misleading metrics. Both fail to recognise the asset base required to deliver the production in each system and therefore the cost of that asset base. As such they are valid for short to medium term comparisons but for the longer term competiveness as explained by Thorne & Fingleton (2006) it is the full economic costing of the CoP that is relevant.

There was no significant difference between the operating expenses per kilogram of milksolids in all systems in 06/07 and 07/08. In 08/09, system 5 had significantly higher operating expenses than systems 3,2 and 1 and system 4 was significantly higher than systems 2 and 1 (Figure 3). The phenomenon described by Smyth et al (2009) as 'stickiness of costs' in which there is little mobility in costs, a limited ability of farmers to manage costs down, could explain the significant difference noted in the higher input systems. In the Lincoln University Dairy Farm Focus Day report (July 1st, 2010) it was noted that in 2008/09 there was a strong and negative relationship between operating expenses per kilogram of milksolids and operating profit per hectare. The results presented in Table 2 and Figure 5 echo that relationship in 2008/09 for system 5 (and to a lesser extent system 4) but not for systems 1, 2 and 3.

In contrast, and in line with the Thorne and Fingleton (2006) study when comparing the cost of production per kilogram of milksolids (the full economic costing) the competitive position of the systems changed. In 06/07 systems 2, 3 and 4 were all significantly less than system 1. In 07/08 the system 4 cost of production was significantly less than systems 1, 2 and 3. However, in 08/09 there was no significant difference between any of the systems. Smyth et al (2009) determined that costs decreased as stocking rate increased, suggesting scale and improving efficiency are key to reducing costs. As shown in Figure 1 there was a significant increase in stocking rate between systems, system 4 achieves cost of production benefits from this in two of the three years analysed.

The benefit of increased production levels on cost of production, the denominator effect, while apparent in 06/07 and, to a lesser extent, in 07/08 was not present in 08/09 due to it being insufficient to counteract the combination of the high input costs and additional capital required to generate higher production levels. Increasing production intensity improved cost leadership in average and favourable market conditions but this advantage disappeared under unfavourable milk price to input cost ratios. The concern that New Zealand's competitive advantage that has relied heavily on the use of low cost grazed pasture is being eroded by more intensive production systems is refuted by these results. When using a metric that incorporates opportunity cost of capital it can be seen the cost of production per kilogram of milksolids at worst doesn't change and, at best, reduces as systems intensify.

4. Conclusion

The more intensified systems consistently produce more milk per hectare than the other systems. However in 06/07 and 07/08 there was no difference in profits (RoA and RoE). Although in 06/07 and 07/08 the more intensified systems achieved a lower cost of production they were not able to achieve a higher RoA or RoE. As

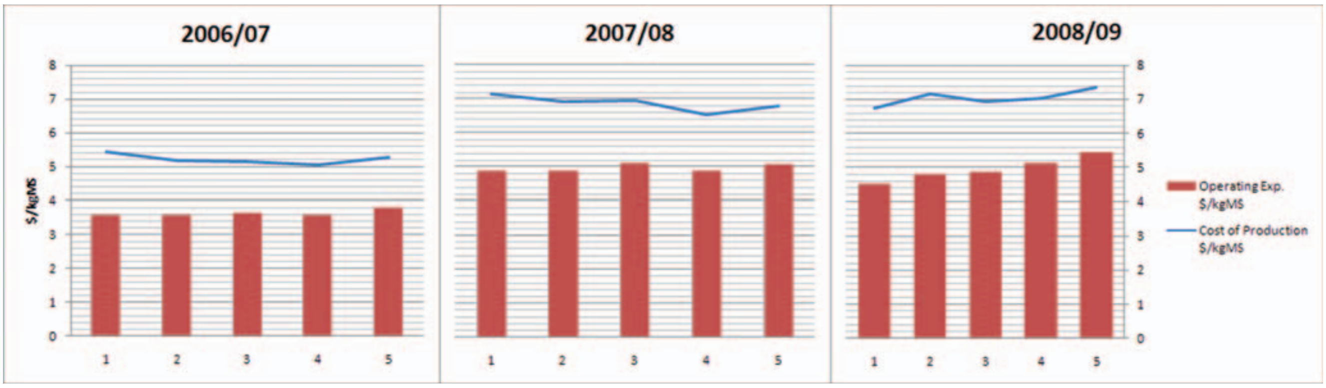

Figure 3: Operating Expenses and Cost of Production ($/kgMS) for the three years of 06/07, 07/08 and 08/09 by farming systems (1,2,3,4,5).

all systems are following the same strategy of cost leadership these results would concur with the conclusion of Pertusa-Ortega et al (2010) that while organizational structure can influence competitive strategy it will not directly influence performance. Strategy influences performance most as it directly influences costs and revenues.

System 1 is the traditional NZ pastoral farming system in which cost control is a key driver in profitability. As this system has been intensified by farmers the operating efficiency has not changed across systems indicating that cost control with respect to revenue has been maintained. When market conditions deteriorated in 08/09 it was the inability of the more intensive systems to maintain their operating efficiency (OPM) that resulted in their inferior performance despite maintaining capital efficiency (ATR).

While 08/09 was an unusual season, input prices usually reduce as output prices fall and vice versa, it is a concern that the intensive systems performed so poorly and were unable to adjust within the season to price changes. Further research on the degree of flexibility that each system exhibits is called for to determine how resilient each is to market volatility. Tracking individual farms through the seasons is also required to determine if and when they might switch between systems; the season specific analysis carried out in this research did not examine such time lines.

New Zealand's competitive advantage still relies heavily on the use of low cost grazed pasture, and the results show (when calculated using metrics as advocated in this paper) that this is not being eroded by more intensive production systems. The methodology enabled the clear distinction to be made between measures that progressed from production to profit per hectare and cost per unit of output, culminating with the return on assets and return on equity. The use of the Du Pont model to then unravel the RoA and RoE provided a unique insight of the drivers of asset turnover and operating profit margin with respect to competitive advantage of pastoral dairy systems. The similarity between the financial performances of the systems suggests that farmers, on average, achieve similar resource efficiency and operating efficiency regardless of the system they adopt. There is a need now to delve further into these statistics to identify the characteristics of the superior and inferior performers and to determine the best practices that deliver better metrics. The literature would suggest that the better performers consistently achieve high levels of revenue from their assets (capital efficiency) and simultaneously manage operating expenses in line with revenue (operating efficiency).

In conclusion, it is apparent that the cost leadership strategy is pursued by all pastoral dairy farming systems analysed over the three seasons of 06/07 to 08/09. The resource configuration of each system in most years led to no significant difference in either OPM or ATR, the drivers of RoA, or RoE. This similarity is in stark contrast to the conclusions drawn when examining the commonly used metrics of production and operating profit per hectare and demonstrates how misleading they are.

Profitability differs little between systems so what benefits are there from changing systems apart from an improvement in cost leadership that disappears when market conditions are unfavourable? It is possible to conclude from the data from the first two years that the choice of system a farmer makes could be based purely on personal preference and attitude to different sources of risk as it made no difference, on average, to returns.

About the author

Nicola Shadbolt is Professor in Farm Business Management at Massey University, New Zealand. Specific research interests include strategic management and business analysis. She achieved registration in 1986 and was recently made a Fellow of the NZ Institute of Primary Industry Management. In 2005 she published a textbook, 'Farm Management in New Zealand', that was jointly produced with Dr Sandra Martin from Lincoln University. Before joining Massey she spent 15 years working in a variety of jobs in government, agribusiness and consultancy. Outside academia Nicola is involved in five equity partnerships; two are for forestry, one a dairy farm, another a beef finishing farm and the fifth is a 2200 hectare pastoral farm producing milk, beef, sheepmeat, wool, venison, velvet and timber. The farm business in 2006 won the Supreme Farm Environment Award for its region. In 2009 Nicola was elected onto the board of Fonterra Cooperative.

Acknowledgements

The author is grateful to three anonymous reviewers for their valuable comments on an earlier draft of this article.

REFERENCES

Barnard, F.; Boehlje, M (1999) The financial troubleshooting of farm businesses: a diagnostic and evaluation system (DES) *Journal of the ASFMRA*. Professional Forum, 1998/99. Pp 6–14

Barney, J.B. (1991) Firm resources and sustained competitive advantage. *Journal of Management*. Vol.17, No.1, pp99–120

Barry, P.J.; Ellinger, P.N.; Hopkin, J.A.; Baker, C.B. *Financial Management in Agriculture*. Interstate Publishers, Inc. 2000.

Boehlje, M (1995) Evaluating Farm Financial Performance. *Journal of the ASFMRA*. Vol 58, No 1, pp109–115

Benson, G.A. (2008) Pasture-Based and Confinement Dairy Farming in the United States: An Assessment. *Journal of International Farm Management* Vol.4, No.2 –February, 2008. www.ifmaonline.org [accessed 20 January 2012]

Chandler, A. (1962) *Strategy and Structure*. The MIT Press, Cambridge, MA

DairyNZ (2009) DairyNZ Economic Survey 2008–09. www.dairynz.co.nz [accessed 20 January 2012]

FFSC (1995). Financial Guidelines for Agricultural Producers: Recommendations of the Farm Financial Standards Council. July (Revised).

Hansen, B.G., Stoksad, G., Hegrenes, A., Sehested, E., Larsen, S. (2005) Key Performance Indicators on Dairy Farms. *Journal of International Farm Management* Vol.3, No.1 – July, 2005. www.ifmaonline.org [accessed 20 January 2012]

Hedley, P. and E. Kolver (2006). Achieving high performance from a range of farm systems in Southland. *South Island Dairy Event*.

Langemeier, M. (2010). Persistence in Financial Performance. *Journal of International Farm Management* Vol.5, No.2 –April 2010. www.ifmaonline.org [accessed 20 January 2012]

Lincoln University Dairy Farm Focus Day, 1 July, 2010. www.siddc.org.nz [accessed 20 January 2012]

Little, P.L., Little B.L, Coffee, D. (2009) The Du Pont Model: evaluating alternative strategies in the retail industry. *Academy of Strategic Management Journal*. Jan 2009, vol.8, pp 71–80

Palepu, K., Healy, P.(2008) *Business analysis and valuation: using financial statements* (Fourth Edition). Mason, OH: Thomson Southwestern

Pertusa-Ortega, E.M., Molina-Azorin, J.F., Claver-Cortes, E. (2010) Competitive strategy, structure and firm performance. A comparison of the resource-based view and the contingency approach. *Management Decision*. Vol.48, No.8, pp1282–1303

Porter, E.M (1985) *Competitive Advantage: Creating and sustaining superior performance*. Free press: New York.

Roche, J. and A. Reid (2002) High input dairy farming - the road to a better life. More money more options. *South Island Dairy Event*.

Roche, J. and M. Newman (2008) Profitable low input systems - Separating the myth from the magic. *South Island Dairy Event*.

Shadbolt, N.M. (1997) Key Performance Indicators. 1997 *Dairyfarming Annual including the Proceedings of the 49th Meeting of Dairyfarmers* conducted by Massey University; 1997 May 13–1997 May 15; Palmerston North. Massey University: Pages 107–111. ISBN: 1301–8830.

Shadbolt, N.M., Martin S. (2005) *Farm Management in New Zealand*. Oxford Univerity Press.

Shadbolt, N.M., Holmes, C., Buron de Machado M., Silva-Villacorta, D. (2005) How Best to Compare Low and High Input Pastoral Systems, *15th International Farm Management Conference Proceedings* pp. 367—376.

Smyth, P., Butler, A.M., Hennessy, T. (2009) Explaining the Variability in the Economic Performance of Irish Dairy Farmers 1998–2006 *Journal of International Farm Management* Vol.4, No.4 –February 2009. www.ifmaonline.org [accessed 20 January 2012]

Tang, Y-C, Liou, F-M (2010) Does firm performance reveal its own causes? The role of Bayesion inference. *Strategic Management Journal*. Jan 2010, vol.31, issue 1, pp39–57

Thorne, F.S., Fingleton, W. (2006) Examining the Relative Competitiveness of Milk Production: An Irish Case Study (1996–2004). *Journal of International Farm Management* Vol.3, No.4 – December 2006 www.ifmaonline.org [accessed 20 January 2012]

Appendix A: Definitions of measures used in the analysis

Return on Assets (RoA) = OPM * ATR
Operating profit margin (OPM) = operating profit / gross farm revenue
Asset turnover (ATR) = gross farm revenue / opening assets

Operating Profit (OP) = GFR – OE
Gross Farm revenue (GFR) = sales - purchases + change in livestock inventory
Operating Expenses (OE) = cash farm working expenses + feed inventory & run- off adjustments + depreciation + value of family labour & management
Return on Assets (RoA) = (operating profit – rent) / opening assets
Return on Equity (RoE) = (operating profit – (interest & rent))/ opening equity
Opening equity = opening assets – opening liabilities
Opening assets = fixed assets, livestock & shares

Opening liabilities = fixed liabilities + (current liabilities – current assets)
The cost of production per unit of output (CoP) = (OE +CF) / unit of output
Cost of Funds (CF) = opening assets * 4%

Risk perceptions and management strategies by smallholder farmers in KwaZulu-Natal Province, South Africa

MAGGIE KISAKA-LWAYO[1] and AJURUCHUKWU OBI[1]

ABSTRACT

Risk is a central issue in rural areas that affects many different aspects of people's livelihoods in the developing world. Unless well managed, risks in agriculture can slow development and hinder poverty reduction. Farmers' perceptions of and responses to risk are therefore important in understanding their risk behaviour. This paper examines risk perceptions and management strategies using field data collected from 200 smallholder rural farmers. The relationships between various socioeconomic characteristics and perceived sources of risk were also examined. In general, price, production and financial risks were perceived as the most important sources of risk. Using Principal Components Analysis, seven principal components (PCs) that explained 66.13% of the variation were extracted. Socio economic factors identified to have a significant relationship with the various sources of risk are age, gender, education, location, information access and risk-taking ability. The most important traditional risk management strategies used by the surveyed farmers were identified as crop diversification, precautionary savings and participating in social networks. The result of this study provides useful insights for policy makers, advisers, developers and sellers of risk management instruments.

KEYWORDS: Risk; Risk management; principal components analysis; smallholder farmers; social networks

1. Introduction

Smallholder agriculture is the key to local and global food security and is the engine for development and economic growth for most developing countries (Fan, 2011). World-wide, there are about 500 million smallholder farms supporting almost 2 billion people (International Fund for Agricultural Development, 2010). In much of Africa and South Asia, small farms still account for the largest share of agricultural output. Africa has approximately 33 million small farms, representing 80 percent of all farms in the region (International Fund for Agricultural Development (IFAD), 2011). The majority of African farmers (many of them women) who are smallholders with farms below two hectares, produce a significant amount of basic food crops with virtually no or little use of fertilizers and improved seed (IFAD, 2011; Altieri, 2009; Altieri and Koohafkan, 2008). They instead rely mainly on nature and natural processes, agricultural biodiversity, local resources and local knowledge to farm.

Agriculture is by nature a risky activity and agricultural enterprises, most especially in developing countries, operate under a situation of risk and uncertainty (Akcaoz and Ozkan, 2005). Risk and uncertainty are therefore pervasive characteristics of agricultural production (Adesina and Quattara, 2000). Farmers' perceptions and responses to risk are important in understanding their risk behaviour (Alimi and Ayanwale, 2005). Risk could arise due to several biophysical factors such as highly variable weather events, diseases or pest infestations. Other factors such as changing economic environment, introduction of new crops or technologies and uncertainties surrounding the public institutions and their policy implementation also combine with these natural factors to create a plethora of production, institutional, price, human and financial risks for farmers (Adesina and Brorsen, 1987). This risk situation affects the fortunes of the majority smallholder agricultural producers in sub-Saharan Africa. According to Wenner (2002), in the absence of institutional innovations (for example, crop insurance, disaster payments, and/or emergency loans) to cushion the impact of risk and uncertainty, risk-management is a critical part of farmer's decision making.

IFAD's (2011) rural poverty report shows that there are nearly 1.4 billion people living on less than US$1.25 a day. At least 70% live in rural areas where they depend on agriculture, but where they are also at risk from recurrent natural disasters. Natural disasters have a devastating impact on the food security and overall social and economic development of poor rural households. Rural economies remain some of the most vulnerable areas to climate change in Africa in terms of declines in agricultural production and uncertain climate that significantly affect food security (Armah, Yawson, Yengoh, Odoi and Afrira, 2010). The global crisis of 2008 led to the incidence of agrarian upheaval

[1] Department of Agricultural Economics & Extension, University of Fort Hare, Private Bag X1314, Alice 5700 South Africa

and inadequacy of staple food supplies which was most acute in Sub-Saharan Africa. According to Banerjee (2009), the financial crisis of 2008 resulted in the intensification of constraints on the production systems of the rural economy through plummeting product prices of agricultural commodities, declining availability of credit to small-scale agriculture, and shrinkage of non-farm employment opportunities in the secondary and tertiary sectors and increasing pressure of the work force on the primary sector.

Agriculture's inherent dependence on the vagaries of weather leads to production risks, and affects the farmers' ability to repay debt, to meet land rents and to cover essential living costs for their families. Ultimately, the precariousness of farmers and producers translates into macroeconomic vulnerability (Benson and Clay, 1998). Unless well managed, risk in agriculture slows development and hinders poverty reduction, ultimately resulting in humanitarian crises. Poor farmers have few options for coping with significant losses, and in order to reduce their exposure to risk, they often forgo opportunities to increase their productivity (Kanwar, 2005).

In the empirical literature, many researchers have found that risks cause farmers to be less willing to undertake activities and investments that have higher expected outcomes, but carry with them risks of failure (Alderman, 2008). The failure to cope with agricultural risk is not only reflected in household consumption fluctuations but also affects nutrition, health and education and contributes to inefficient and unequal intra-household allocations (Dercon, 2002). Households therefore habitually adopt diverse strategies to cope with or reduce risks to the maximum extent practicable. Traditional risk reducing strategies, however incomplete, help to cope with risky incomes (Morduch, 1999). There is vast literature documenting strategies employed by rural households to offset the adverse effects of income shortfalls and entitlement failures (Alderman, 2008). These efforts are however hampered by the absence of formal credit and insurance markets which often creates the impression that these households do not have strategies for dealing with income uncertainties.

According to Dercon (2007), in their daily lives, farmers experience at the same time "*fear and fate*". Out of the numerous risks they fear, at least one shock happens per day. Organic farmers particularly are faced with additional and different sources to risk due to limitations on their farming methods and practices (Flaten, Lien, Koesling, Valle and Ebbesvik, 2005). Restrictions on the use of chemicals influence production risk. Smaller organic markets influence price stability (Winter and Davis, 2006). Relatively recent studies that identified the sources of risk in agriculture include Tru and Cheong (2009); Salimonu and Falusi (2009) and Meuwissen, Huirne, and Hardaker (2001), but they largely refer to large scale commercial farmers.

In South Africa, there are few studies where farm-level data sets have been used to identify the perceived importance of multiple risk sources. These include MacNicol, Ortmann and Ferrer (2006) who identified sources of risk that commercial sugarcane farmers in the province of KwaZulu-Natal (KZN), South Africa, perceived to pose the greatest threat to the viability of their businesses. The most important risk sources were found to be the threat posed by land reform, minimum wage legislation and the variability of the sugar price. These findings confirm that government legislation risks (particularly relating to agrarian reform) have become increasingly important relative to price and production risks. Concerns among respondents regarding the land reform process in South Africa have become more pertinent with the shifting views on the willing-seller-willing-buyer principle to consideration of possible expropriation as per the Restitution of Land Rights Act 22 of 1994 (Nailana and Gotte, 2006). Stockil and Ortmann (1997) identified changes in the cost of farm inputs, government legislation (tax, labour, and land redistribution), the Rand exchange rate, and product prices as the most important sources of risk. Factor analysis of risk sources showed that various dimensions to risk exist, including changes in government policy, enterprise gross income, credit access and cost changes.

While these studies have established farmers sources of risk and shown how farmers behave under uncertainty, less work has been done to examine how smallholder farmers perceive risk and manage it in practice. Risks faced by smallholder farmers in rural settings have not received sufficient attention. The relative lack of information about (especially organic) farmers' risky environment and their approach to it means there are few useful practical insights for policy makers, researchers, extension officers and advisers. This paper seeks to explore smallholder rural farmers' perception of risk and risk management strategies.

2. The state of organic farming in South Africa

The South African organic sector has a long history dating back to the 1970s. The sector had about 50 small scale organic farmers in 1990 and the first group of farmers was certified by the United Kingdom Soil Association in 1993 (Moffet, 2001). While there is no consensus on the exact number of smallholder farmers and on the number of organic farms (Rundgren, 2006), there is evidence of substantial growth over the years. The available statistics focus on large commercial farms and mask the extent of the communal and subsistence farmers' involvement in organic farming (Auberch, 2003). South Africa has very few cases of documented smallholder organic growers and groups. According to Rundgren (2006), South Africa has begun to appreciate the role of organic agriculture in creating incomes and generating foreign exchange for the national economy, but like many other African states, the non-financial benefits of organic farming are rarely acknowledged and recognised.

Grolink (2002) notes that the potential for organic growth in South Africa is huge, not only driven by exports, but by a growing substantial domestic organic market unlike in many other African states. The Department of Agriculture, Forestry and Fisheries' (2006) National Policy on organic farming estimates that the value of the organic produce in South Africa is estimated to be between R200 million and R400 million, of this less than half is certified. This is across all categories of produce, a testimony to the rapid growth of this agricultural sector over the last 15 years. Grolink

(2002) further states that many large retail chains are also actively promoting organic products, particularly those supplied by smallholders who are given very little support despite being extensively used in the retailers' advertising campaigns. Mahlanza, Mendes and Vink (2003) emphasize that the growth in organic agriculture has been paralleled and promoted by the public's increasing awareness of health and lifestyle issues. Following the major global trends in food consumption, consumers' focus on health, convenience and the growing impact of private supermarket labels are taking stance in the South African context (ACNielsen 2005, 2006).

There are two distinct classes of organic agriculture observable in South Africa, namely certified organic production and non-certified or agro-ecological production (Parrott *et al.,* 2006). Certified production is earmarked mainly for export markets in Europe and North America, while agro-ecological farming is practiced to address challenges faced by smallholders. Arnold (1997) and Millstone and Lang (2002) argue that organic approaches have to make a trade-off between market oriented commercial production and increasing the productive capacity of marginalized communities. According to Byerlee and Alex (2005) organic agriculture is one of the sustainable approaches to farming and offers insights towards a paradigm shift in food and nutritional security. The UNEP-UNCTAD (2007) indicates that organic agriculture offers developing countries a wide range of economic, environmental, social and cultural benefits and it is well-suited for smallholder farmers, who comprise the majority of the world's poor.

The identification of organic agriculture as a development pathway, leading to improved livelihoods, is based on a central assumption that decreased use of external inputs, combined with price premiums for products will provide economic gain which can improve aspects of farmer's livelihood, for example food access, health, or education (Kilcher,2007). Organic agriculture is generally considered to reduce external input costs due to the cessation of use of pesticides and mineral fertilizers and increased internal nutrient recycling using green manures, composts and animal manures. However the farm scale effects of the adoption of organic agriculture in developing countries and the associated sources of risk are under-researched. In South Africa, to the best of the author's knowledge, there is no such study. Bakewell-Stone, Lieblein and Francis (2008) investigated the potential of organic agriculture to sustain livelihoods in Tanzania and found that, whilst there may be benefits for farmers, there are also a number of risks associated with the production and marketing of organic crops.

3. Materials

The selected study area is in the rural Umbumbulu magisterial district, uMgungundlovu District Municipality, Mkhambathini Local Municipality of KwaZulu-Natal Province. This province has the largest concentration of people who are relatively poor, and social indicators point to below average levels of social development (Statistics South Africa, 2006). According to the mid-year population estimates by Statistics South Africa (2010), the province has a population of 10.6 Million people 67% of whom reside in communal areas of the former KwaZulu-Natal homeland (Statistics South Africa, 2010). The land use pattern in Umbumbulu is predominantly agricultural in nature and has been characterized by small-scale subsistence farming and some marginal sugarcane cultivation. Smallholder agriculture is an important livelihood option for many rural families contributing a significant portion of their household income at a time when the population pressure is increasing and urban incomes are diminishing (Agergaard and Thomsen, 2006).

A survey was conducted during October-December 2004 to obtain socio-economic, demographic, institutional and household data via questionnaires through interview sessions with the principal decision maker in the participating households. The survey farmers were stratified into three groups: fully-certified organic farmers, partially-certified organic farmers and non-organic farmers. The fully-certified farmers are those who have been certified by the accreditation body Africa's Farms Certified Organic (AFRISCO) and are selling through the formal supply chain, the partially-certified are in the process of getting organic certified, while the non-organic group are not certified and are not entirely following organic practices. A total of 200 farmers were surveyed consisting of a census survey of 151 organic farmers and 49 non-organic farmers that were randomly selected from a sample frame constructed for each of the five neighbouring wards. The 151 organic farmers consisted of 48 fully-certified and 103 partially-certified organic farmers.

The 200 farmers were asked in the survey to give their perceptions of the main sources of risk that affect their farming activity by ranking the set of 20 perceived sources of risk on a 3-point Likert-type scales ranging from 1 (no problem) to 3 (severe problem) were employed. The listed perceived sources of risk used in the questionnaire were developed from findings of the research survey, past research on the perceived sources of risk in agriculture and challenges that smallholder farmers face in trying to access formal supply chains. The farmers were also requested to score any other perceived source(s) of risk(s) that they wanted to add to the list of hypothesized sources of risk. The additional sources of risk mentioned were crop damage by wild pigs, wild rabbits, moles, red ants and millipedes. However, less than 0.01% of the respondents cited these and they were therefore excluded as a category of risks for purposes of this analysis. These perceived risks are ranked from 1-being the most important/ having most impact to 20-being the least important/having the least impact. The ranking was done by averaging the scores on each source of risk and assigning a rank accordingly in ascending order. The farmers were also asked hypothetical questions designed to elicit their risk attitudes. The risk aversion of the sampled farmers was measured using the Arrow Pratt Absolute Risk Aversion (APARA) coefficient. The application of the Principal Component Analysis to quantify these preferences is described in detail in section 4 below.

4. Methods

All computations were conducted using the Statistical Package for Social Scientists (SPSS) version 19. Descriptive statistics were applied to analyze the general characteristics of the respondents as well as to evaluate the farmer's perceptions to risk and risk management decisions. The statistical analysis in this paper is based on the Principal Components Analysis (PCA) model using STATA 11. The general purpose of factor analytic techniques is to find a way of condensing the information contained in a number of original variables into a smaller set of new composite factors with minimum loss of information. The PCA is the most successful method under the factor analysis approach (Rao, 1964). Given a dataset with *P* numeric variables, one can compute *PC* principal components. Each principal component is a linear combination of the original variables, with coefficients equal to the eigenvectors of the correlation or covariance matrices. Principal components have a variety of useful properties (Rao, 1964; Kshirsagar, 1972). The implicit form for computing the first principal component (PC_n) is:

$$PC_n = f(a_{ni}X_i, \ldots\ldots\ldots a_{1k}X_k) \quad (1)$$

This simply means that, where there are a number of principal components, say *n* which represents any number greater than 1, each principal component will be a continuous variable or quantity related to the products of the values of the constituent variables and their respective weightings or component loading (*a*). As is well known, the relationship is an additive one and it is conventional to add up the products to obtain a value for the principal component. This is given by the following expression, for the first *PC*:

$$PC1 = a_{11}X_1 + a_{12}X_2 + \cdots a_{1k}X_k \quad (2)$$

Where:

PC_1 is the first principal component,

a_{1k} is the regression coefficient for the *k*th variable, that is the eigenvector of the covariance matrix between the variables, and

X_k is the value of the *k*th variable. This general model can be re-written as a functional equation.

The indication from equation (2) above is that a linear additive model is required to derive the principal components. Thus, if there are *n* principal components then a series of *n* equations can be written, each of them representing the linear combinations of component loadings and variable values and can be shown as equation (3) below:

$$\begin{aligned} PC_1 &= a_{11}X_1 + a_{12}X_2 + \ldots + a_{1k}X_k \\ PC_2 &= a_{21}X_1 + a_{22}X_2 + \ldots + a_{2k}X_k \\ &\vdots \\ PC_n &= a_{n1}X_1 + a_{i2}X_2 + \ldots + a_{ik}X_k \end{aligned} \quad (3)$$

Where:

$n = 1\ldots.7;$

$k = 1 \ldots 20;$

$a_{i1} \ldots a_{ik}$ = the component loadings; and

$X_1 \ldots X_k$ = the sources of risk

In this study, seven principal components have been extracted while 20 sources of risks have been identified. The coefficients $a_{i1}, a_{i2}, \ldots a_{ik}$ were chosen such that the first PC (PC1) will have a large variance as possible, the second PC *(PC2)* was chosen to be uncorrelated with the first, and to have as large variance as possible, etc. The PCs thus provide measures of the amount of common variation as well as magnitudes and nature of divergences in the farmers' scores for their perceptions of sources of risk.

There are various methods for determining the optimum number of factors, such as the Scree test, proportion of variance, analysis of residuals and a priori hypotheses. In this paper, the Kaiser–Guttman rule, which has been most commonly used due to its simplicity and availability in various computer packages (Kaiser, 1960). The Kaiser–Guttman rule states that "the number of factors to be extracted should equal the number of factors having an Eigen value greater than one". The rationale for choosing this particular value is that a factor must have variance at least as large as that of a single standardized original variable.

Note that the assumption of PCA is that interval data that is multivariate normally distributed should be used, but Kim and Mueller (1978) justify the use of ordinal data like Likert-type scales under two conditions: firstly, if the PCA is used to find general clustering of variables for exploratory purpose and secondly, if the underlying correlations among variables are believed to be moderate – say less than 0.6 or 0.7. The principal components (PCs) in this study are estimated using the covariance matrix as the scores are of the same units, implying that no source of risk is likely to have an undue influence on the principal components (PCs) due to a much larger relative variance (Manly, 2005).

The relationships between the perceptions of risk sources against farm and farmer socioeconomic characteristics were explored using factor analysis and multivariate regression methods. In regression analysis, the standard factor scores achieved from the factor analyses of the sources of risk were regressed on farms' and farmers' socioeconomic characteristics to identify the impact of these characteristics on the farmers' perceptions of risk sources. Specifically, the regression models can be represented in the form of equation 4 and 5:

$$\begin{aligned} FSR_{it} = f(&\text{Age, Gender, Education, Geography,} \\ &\text{Land size, Information access, Household size,} \\ &\text{Household Income, Risk taking, } \varepsilon_t) \end{aligned} \quad (4)$$

$$\begin{aligned} FSR_{it} = \beta 0 &+ \beta\text{Age} + \beta\text{Gender} + \beta\text{Education} \\ &+ \beta\text{Geography} + \beta\text{Land } \beta\text{size} + \beta\text{Information} \\ &+ \beta\text{access} + \beta\text{Household size} \\ &+ \beta\text{Household Income} + \beta\text{Risk taking} \end{aligned} \quad (5)$$

Where:

FSR_{it} = standardized factor scores for sources of risk factors (I = 1, 2, 3, . . . , 10), achieved from the factor analyses of sources of risk.

Age, Gender, Education, Geography, Land size, Information access, Household size, Household Income, Risk taking = Explanatory variables

ε_t = Error term

All of the regression models were tested for possible violations of the basic assumptions of a linear regression model. Specifically, a simple correlation matrix and collinearity diagnostics were inspected to detect any potential multi-collinearity. The first order autocorrelation problem was tested using the Durbin-Watson statistics.

A Herfindahl index (DH) is used to calculate enterprise diversification and represents the specialization variable. Although this index is mainly used in the marketing industry to analyze market concentration, it has also been used to represent crop diversification (Llewellyn and Williams, 1996; Bradshaw, 2004). Herfindhal index is the sum of squares of the proportion of individual activities in a portfolio. With an increase in diversification, the sum of squares of the proportion of activities decreases, so also the indices (DH). In this way, it is an inverse measure of diversification. The Herfindhal index is bound by zero (complete diversification) to one (complete specialization). Herfindhal index $(\mathrm{DH}) = \sum_{i=1}^{N} s_i^2$ where N is the number of enterprises and s_i is the value share of each *i-th* farm enterprise in the farm's output. $s_i = x_i / \sum_1 x_i$ is the proportion of the *i-th* activity in acreage / income.

5. Results and discussions

General characteristics of respondents

The summary statistics of the enumerated smallholder farmer groups are presented and compared in Table 1[2].

The average age of respondents in the study area was generally high (around 51 years) with most farmers being female. These findings were consistent with previous studies in the province that estimated the average rural household head to be 60 years of age (Matungul, 2001) and found that most *de facto* heads were female (Marcus, MacDonald, Maharaj, Manicon and Phewa, 1995). The literacy level in the study area was low while the household sizes were above the national average of 4.83 (PROVIDE, 2009). Fully-certified organic farmers appeared to farm more intensively with smaller farm sizes (0.59 hectares), more family labour (9.49), highest farm income (R973.17) per annum and the highest proportion of income from farming (0.62). This latter is an indication that fully-certified organic farming and its commercialization has brought economic benefits to these otherwise poor rural households and is an important contributor to household income, albeit the high input costs.

A majority of the fully-certified and partially-certified organic farmers are located in the Ogagwini and Ezigeni sub-wards while non-organic farmers reside in Nungwane sub-ward. The estimated Arrow Pratt Absolute Risk Aversion coefficient shows that non-organic farmers are more risk averse than the organic farmers. Fully-certified organic farmers had the highest number of chicken (15.3 per household) as chicken manure is the main source of fertilization among smallholder rural farmers. The fully-certified organic farmers had more assets wealth than the other farmer groups. Smallholder farmers in rural KwaZulu-Natal have access to land through permission to occupy with allocation done by the traditional chief of the tribe (*inkosi*) and his headman (*induna*). On average the respondents across the farmer groups acknowledged that the household had rights to exercise on its own cropland the following: build structures, plant trees, bequeath to family members or lease out.

Perceptions of sources of risk

The identified risk sources and their ranking in order of importance are presented in Table 2.

The fully-certified organic farmers cited uncertain climate (mean 2.96), lack of cash and credit to finance inputs (mean 2.78) and tractor unavailability when needed (mean 2.76) as main sources of risk. These risks have a direct bearing on production. The key ranking for uncertain climate while beyond the control of the farmer, probably reflects the farmers' concerns about

Table 1: Summary statistics of respondents

Variable	Fully-certified organic (n= 48)		Partially-certified organic (n= 103)		Non-organic (n =49)	
	Mean	std. dev.	Mean	std. dev.	Mean	std. dev.
Age (years)	52.60	1.90	48.60	1.41	52.7	2.11
Gender (%female)	82	0.05	71	0.05	84	0.05
Education (years)	4.98	4.24	4.37	4.49	3.38	0.61
Household size(number)	9.49	5.23	7.72	3.68	6.60	3.46
Land size (hectares)	0.59	1.22	0.71	1.16	0.67	1.43
Input costs (rands)	812.90	884.91	309.30	343.40	318.20	302.90
Farm income (rands)	973.17	1074.51	417.26	471.50	400.28	429.53
Farm income (proportion of income from farming)	0.62	0.79	0.38	1.04	0.39	0.63
Location (Ogagwini /Ezigoleni =1; Other =0)	2.56	0.60	1.91	0.54	4.00	0.00
Risk attitude(Arrow Pratt Absolute Risk Aversion Coefficient)	0.522	0.29	0.581	0.307	0.756	0.29
Land rights (1= full access to land; 0=otherwise)	1.98	0.14	1.75	0.56	1.93	0.33
Chicken(number)	15.29	13.16	9.25	8.69	6.40	6.62
Asset ownership (index)	0.98	0.59	0.56	0.58	0.67	0.75

Table 2: Identification of risk sources and rank

Constraint	Fully-certified organic (n=48)			Partially-certified organic (n=103)			Non-organic (n=49)		
	Mean	Std dev.	Rank	Mean	Std dev.	Rank	Mean	Std dev.	Rank
Livestock damage crops	2.56	.744	7	2.82	.488	4	2.80	.539	**2**
Uncertain climate	2.96	.189	**1**	2.83	.409	**3**	2.82	.486	**1**
Uncertain prices for products sold to pack house	2.21	.793	13	2.13	.591	16	–	–	–
Uncertain prices for products sold to other markets	1.94	.811	17	2.02	.595	18	2.17	.761	10
More work than the family can handle	2.58	.599	6	2.32	.688	12	2.53	.649	4
Lack of cash and credit to finance inputs	2.78	.567	**2**	2.58	.615	6	2.78	.468	**3**
Lack of information about organic farming	2.02	.687	15	2.20	.632	14	2.16	.717	11
Lack of information about alternative markets	2.38	.623	10	2.29	.602	13	–	–	–
Lack of proper storage facilities	2.56	.660	7	2.46	.543	9	2.41	.643	7
Lack of affordable transport for products	2.72	.492	4	2.42	.560	11	2.06	.852	**12**
Lack of telephones to negotiate sales	2.69	.509	5	2.55	.633	8	2.22	.771	8
Inputs not available at affordable prices	2.52	.642	9	2.80	.447	5	2.51	.545	5
Tractor is not available when I need it	2.76	.501	**3**	2.89	.416	**1**	2.46	.713	6
Cannot find manure to purchase	1.92	.778	**18**	2.56	.660	7	2.20	.645	8
Cannot find labour to hire	1.73	.764	**20**	1.76	.816	**20**	2.00	.764	**13**
Cannot access more cropland	1.95	.753	16	1.98	.805	**19**	1.92	.794	**14**
Delays in payment for products sent to pack-house	2.22	.723	12	2.89	.315	**1**	–	–	–
Lack of bargaining power over product prices at the pack-house	2.16	.672	14	2.20	.704	14	–	–	–
Lack of information about consumer preferences for our organic products	2.23	.654	11	2.44	.604	10	–	–	–
Pack-house does not reward me fully for my own product	1.86	.780	**19**	2.02	.866	17	–	–	–

[1]*mean score (1 (no problem) to 3 (severe problem)*
[2]*Rank is in ascending order; 1 means most important and 20 least important.*

the effects of recent drought in rural KwaZulu-Natal, which impacted negatively on crop yield. Due to communal land tenure system and collateral required for credit, farmers have limited options to obtain credit from financial institutions for farming. Tractor unavailability can be attributed to the fact that the one tractor available in the area, has been allocated to the local farmer group. This tractor is leased out at a rental fees to members and poses a challenge during land preparation when demand is at peak. Similarly, partially-certified farmers' also ranked tractor not available when needed (mean 2.89) and uncertain climate (mean 2.83) as identified sources of risk. The risk of delays in payment for products sent to pack house (mean 2.89) are attributed to the long value chain processes. Non-organic farmers also cited uncertain climate (mean 2.82), livestock damage to crops (mean 2.80) and lack of cash and credit to finance farm inputs (mean 2.78).

It is evident from the rankings in Tables 2 that some of the perceived sources of risk were common across the farmer groups. These include the uncertain climate and lack of cash and credit to finance inputs. Through better communication, joint-problem solving and commitment, these specific risk sources can be made known to both downstream and upstream players. Investment in water harvesting technologies may alleviate the problem of drought whose occurrence is uncertain. Access to credit however will need the support of government and other role players in the financial sector to address lack of collateral among smallholder farmers.

All the farmer groups ranked "cannot find labour" lowest. This is a clear indication that labour is not a constraining factor and is relatively. Similarly, lack of access to land was not a major risk as land is readily available through the communal system of allotment.

The optimal number of components was obtained by the Kaiser-Guttman rule. Table 3 below represents the Eigen value proportions of variance for selecting the optimal number of components. The correlation matrix shows that all of the estimated correlation coefficients between the sources of risk scores are less than 0.7 as required (see Kim and Mueller 1978). Seven principal components (PCs) that explained 66.13% of the variance in the original scores were extracted from the covariance matrix (see Table 3). Koutsoyiannis (1987) suggests retaining principal components (PCs) that meet Kaiser's criterion. The Eigen values for the seven principal components (PCs) are all above one. Varimax rotation did not improve the interpretation of these PCs and the reported PCs are thus unrotated as explained by Norusis (2008).

According to the factor loadings in Table 3, the factors 1 to 7 can best be described as 'financial and incentives index', 'input-output index', 'crop production index', 'labour availability index', 'lack of production information index', 'lack of market opportunity index', and 'input availability index' respectively. The first principal component (PC1) explained 18.37% of the variance in the explanatory variables with all six estimated coefficients above 0.3 being positive. This

Table 3: Estimated principal components for the perceived sources of risk

Sources of risk	Financial and Incentive	Input-output	Crop production	Labour availability	Production information	Market opportunity	Input availability
Proportion of variance explained	**18.37**	**12.74**	**8.94**	**7.66**	**7.43**	**5.77**	**5.21**
Eigen Values	**3.6748**	**2.5483**	**1.7874**	**1.5325**	**1.4866**	**1.1538**	**1.0417**
	Factor Loadings						
Livestock damage crops	0.1100	−0.1156	**0.3452**	0.2196	0.2857	−0.0013	−0.2347
Uncertain climate	0.0757	0.0462	0.0187	−0.2487	−**0.4786**	−0.1421	0.2498
Uncertain prices for products sold to pack house	**0.3281**	−0.0683	−0.0500	0.0549	−**0.3858**	−0.0258	0.2812
Uncertain prices for products sold to other markets	**0.3690**	−0.1476	−0.0176	−0.0476	−0.0498	0.1235	−0.1389
More work than the family can handle	0.1083	0.0648	0.2948	**0.5425**	0.0253	0.1286	−0.0136
Lack of cash and credit to finance inputs	0.0279	**0.3881**	**0.3753**	−0.0694	0.1017	0.1417	0.0874
Lack of information about organic farming	0.1746	−0.0545	−0.0123	0.0754	**0.3494**	−0.1293	0.1272
Lack of information about alternative markets	0.2371	0.0901	0.1686	0.1849	0.0141	**0.5791**	−0.1677
Lack of proper storage facilities	−0.0776	**0.3881**	−0.2332	−0.0969	0.2711	−0.1649	−0.0234
Lack of affordable transport for products	0.0498	0.1455	−**0.4236**	0.2461	0.2707	0.1866	0.2077
Lack of telephones to negotiate sales	0.2397	−0.1594	0.0795	−0.2056	0.2309	**0.3997**	0.2935
Inputs not available at affordable prices	0.0256	0.2961	**0.4164**	0.1253	−0.1322	0.1380	**0.3008**
Tractor is not available when I need it	0.0195	0.2949	0.0251	−0.2040	0.2671	−0.2627	**0.4099**
Cannot find manure to purchase	0.0410	**0.4545**	−0.0444	0.0499	−0.2645	0.1226	−0.2108
Cannot find labour to hire	**0.3307**	−0.0497	0.2221	0.0955	−0.0049	−**0.3651**	−0.1058
Cannot access more cropland	0.1567	0.1187	0.2744	−**0.5214**	0.1259	0.0288	−0.1877
Delays in payment for products sent to pack-house	0.1748	**0.4314**	−0.1998	0.2250	−0.1263	−0.0296	−0.2235
Lack of bargaining power over product prices at the pack-house	**0.3734**	0.0006	−0.0859	−0.1015	0.0098	−0.1224	−0.2903
Lack of information about consumer preferences for our organic products	**0.3706**	0.0829	−0.0977	−0.0456	0.1177	−**0.3165**	−0.0481
Pack-house does not reward me fully for my own product	**0.3594**	−0.0640	−0.1541	0.1723	−0.0063	0.0119	**0.3410**

Note: Factor Loadings >|0.3| are in bold and underlined

index suggests that respondents who were concerned with uncertain prices for the formal and informal market options are also faced with the risk of labour unavailability as well as lack of bargaining power. These farmers are also concerned about the lack of information on consumer preferences and the ability of the pack house to give farmers incentives for production.

According to Hough, Thompson, Strickland III, and Gable (2008), buyers have a stronger competitive advantage when they can exercise bargaining leverage over price, quality, service or other terms of sale. This component seems to capture risks associated with financial or farmer liquidity and incentives. It is important to note these risks are associated with production and marketing by the organic farmers. These farmers by targeting the niche of health conscious consumers may obtain premium prices associated with certified organic produce. The fully-certified organic and partially-certified organic farmers through their farmer association could exercise their bargaining power as a social network entity in order to influence better prices for producers.

Similarly, contract farming may limit the risk associated with unreliable market and prices for producers while buyers will have a guaranteed supply of organic produce. Information on consumer demand and preferences may enable the farmers better understand how to meet market demand. It is important to note that while information on organic production and marketing is readily available at the South Africa's Department of Agriculture, Forestry and Fisheries, and through various economic bureaus, the challenge remains accessibility, packaging and dissemination to smallholder farmers.

The second principal component (PC2) accounted for 12.74% of the variance in the explanatory variables, and shows that fully-certified and partially-certified farmers who rank lack of cash and credit to finance inputs as a source of risk, are also concerned with the lack of proper storage facilities to store their crops. These farmers also experience challenges to purchase manure for organic farming and experience delays in payment for produce sent to the pack house. This component could be interpreted as reflecting Input-output risk. Lack of liquidity may remain a risk in the short and medium-term as the rural farmers do not have collateral required by the financial institution for access to credit. The indigenous communal land tenure system in the rural areas is a further hindrance to access to credit and finance.

The third principal Component (PC3) accounted for 8.94% of the variation and shows that farmers who strongly perceive livestock damage to crops as a major source of risk are also concerned about inputs not being available at affordable prices. Across the three farmer groups, lack of cash and credit to finance inputs was identified as a source of risk. However, these farmers did not perceive lack of affordable transport for products as a major risk. The latter could be attributed to the fact that the produce is collected at the farm gate and transport costs are limited to produce sold in the local market or surrounding farms. This dimension reflects a crop production risk.

The fourth component (PC4) explained 7.66% of the variance in the explanatory variables and implies a labour availability risk. More work than the household can handle was identified as a major risk. However lack of crop land was not perceived as a risk. The latter is due to the fact that land in the area is not a constraining factor and expansion of cropland is available at the request of the local headman. Organic farming is a labour intensive technology and would require more labour than conventional farming however the returns may be higher if farmers access the niche markets as is currently the case with the fully-certified and partially-certified smallholder farmers who are supplying an up market food retail store in KwaZulu-Natal. The labour bottlenecks experienced could also be attributed to increasing disability and ailments due to HIV/AIDS and outmigration of the youth.

The fifth principal component (PC5) displays a variation of 7.43% in the farmers' rankings, and captures a lack of production information. This risk is closely linked to weak support for extension services and advice to enable smallholder farmers to improve and increase production. The South Africa Government is in the process of revitalizing extension services to ensure access to rural advisory services and improved agricultural practices among smallholder farmers especially in rural areas. The sixth principal component (PC6) refers to a lack of market opportunity and accounted for 5.77% of the variation in the farmers' scores for the sources of risk. What both established and emerging black smallholders have in common is that they farm mainly to add to household food security. Surplus production has remained rare in the rural context. Moreover, the limited excess farming output is usually sold in local markets. Their access to established markets is limited by infrastructure and related transactional costs. Finally the seventh principal component is an input availability risk. The farmers perceived lack of inputs at affordable prices and tractor not available when needed as major risk sources. Lack of access to inputs and incentives is a deterrent to the development and growth of smallholder farming. According to the Southern African Trust (2009), Malawi is a great example of how government intervention and support prioritized smallholder farmers to overcome chronic hunger and achieve national food security.

Relationship between perceptions of risk sources against farm and farmer socioeconomic characteristics

Relationships between "perceptions of sources of risk" and "farm and farmer socioeconomic" variables were assessed using multiple regressions, the results of which are shown in Table 4. For each of the independent variables, the table depicts the partial regression coefficients and the levels of significance for the two-tailed t-tests. The goodness-of-fit of the models is indicated by adjusted R^2.

In the regression analyses, multi-collinearity between the independent variables was not found to be a problem (i.e. no variables have been omitted): Correlations were low, nonlinear principal components analysis (Gifi, 1990) for socioeconomic variables did not show strong relationships, and variance inflation factors (Hair *et al.*, 2006) had all values around 1. As shown in Table 4, the regression models for Financial and Incentive, Input-output and Labour availability are statistically significant at a 1%, 1% and 5% level of significance respectively. All Durbin-Watson statistics for the six regression models ranged from 1.5 to 2.5, suggesting that autocorrelation is not a problem for these models. The goodness-of-fit is low as is often the case for discrete choice models (Verbeek, 2008).

An analysis of the socio economic factors identified the following variables to have a significant association with the various sources of risk: age, gender, education, location, information access and risk taking ability. Older farmers were concerned about the availability of labour while female farmers considered input-output risk and crop production risks as significant and relevant. Farmers residing in the non-organic areas of Hwayi and Numgwane sub-wards were more concerned about financial and incentive risk as well as input availability. These farmers have limited access to financial resources and incentives for production while farmers residing in the pioneer organic areas of Ogagwini and Ezigoleni considered input-output risk as less relevant. Farmers with access to information perceived input output risk and crop production risks as less relevant but financial and incentive risk are significant and more relevant. Farmers who were more

Table 4: Results of multiple regressions for sources of risk against socio-economic variables

Independent Variables	Sources of risk													
	Financial and Incentive	*p*-value	Input-output	*p*-value	Crop production	*p*-value	Labour availability	*p*-value	Production information	*p*-value	Market opportunity	*p*-value	Input availability	*p*-value
Constant	−1.35**	0.041	−0.362	0.564	−0.674	0.251	−1.202*	0.087	0.291	0.643	−0.638	0.255	0.1	0.893
Age	−0.004	0.594	0.008	0.29	−0.009	0.177	0.017**	0.039	−0.001	0.89	0.007	0.294	−0.01	0.281
Gender	−0.321	0.196	0.626***	0.01	0.52**	0.022	−0.127	0.63	−0.019	0.937	0.024	0.911	−0.194	0.493
Education	−0.013	0.612	0.065***	0.009	0.002	0.922	−0.046*	0.088	0.022	0.364	0.02	0.36	−0.026	0.376
Geography	0.243***	0.001	−0.114*	0.085	0.074	0.231	0.073	0.316	−0.049	0.453	0.004	0.95	0.18**	0.023
Land Size	0.101	0.282	−0.084	0.356	0.086	0.31	−0.208**	0.041	−0.028	0.753	−0.079	0.326	−0.115	0.286
Information	0.089***	0.001	−0.051***	0.01	0.021	0.253	0.03	0.179	−0.05**	0.013	−0.007	0.698	−0.008	0.742
Household size	0.032	0.211	0.029	0.231	0.028	0.226	−0.007	0.805	0.02	0.409	−0.012	0.598	−0.017	0.56
Household Income	0.045	0.222	0.005	0.878	0.013	0.691	−0.004	0.918	−0.001	0.966	0.035	0.265	−0.008	0.849
Risk taking	0.05	0.666	−0.135	0.231	0.057	0.588	0.191*	0.128	0.064	0.572	0.002	0.981	0.117	0.383
R2 adj	0.223***		0.188***		0.048		0.12**		0.003		−0.070		0.028	
p-value	0.002		0.005		0.196		0.036		0.428		0.906		0.287	
Durbin watson statistics	1.464		1.785		1.632		1.642		2.147		2.447		1.779	

****,**,* represents statistical significance at 1%,5% and 10% respectively*

likely to take risk perceived labour availability risks as much less relevant.

Risk management strategies

The production, financial, market and institutional risk, along with a farmer's attitude toward risk, have a major impact on the choice of risk management strategies and tools. Risk sources cause adversity in yield, prices and production units. Each or any combination of the outcomes of the risk sources may lead to low or declining farm income. There are several strategies that farm operators can use to reduce the farm exposure to risks. The strategies can be classified into modern and traditional risk management tools. The modern instruments include crop insurance, forward contract, and futures among others. In the absence of modern risk management tools especially among rural smallholder farmers, farmers can rely on some traditional strategies to deal with risk. This section summarizes the most important traditional risk management strategies used by the surveyed farmers. These are crop diversification, precautionary savings and participating in social network.

Diversification is a frequently used risk management strategy that involves participating in more than one activity. The rationale for diversifying is that returns from various enterprises do not move up and down in lockstep, so that when one activity has low returns, other activities likely would have higher returns. The extent to which a farmer uses on-farm diversification as a risk management strategy was measured using the Enterprise Diversification Index (EDI) also referred to as the Herfindahl Index (DH). Enterprise diversification is a self-insuring strategy used by farmers to protect against risk (Bradshaw, 2004).

The estimated Herfindahl index was 0.72, 0.89 and 0.23 for fully-certified organic, partially-certified organic and non-organic farmers (Table 5), an indication that the cropping system is relatively diverse. These results are consistent with previous findings in this study measuring farmers risk attitudes, that established that non-organic farmers are more risk averse than organic farmers. These results also confirm previous findings by Rahman (2009) who obtained an estimated DH of 0.49–0.69 among smallholder farmers in three regions in Bangladesh. The proportions of farmers using different risk management strategies are presented in Table 5.

Similarly, 69.1% of fully-certified farmers practised crop diversification compared to 96.8% of the non-organic farmers. A total of 81.2% of the partially-certified farmers practised crop diversification. The common crops grown by the organic farmers are *amadumbe*[3], potatoes, sweet potatoes and green beans while non-organic farmers grew *amadumbe*, potatoes, sweet potatoes, green beans, maize, sugarcane, bananas, chilies and peas. Precautionary saving occurs in response to risk and uncertainty (Feigenbaum, 2011). The smallholder farmers' precautionary motive was to delay/minimize consumption and save in the current period due to their lack of crop insurance markets. According to Cunha, Heckman and Navarro (2005) the

[3] This is a starchy, herbaceous and perennial tuber crop identified scientifically as *Colocasia esculenta,* and important as a famine reserve crop among smallholders.

Table 5: Risk management strategies used by the different farmer groups

Risk management strategy	Fully-Certified organic (n=48)	Partially-certified organic (n= 103)	Non-organic (n= 49)
Enterprise diversification index(DH)	0.7220	0.8962	0.2303
Practice crop diversification (% of respondents)	69.1	81.2	96.8
Savings (% of respondents)			
• Savings bank account	60.9	48.9	46.8
Current level of savings (% of respondents)			
• less than R500	27.27	37.84	35.29
• R501 – R1000	45.45	29.73	41.18
• R1001 – R5000	21.21	29.73	17.65
• More than 5000	6.07	2.70	5.88
Social networks (% of respondents)			
Membership of farmer associations	100	100	10
Others(burial clubs, *stockvel*[1])	33	25	25

[1]*A Stokvel is a club serving as a rotating credit union in South Africa where members contribute fixed sums of money to a central fund on a weekly, fortnightly or monthly basis.*

quantitative significance of precautionary saving depends on how much risk consumers face. Whereas 60.9% of the fully-certified farmers had savings bank accounts, only 46.8% non-organic farmers had bank accounts. The current level of saving in the study area was low with savings ranging from less than R500 to over R5000 per month. Among the fully-certified organic group, most of the respondents (45.45%) saved between R1000-R5001 whereas most of the of partially-certified farmers(37.84%) saved less than R500 per month. Most of the non-organic farmers (41.18%) saved between R501-R1000 per month. Across all groups, however the level of saving greater than R5000 was minimal.

The farmers also engage in social networks as a risk sharing strategy. There were two main categories of social networks that the farmers engaged in. These are farmers' associations and other social networks, most notably burial clubs and *stockvels*. The farmers' association is used as a vehicle for the organic farmers for purposes of production and access to markets for their organic produce while the burial clubs and *stockvels* are a source of access to credit and or loans. In the latter instance, farmers do not have to produce collateral. The burial clubs and *stockvels* are common in most rural areas and a means for mitigating liquidity and financial risk where possible.

6. Conclusion

The study seeks to establish the smallholder farmers' perception of risk and risk management strategies in rural KwaZulu-Natal and to contribute towards ongoing research into risk and risk management by smallholder farmers in developing countries. Summary statistics analysis shows that farming in rural KwaZulu-Natal is generally done by older female smallholder farmers with low literacy levels. Fully-certified organic farmers appeared to farm more intensively with the proportion of income from farming also recorded as higher than the other farmer groups. The majority of the organic farmers are located in the Ogagwini and Ezigeni sub wards locations and were found to be less risk averse than non-organic farmers. Chicken manure was the main source of fertilization and fully-certified organic farmers also had more asset wealth. Access to land for these smallholder farmers is through permission to occupy allocated by the traditional authority.

In general price, production and financial risks were perceived as the most important sources of risk. These were identified across the farmer groups as: uncertain climate, lack of cash and credit to finance inputs; tractor is not available when needed, delays in payment for products sent to pack house and livestock damage to crops. Seven principal components (PCs) that explained 66.13% of the variance in the original scores were extracted from the covariance matrix. These were labeled as follows: 'financial and incentives index', 'input-output index', 'crop production index', 'labour availability index', 'lack of production information index', 'lack of market opportunity index', and 'input availability index'.

Using multiple regression analysis, age, gender, education, location, information access and risk taking ability were found to have a significant association with the various sources of risk, the most important traditional risk management strategies used by the surveyed farmers in rural KwaZulu-Natal are crop diversification, precautionary savings and participating in social network. The findings are consistent with economic theory which postulates that in the absence of insurance markets, poor farm households tend to be risk averse and are reluctant to participate in farm investment decisions that are uncertain or involve higher risk. Risk research in agricultural economics and farm management has placed more emphasis on production and market risks (Musser and Patrick 2002). The result of this study provides useful insights for policy makers, advisers, developers and sellers of risk management strategies. It recommends that attention should be paid to studying and understanding price, production and financial risks common among smallholder rural farmers. Similarly, policy makers, researchers and advisers should use decision analysis tools that incorporate these identified risks.

Acknowledgements

The authors wish to express sincere appreciation to the rural farmers of Mkhambathini Local Municipality, who participated in the study. Recognition is also given to the two anonymous reviewers for their valuable inputs and comments. This study was partially funded by the FORD Foundation.

About the authors

Maggie Kisaka-Lwayo (maggiekisaka@yahoo.com) is a PhD student at the University of Fort Hare in South Africa. She holds a Master's degree in Agriculture, Resource Economics and Management and a BSc (Honours) degree in Agricultural Economics. Ms Lwayo has many years' experience as an agricultural economist working with smallholder farmers and rural communities in Kenya and South Africa. She has previously taught at the University and worked with various local and international research institutions, including the World Agroforestry Centre (ICRAF) and the International Livestock Research Institute (ILRI). She has several publications in her main areas of research interest of (i) Technology adoption, its determinants and impact on poverty and natural resource utilisation; (ii) Policy research and institutional reform on rural livelihood; and (iii) Natural resource management and its implications for rural development.

Ajuruchukwu Obi (aobi@ufh.ac.za) is Professor in the Department of Agricultural Economics and Extension of the University of Fort Hare, South Africa. Professor Obi obtained his degrees in Agricultural Economics and Economic Policy Management from the University of Nigeria, University of the Free State (South Africa) and McGill University. He has previously worked for the University of Nigeria, International Labour Organization (ILO), the United Nations Development Programme (UNDP), and the United Nations Volunteers (UNV), among other institutions. His main research interests include agricultural land prices and land reforms, crop-livestock integration in smallholder agriculture, water use in agriculture, value chain analysis, technology adoption and technical and institutional constraints to smallholder farming.

REFERENCES

ACNielsen (2005). What's Hot in SA? A C Nielsen Market Intelligence report, 1 February 2005. [Online].www.foodreview.co.za. Accessed 11 October 2011

ACNielsen (2006). *SA spend trends. A C Nielsen Market Intelligence report, January 2006*. [Online]. www.foodreview.co.za. Accessed 11 October 2011

Adesina, A. and Brorsen, B.W. (1987). A risk responsive acreage response function for millet in Niger. *Agricultural Economics.* 1(3): 229–239.

Adesina, A.A. and Quattara, A.D. (2000). *Risk* and *agricultural* systems in Northern Cote d'Ivoire. *Agricultural Systems.* 66(1): 17–32.

Agergaard, J. and Birch-Thomsen, T. (2006). Transitional rural landscapes: The role of small-scale commercial farming in former homelands of Post-Apartheid KwaZulu-Natal. *Danish Journal of Geography*. 106(2): 87–102.

Akcaoz, H. and Ozkan, B. (2005). Determining risk sources and strategies among farmers of contrasting risk awareness: A case study for Cukurova region of Turkey. *Journal of Arid Environments.* 62(4): 661–675.

Alderman, H. (2008). *Managing risks to increase efficiency and reduce poverty*. World Development Report 2008. Washington D.C: World Bank.

Alimi, T. and Ayanwale, A.B. (2005). Risk and risk management strategies in onion production in Kebbi State of Nigeria. *Journal of Social Science*. 10(1): 1–8.

Altieri, M (2009). Agro ecology, small farms, and food sovereignty. *Monthly Review*. 61(3): 102–113.

Altieri, M.A. and Koohafkan, P. (2008). Enduring farms: climate change, smallholders and traditional farming communities. Environment and Development Series No. 6. Third World Network, Penang.

Armah, F.A., Yawson, D.O., Yengoh, G.T., Odoi, J.O and Afrifa, E.K.A. (2010). Impact of floods on livelihoods and vulnerability of natural resource dependent Communities in Northern Ghana. *Water* 2(2): 120–139.

Arnold, G. (1997). *The Resources of the Third World*. London, Cassell.

Auerbach, R. (2003). Organic farming: a world revolution in agriculture: by invitation. *Farmer's weekly,* Issue 93003: 20–21.

Bakewell-Stone, P., Lieblein, G., Francis, C. (2008). Potentials for organic agriculture to sustain livelihoods in Tanzania. *International Journal of Agricultural Sustainability*. 6(1): 22–36.

Banerjee, A. (2009). Emerging constraints on smallholder agriculture in developing countries under neo-liberalism and impact of the global crisis: Evidence from the rural economy in India. Presentation at the UNRISD Conference on '*Social and Political Dimensions of the Global Crisis: Implications for Developing Countries*' Palais Des nation, Geneva, Switzerland, 12–13th November, 2009.

Benson, C. and Clay, E. (1998). *The impact of drought on Sub-Saharan African economies.* World Bank Technical Paper Series No. 401. Washington, D.C. World Bank.

Bradshaw, B. (2004). Questioning crop diversification as a response to agricultural deregulation in Saskatchewan, Canada. *Journal of Rural Studies.* 20(1): 35–48.

Brock, A. and Paasch, A. (2009). *International responses to the food Crisis. Assessment from a right to food perspective*. Heidelberg: FIAN International.

Byerlee, D. and Alex, G. (2005). *Organic farming: a contribution to sustainable poverty alleviation in developing countries*? German NGO Forum on Environment and Development, Bonn. Misereor, Naturland, EED, NABU and WWF.

Cunha, F., Heckman, J. and Navarro, S. (2005). Separating uncertainty from heterogeneity in life cycle earnings. *Oxford Economic Papers.* 57(2): 191–261.

Department of Agriculture, Forestry and Fisheries (2006). *The National Policy on Organic Production. Discussion Document.* [Online]. www.nda.agric.za/doaDev/NationalPolicyOrganic Farming. Accessed 7 January 2011.

Dercon, S. (2007). Fate and fear: risk and its consequences in Africa. *Journal of African Economies*. 17(2): 97–127

Gifi, A. (1990). *Nonlinear multivariate analysis*. John Wiley and Sons, NJ

Grolink, (2002). Feasibility study for the establishment of certification bodies for organic agriculture in Eastern and Southern Africa. Report commissioned by Sida/INEC, Höje

Fan, S. (2011). Leveraging smallholder agriculture for development. *Symposium on Global Agriculture and Food Security: Progress and Strategies for Success*. 24 May, Washington DC.

Feigenbaum, J. (2011). Precautionary saving or denied dis-saving. *Economic Modeling.* 28(4): 1559–1572.

Flaten, O., Lien, G., Koesling, M., Valle, P.S. and Ebbesvik, M. (2005). Comparing risk perceptions and risk management in organic and conventional dairy farming: empirical results from Norway. *Livestock Production Science.* 95(1–2): 11–25.

Hair, J.J.F., Black, W.C., Babin, B.J., Anderson, R.E., and Tatham, R.L. (2006). *Multivariate data analysis*. Pearson Prentice Hall. NJ.

Hough, J., Thompson, A. A. Jr., Strickland III, A. J. and Gable, J. E. (2008). *Strategic management: concepts and case studies.* 13th edition. Boston: McGraw Hill.

International Fund for Agricultural Development (IFAD) (2011). *Rural poverty report. New realities new challenges: New opportunities for tomorrow's generation*. Rome, Italy.

International Fund for Agricultural Development (IFAD) (2010). *The future of world food security: investing in smallholder agriculture.* IFAD publication, Rome. Italy.

Kaiser, H.F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*. 20: 141–151.

Kanwar, A.A. (2005). Risk management for bank in Pakistan. *Market Forces.* 1(1); 1–7.

Kim, J.O. and Mueller, C. W. (1987). Factor analysis. Statistical methods and practical issues. Beverly Hills, CA: Sage

Kilcher, L. (2007). How organic agriculture contributes to sustainable development. Journal of Agricultural Research in the Tropics and Subtropics. *Supplement.* 89: 31–49.

Koutsoyiannis, A. (1987). *Theory of econometric.,* McMillan Education Limited: London

Kshirsagar, A.M. (1972). *Multivariate analysis*. Marcel Dekker, Inc: New York.

Llewellyn, R.V. and Williams, J.R. (1996). Nonparametric analysis of technical, pure technical, and scale efficiencies for food crop production in East Java, Indonesia. *Agricultural Economics.* 15(2): 113–126.

MacNicol, R., Ortmann, G.F. and Ferrer, S.R.D. (2007). Perceptions of key business and financial risks by large-scale sugarcane farmers in KwaZulu-Natal in a dynamic socio-political environment. *Agrekon*. 46(3): 351–370.

Mahlanza, B., Mendes, E. and Vink, N. (2003). A comparative advantage of organic wheat production in the Western Cape. *Agrekon*. (42)2: 145–151

Manly, B.F.J. (2005). *Multivariate statistical methods: A primer*. Chapman and Hall: London.

Marcus, T., MacDonald, C., Maharaj, P., Manicon, D. and Phewa, R. (1995). *An analysis of land availability, social demography, stakeholders and institutional arrangements*. School for Rural Community Development, University of Natal, Pietermaritzburg, South Africa.

Matungul, M. P. (2001). Transaction costs and crop/marketing in the communal areas of Impendle and Swayimana, KwaZulu-Natal. *Development Southern Africa.* 18(3): 347–363.

Meuwissen, M.P.M., Huirne, R.B.M. and Hardaker, J.B. (2001). Risk and risk management: an empirical analysis of Dutch livestock farmers. *Livestock Production Science.* 69(1): 43–53.

Millstone, E. and Lang, T. (2002). *The atlas of food: who eats what, where and why?* Easrthscan: London.

Moffet, J. (2001). *Principles of organic farming*. Paper contributed at the 1st short course in organic farming organised by the Spier Institute and the Elsenburg Agricultural College, 25th–27th October 2001.

Morduch, J. (1999). Between the state and the market: Can informal insurance patch the safety net? *World Bank Research Observer*. 14(2): 187–207.

Musser, W.N. and Patrick, G.F. (2002). How much does risk really matter to farmers? In: Just, R.E. and Pope, R.D. (Eds.): *A comprehensive assessment of the role of risk in U.S. agriculture*. Kluwer: Boston.

Nailana, K. and Gotte, S. (2006). Expropriation – your questions answered. *AgriReview, Standard Bank,* fourth quarter 2006. [Online]. http://www.standardbank.co.za/za/vgn/images/portal/cit_4931/41/47/24740676aGRIq42006.pdf. Accessed on 29 August 2011.

Norusis, J. M. (2008). SPSS statistics 17.0. Guide to data analysis. Prentice Hall: NJ

Parrott, N., Ssekyewa, C., Makunike,C. and Ntambi, M.S. (2006). Organic farming in Africa. In: Willer, H., and Yussefi, M. (Ed.): *The world of organic agriculture, statistics and emerging trends 2006*. International Federation of Organic Agriculture Movements (IFOAM), Bonn, Germany

Rahman, S. (2009). Whether crop diversification is a desired strategy for agricultural growth in Bangladesh? *Food Policy*. 34(4): 340–349.

Rao, C.R. (1964). The use and interpretation of principal component analysis in applied research. *The Indian Journal of Statistics*. 26(4): 329–358.

Rundgren, G. (2006). *Best practices for organic policy: what developing country governments can do to promote the organic sector.* Developing country organic policy. UNEP-UNCTAD. [Online]. http://www.unep-unctad.org/. Accessed 12 September 2011

Salimonu, K.K. and Falusi, A.O. (2009). Sources of risk and management strategies among food crop farmers in Osun state, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development.* 9(7): 1591–1605.

Southern African Trust (2009). *Boosting Smallholder Farming is Key to Easing Hunger at Household Level in Southern Africa*. [Online]. http://www.southernafricatrust.org/docs/Media_Release_Seeds_of_Plenty_20090831.pdf. Accessed 3 January 2011.

Statistics South Africa. (2010). Mid-year population estimates by Province. [Online]. http://www.statssa.gov.za/publications/P0302/P03022010.pdf. Accessed 12 September 2011.

Statistics South Africa. (2006). Online data files. http://www.statssa.gov.za/extract.htm. Accessed 25 February 2011.

Stockil, R.C. and Ortmann, G.F. (1997). Perceptions of risk among commercial farmers in KwaZulu-Natal in a changing economic environment. *Agrekon.* 36(2): 139–156.

Tru C. L. and Cheong, F. (2010). Perceptions of risk and risk management in Vietnamese catfish farming: an empirical study. *Aquaculture Economics and Management*. 14(4): 282–314.

UNEP-UNCTAD (2007). *Sector Background Note – Organic Agriculture.* [Online].http://www. unep-unctad.org/cbtf/events/geneva5/WordBackgroundnote_organicagriculture_1102007.pdf. Accessed 15 June 2011

Verbeek, M. (2008). A Guide to Modern Econometrics. 3rd Edition. John Wiley and Sons: NJ

Wenner, Mark. (2002). *Lessons learned in rural finance.* Technical papers series, IADB-SDS. Washington, DC.

Winter, C.K and Davis, S.F. (2006). Organic foods. *Journal of food science*. 71(9): 117–124.

Repair and Maintenance Costs for Agricultural Machines

MARKUS LIPS[1] and FRANK BUROSE[1]

ABSTRACT

The paper presents an approach for deriving repair and maintenance factors intended to indicate the accumulated repair and maintenance costs for agricultural machines. In a two-stage approach, an annual repair and maintenance cost function is estimated and afterwards aggregated for the machine's estimated service life. Based on cross-sectional data, the approach is applied for tractors, ploughs, mowers and self-loading trailers in Switzerland, covering a wide range of agricultural mechanisation.

The results of our study show that, in line with the literature, an additional year in service increases annual repair and maintenance costs for all machine types under consideration. Furthermore, annual utilisation strongly influences repair and maintenance costs, a fact which, to our knowledge, has so far not been taken account of in the literature. For all analysed machines, increasing annual utilisation leads to a disproportionately low increase in repair and maintenance costs, revealing the existence of an economy-of-scale effect. Assuming that the machine's estimated service life (also called estimated useful life) is completely exploited, the accumulated repair and maintenance costs depend strongly on the machine's annual utilisation. Accordingly, in order to minimise accumulated repair and maintenance costs, high annual utilisation coupled with a short length of service life is beneficial.

KEYWORDS: Repair costs; maintenance; agricultural machines; Switzerland

JEL codes: M11, Q12

1. Introduction

Machinery is an important cost factor in agriculture. Looking at wheat production in France, Germany and Canada, for instance, machinery costs account for 20 to 30% of total costs (Agri Benchmark 2009, p. 83). Accurate information on machinery costs is therefore an essential input for farm managers.

Machinery costs consist of several sub-cost items such as depreciation, interest rate, insurance, housing, fuel costs, and repair and maintenance costs. All of these sub-cost items are straightforward to calculate except for depreciation and repair and maintenance costs. As regards depreciation, two recent analyses compare different functional forms (Wu and Perry 2004, Wilson 2010). Dumler et al. (2003) as well as Wilson and Tolley (2004) apply several depreciation methods in order to compare their accuracies with prices of second-hand tractors from auction results, dealer or trade advertisements. Based on an estimated depreciation function, Wilson and Davis (1998) present an approach for calculating hourly costs of depreciation and interest charges for tractors.

By contrast, analyses of repair and maintenance costs have been few in number over the last 15 years. As pointed out by Stiens & Windhüffel (1990, p. 148), repair data is the key issue in machinery costs, representing a substantial pitfall. An important reason for this is that repair and maintenance costs tend to increase with machine age (Rotz 1987, p. 4). Farm-management literature focuses on the cumulative or accumulated repair and maintenance costs for the machine's estimated service life (also called estimated useful life or wear-out life). Typically, costs are represented as simplified factors indicating total accumulated repair and maintenance costs, formulated as a fraction of the machines' list price. These 'easy-to-apply' figures are provided to farmers in many countries for a broad variety of agricultural devices (e.g. ASAE 2003a and 2003b, Whitehead & Archer 2010, Gazzarin & Albisser 2010). As an example, a repair and maintenance factor of 0.5 for a tractor with a list price of Swiss Francs[2] (CHF) 100,000 indicates that repair and maintenance costs of CHF 50,000 accrue during the machine's estimated service life, i.e. 10,000 hours for tractors. Dividing the accumulated repair and maintenance costs by the estimated service life of the machine yields the average repair and maintenance costs per work unit (i.e. per hour for tractors).

In order to specify the repair and maintenance factor, a regression analysis explaining the accumulated repair and maintenance costs as a function of accumulated work units is typically performed (e.g. Ward et al. 1985, Morris 1988, Wendel 1989, Bruhn 2000, Khoub bakht et al. 2008). Introducing the estimated service life as accumulated work units in the estimated function yields the repair and maintenance factor.

[1] Agroscope Reckenholz Tänikon Research Station ART, Tänikon, CH-8356 Ettenhausen, Switzerland; Email: markus.lips@art.admin.ch

[2] At mid-January 2012 one Swiss Franc (CHF1) was worth approximately US$1.07, £0.70 or €0.83

Although widely applied, this approach suffers from two limitations. Firstly, only one independent variable is used, which reduces the explanatory power. As an important reason for this, a couple of analyses compare several functional forms, including quadratic form (Morris 1988, Bruhn 2000). Secondly, data requirements are substantial, with accumulated repair and maintenance costs as well as accumulated work units being necessary for each machine. To follow the trend of costs for each machine, the accumulated repair and maintenance costs for each service interval, say every 1,000 hours for tractors, is required. Bearing in mind that agricultural machinery can easily be used for 15 years or more, detailed records kept by the farm manager over decades are essential.

Morris (1988, p. 195f) also applies an alternative approach in his analysis. Instead of directly estimating an accumulated repair-and-maintenance-costs function, he tackles the problem in two steps. Firstly, the repair-and-maintenance-costs function per work unit is estimated by means of a regression analysis. Secondly, the integration of the cost function over work units approximates the accumulated repair and maintenance costs.

Similarly to Morris (1988), this paper suggests a two-stage approach allowing the introduction of several independent variables, particularly age and annual utilisation. Based on cross-sectional rather than accumulated data for repair and maintenance costs, the demonstrated approach substantially reduces data requirements. Using data from a recent survey, the approach is applied for four types of agricultural machines in Switzerland covering a wide range of agricultural mechanisation: tractors, ploughs, mowers and self-loading trailers (also known as self-loading forage wagons).

The paper is organised as follows: the data used are briefly described in the second section. Section three focuses on the suggested approach covering the estimation procedure, as well as the necessary aggregation. The results are reported in section four. Sections five and six are devoted to discussion and conclusions, respectively.

2. Data

In 2008, Albisser et al. (2009) conducted a postal survey on machinery costs in Switzerland. Out of the 2,000 randomly selected farms, 351 or 18% took part. Farm managers were asked to give detailed information on 14 selected machinery types frequently used in Swiss agriculture.

For each machine, farmers were asked to indicate some type-specific attributes, such as engine power for tractors or number of ploughshares for ploughs. In addition, the age of the machines and their annual utilisation over the last three years were recorded. To keep the effort required in responding to an acceptable level, the accumulated repair and maintenance costs were not included in the questionnaire. Instead, farm managers were asked to indicate their annual repair costs, including service agents' bills for the last three years. In addition, the material expenses for the last three years for repairs executed by farm employees are also taken into account[3]. Unfortunately, farm-employee labour input for on-farm repairs is not recorded in the survey. This leads to an underestimation of repair costs, and must be borne in mind when interpreting results. To summarise, average annual repair costs are derived from service agents' bills and material expenses on-farm.

For maintenance activities, farm managers were questioned about annual material costs and farm-employee labour input. The latter is calculated at the rate of CHF 28 per hour, the standard hourly agricultural wage in Switzerland (Gazzarin & Albisser, 2010). Repair and maintenance costs are then added together. As a further step, repair and maintenance costs are divided by the machine type's list price, which reflects machine size (ASAE 2003b, p. 370). The list prices from the most recent machinery cost report (Gazzarin & Albisser, 2010) are applied, taking account of the specific type and size of machine. The resulting annual repair and maintenance costs expressed as a fraction of the machine's list price can also be interpreted as an annual repair and maintenance factor.

For our analysis, we concentrated on four types of machines: tractors, ploughs, mowers and self-loading trailers. All of these are of interest, either due to their mechanical complexity (tractors, mowers, self-loading trailers) or the substantial wear they undergo (ploughs), as well as their importance for Swiss agriculture. Furthermore, although machines with data gaps for age or annual utilisation are excluded from the analysis, a sufficient number of observations are available for these four machine types[4]. In total, we have 1,083 observations at our disposal. Some key figures for all four machine types are reported in Table 1.

The bulk of the 1,083 available machines – 655 – are tractors. On average, a tractor is utilised 272 hours a year. The average age of the machinery in the sample is 20 years. Assuming that the observed annual utilisation is representative of the entire lifespan, the length of service can be calculated. Given an estimated service life of 10,000 hours for tractors, the length of service is 37 years (= 10,000 h/272 h per year). The lengths of service for ploughs, mowers and self-loading trailers are 47, 23 and 42 years, respectively. It is therefore obvious that machine utilisation in Switzerland is fairly low, and it is doubtful that all machines attain their estimated service lives.

As for annual repair and maintenance costs, these vary between 0.012 and 0.036 of the machine's list price. Expressed per work unit, repair and maintenance costs account for CHF 4.56 (self-loading trailers) to CHF 34.45 (ploughs).

3. Method

Regression Analysis

In order to explain annual repair and maintenance costs as a dependent variable, we carry out a regression analysis leading to a cost function. Because the

[3] Although carrying out repairs requires specific training, we cannot rule out the possibility of such operations being performed on-farm.

[4] Data gaps for machine-type-specific data such as wide-base tyres (tractors) or number of knives (self-loading trailers) are treated differently. For continuous variables, we insert the mean values of the sample. For binary variables, the base case (normally without additional equipment) is applied.

Table 1: Key figures for four machine types

	Tractors	Ploughs	Mowers	Self-Loading Trailers
Number of observations	655	127	90	211
Work unit (WU)	hour	hectare	hectare	cartload
Annual utilisation in WUs[1]	272 h	21 ha	52 ha	130 cartloads
Age, years in service	20	16	10	19
Estimated service life in WUs[2]	10,000 h	1,000 ha	1,200 ha	5,500 cartloads
List price in CHF[2]	72,786	20,721	14,038	55,641
Annual repair and maintenance costs in CHF[1]	1,582	734	453	591
Annual repair and maintenance factor	0.022	0.036	0.035	0.012
Repair and maintenance costs in CHF per WU	5.82	34.45	8.79	4.56

[1]Based on a three-year average
[2]Based on Gazzarin & Albisser (2010)

dependent variable has values close to zero, we are dealing with a skewed distribution. We therefore apply a logarithmic transformation to adjust this distribution. Several machines report repair and maintenance costs of nil. Since we cannot log-transform these cases, we assume an annual minimum value of CHF 1.00 for repair and maintenance costs.

As a consequence of the dependent variable's logarithmic form, only two functional forms, exponential and power, can be applied for the analysis. Testing both of them the power functional form explains a greater percentage of the variation for all machine types. Accordingly, we apply a power functional form, which is also in line with Morris (1988), Bruhn (2000) and Khoub bakht et al. (2008), who compare several functional forms and in the end choose the power function:

$$y = \beta_0 x_1^{\beta_1} x_2^{\beta_2} \quad (1)$$

The dependent variable y represents the annual repair and maintenance costs expressed as a fraction of the machine's list price. Two independent variables x_1 and x_2 represent annual utilisation and the machine's age, respectively. If further machinery-specific variables such as engine power for tractors are available, the cost function is extendable. All coefficients β are estimated by means of a log-log model[5]. Due to the logarithmic transformation, binary variables (0, 1) must be reformulated towards the values 1 (logarithm equal to zero) and 2.

To deal with outliers, we apply the Iteratively Reweighted Least Squares (IRLS) technique, which weights the observations according to their outlierness. The model is estimated by applying Ordinary Least Squares (OLS's) with the resultant weights of the robust regression. To test for heteroscedasticity, we apply the Breusch-Pagan test. If the H_0 of constant variance is rejected, a Huber-White estimator, also known as a sandwich estimator of variance, is applied (StataCorp 2007, p. 268f).

Starting with all available machine-specific variables, the exclusion of variables is analysed by means of an F-test.

Owing to the definition of the dependent variable, the estimated coefficients cannot be interpreted as marginal costs per year. To enable such an interpretation, the marginal effects must be calculated separately. While w represents the value list price of the machine type in question, the marginal costs (MC) for variable x_1 are:

$$MC_{x_1} = w\frac{\partial y}{\partial x_1} = w\beta_0\beta_1 x_1^{\beta_1 - 1} x_2^{\beta_2} \quad (2)$$

The marginal effect is calculated by inserting mean values for all continuous variables. For binary variables, the marginal effect is calculated by changing the binary variable's value.

Aggregation towards Accumulated Costs

After the annual repair and maintenance costs have been estimated, an aggregation is required in order to obtain the repair and maintenance factor representing the accumulated costs for the machine's estimated service life u (e.g. 10,000 hours for tractors). We therefore think of the estimated service life as the product of x_1 work units per year and a reference length of service of u/x_1. The variable x_2 representing the machine's age is supplemented with indices i extending from the first year of service until u/x_1, the last year of service in which the estimated service life is concluded. Based on equation 1, the repair and maintenance factor RMF can be calculated by summing the annual cost function over all years i:

$$RMF = \Sigma_{i=1}^{u/x_1} y_i = \beta_0 x_1^{\beta_1} \Sigma_{i=1}^{u/x1} x_{2i}^{\beta_2} \quad (3)$$

In other words, the estimated cost function (equation 1) is applied for each year and summed up.

To analyse the impact of different annual utilisations on the repair and maintenance factor, Equation 3 is applied for several annual utilisations (x_1) and matched lengths of service (u/x_1) covering a wide range of operating versions (e.g. for tractors, 1,000 hours a year over 10 years vs. 222 hours a year over 45 years). Since the aggregation takes place on an 'annual' level, the length of service must be an integer.

4. Results

Tables 2 to 5 present the regression estimates for annual repair and maintenance costs expressed as a fraction of the machine's list price for tractors, ploughs, mowers and self-loading trailers, respectively. Due to the weighting from the robust regression, one observation for each of the estimates explaining repair and maintenance costs for ploughs and self-loading trailers is omitted. As regards the F-Test, we can reject the

[5] $\ln y = \ln\beta_0 + \beta_1 \ln x_1 + \beta_2 \ln x_2$

Table 2: Regression estimates for annual tractor repair and maintenance costs

Variable	Unit	Coefficient	Standard Error	T-Value	P-Value	Marginal Effect in CHF
Constant	–	−6.74	0.53	−12.81	<0.001	–
Annual utilisation	hours	0.51	0.05	9.99	<0.001	2.67
Age	years	0.28	0.04	6.85	<0.001	19.92
Engine power	HP	−0.21	0.09	−2.20	0.028	−3.96
Wide-base tyre	binary	0.17	0.07	2.40	0.017	172.34
Two-wheel drive	binary	−0.22	0.10	−2.26	0.024	−203.30

HP = horsepower
No. of observations: 655
$F(5,649) = 27.3$; P-Value: <0.001
$R^2 = 0.20$

Table 3: Regression estimates for annual plough repair and maintenance costs

Variable	Unit	Coefficient	Standard Error	T-Value	P-Value	Marginal Effect in CHF
Constant	–	−5.38	0.45	−12.01	<0.001	–
Annual utilisation	hectare	0.36	0.10	3.74	<0.001	11.38
Age	years	0.32	0.10	3.06	0.003	13.75

No. of observations: 126
$F(2,123) = 9.0$; P-Value: <0.001
$R^2 = 0.13$

Table 4: Regression estimates for annual mower repair and maintenance costs

Variable	Unit	Coefficient	Standard Error	T-Value	P-Value	Marginal Effect in CHF
Constant	–	−7.37	0.81	−9.07	<0.001	–
Annual utilisation	hectare	0.47	0.13	3.47	0.001	4.24
Age	years	0.45	0.14	3.24	0.002	21.85
Working width	metre	1.25	0.67	1.88	0.064	241.10
Drum mower	binary	−0.68	0.28	−2.46	0.016	−176.12

No. of observations: 90
$F(4,85) = 6.2$; P-Value: <0.001
$R^2 = 0.23$

Table 5: Regression estimates for annual self-loading trailer repair and maintenance costs

Variable	Unit	Coefficient	Standard Error	T-Value	P-Value	Marginal Effect in CHF
Constant	–	−4.71	0.68	−6.93	<0.001	–
Annual utilisation	hectare	0.42	0.05	8.38	<0.001	1.89
Age	years	0.16	0.09	1.90	0.059	5.16
Volume	cubic metre	−0.83	0.17	−4.95	<0.001	−20.08
Knives	number	0.12	0.07	1.84	0.068	6.44

No. of observations: 210
$F(4,205) = 25.0$; P-Value: <0.001
$R^2 = 0.33$

hypothesis that the estimated coefficients are simultaneously equal to zero for all machine types. The coefficients of determination (R^2) range between 0.13 and 0.33.

For tractors, annual utilisation and age exert highly significant effects (Table 2). The estimated exponent for annual utilisation is far below one (0.51). Accordingly, repair and maintenance costs increase in a disproportionately low manner compared to utilisation. This effect is also confirmed by the marginal effect, which is based on sample mean values. The marginal effect of an additional hour of utilisation is CHF 2.67, which is far below the average hourly repair and maintenance costs (CHF 5.82/h, Table 1). An additional year in service increases annual costs by CHF 19.92. Tractors with more powerful engines have relatively lower costs. In this respect, it is important to note that younger tractors have larger horse power[6].

Wide-base tyres lead to additional repair and maintenance costs of about CHF 172.34 per year (marginal effect based on sample mean values). Similarly, compared to the base-case equipment with four-wheel drive, the cost of two-wheel drive tractors is about CHF 203.30 lower a year.

The estimated exponent for annual plough utilisation is highly significant, and indicates that repair and

[6] Horse power and age are negatively correlated (−0.64).

Table 6: Repair and maintenance factor (RMF) for different operating versions

LS in Years	Tractors		Ploughs		Mowers		Self-loading trailers	
	AU in hours	RMF	AU in ha	RMF	AU in ha	RMF	AU in cartloads	RMF
10	1,000	0.26	100	0.39	120	0.37	550	0.15
15	667	0.34	67	0.57	80	0.54	367	0.21
20	500	0.43	50	0.75	60	0.71	275	0.25
25	400	0.50	40	0.93	48	0.88	220	0.30
30	333	0.58	33	1.10	40	1.04	183	0.34
35	286	0.65	29	1.27	34	1.21	157	0.38
40	250	0.72	25	1.44	30	1.38	138	0.42
45	222	0.79	22	1.62	27	1.54	122	0.46

AU = Annual utilisation
LS = Length of service
RMF = Repair and maintenance factor; accumulated repair and maintenance costs reported in relation to the machine's list price

maintenance costs increase in a disproportionately low manner (value below 1) if annual utilisation increases (Table 3). The marginal effect of an additional hectare amounts to CHF 11.38, which represents less than a third of the average repair and maintenance costs per hectare (Table 1). Costs for ploughs increase with age: An additional year in service leads to additional repair and maintenance costs of about CHF 13.75 per year. According to the F-test, the number of ploughshares can be excluded as an explanatory variable.

For mowers, the results for annual utilisation and age are similar to those of the preceding machines, leading to marginal effects of CHF 4.24 per additional hectare and CHF 21.85 per additional year in service, respectively (Table 4). Working width is only significant on the 10% level. Applying sample mean values for marginal effects an additional metre of working width increases annual costs by CHF 241.10. Lastly, the equipment with discs (base case) or drums (also called a cylinder mower) is important. Drum mowers, which represent 40% of the sample, have lower annual repair and maintenance costs (CHF 176.12), reflecting their lower mechanical complexity.

Whereas the annual utilisation of self-loading trailers exerts a highly significant effect, age is only significant on the 10% level (Table 5). Volume measured in cubic metres refers to the size of cartloads. The bigger the machine, the lower are the relative annual repair and maintenance costs[7]. Applying sample mean values for marginal effects an additional cubic metre of volume reduces annual costs by CHF 20.08. By contrast, an additional knife increases repair and maintenance costs by CHF 6.44 per year.

Table 6 shows the results for the repair and maintenance factors (RMFs) which represent the accumulated repair and maintenance costs over the entire service period reported in relation to the machine's list price. Full utilisation of estimated service life is assumed for all operating versions presented (annual utilisation and reference lengths of service).

The results show clearly that the degree of machine utilisation exerts a huge influence on accumulated repair and maintenance costs. For example, given an annual utilisation of 400 hours and a service life of 25 years, an RMF of 0.50 of the tractor's list price is spent on repair and maintenance. Increasing annual utilisation towards 500 hours with a reference service life of 20 years reduces repair and maintenance costs by about 0.07 of the tractor's list price towards an RMF of 0.43. For the other machines also, an increase in annual utilisation leads to substantially lower repair and maintenance costs.

5. Discussion

Limitations on the interpretation of the results exist for two reasons. Firstly, looking at the coefficients of determination, no more than one-third of the variance can be explained. While Morris (1988) presents similar coefficients of determination for the repair cost functions per hour, it has to be noted that the mentioned studies dealing with either accumulated repair and maintenance costs or depreciation show clearly higher coefficients of determination. Accordingly, there are further important influences on repair and maintenance costs which, could not be taken into account, e.g. make of machinery, additional equipment, operating conditions (e.g. soil type in the case of ploughs), or the treatment of machinery by farm workers, which also includes use of the machinery on different farms (cooperative machine usage). Secondly, based on a survey, repair and maintenance costs must to be understood as minimum values. As mentioned in the data section, farm workers' labour input for repair activities on-farm is not included in the survey data. Accordingly, working time cannot be rated and is missing from the analysis. In addition, while it is unlikely that farmers will inflate the costs with respect to bills from service agents or for material expenses, we cannot rule out the possibility of farm managers forgetting to state costs for individual repairs.

For tractors, we can compare our results for accumulated repair and maintenance costs with the literature. Analysing 172 tractors in Germany with an average annual utilisation of 898 hours, Bruhn (2000) reports accumulated costs of 0.39 of the machine's list price[8]. Our results for an annual utilisation of 1000 and 667 hours – 0.26 and 0.34, respectively – are of a similar

[7] The correlation between volume and age is −0.18.

[8] These tractors are selected out of a sample of 210 tractors. On average, the tractors of the whole sample are more powerful (178 horsepower compared to 75 horsepower) and newer (4.2 years old compared to 20 years old) than those in the Swiss sample.

magnitude. The cost function proposed by Wendel (1989) for 27 90-kW-class (122 horsepower) German tractors with an annual utilisation of 803 hours can be converted into accumulated repair costs of 0.50 using list prices from the reference years (KTBL 1990), which is in excess of our estimates for similar annual utilisations. For the USA, the American Society of Agricultural Engineers (ASAE, 2003a and 2003b) gives repair and maintenance factors resulting in total costs of 0.30 (four-wheel drive and 10,000 hours estimated service life). Our results for an annual utilisation of 1,000 and 667 hours − 0.26 and 0.34, respectively – are similar. Conversely, for two-wheel drive tractors, the ASAE reports far higher repair and maintenance costs of about 0.7 (10,000 hours estimated service life), indicating a substantial technical difference between the two types of tractors. In our results, two-wheel tractors have slightly lower costs than four-wheel tractors (Table 2).

Another four analyses for tractors show different results. Ward et al. (1985) find accumulated repair costs of above 2.00 for four-wheel tractors used in forestry work in Ireland. Rotz (1987) reports accumulated costs of 1.00 for four-wheel-drive tractors for the USA. For the UK, Morris (1988) estimates accumulated repair and maintenance costs by means of his two-stage approach at 0.80 of the machine's list price based on 50 tractors with an annual utilisation of about 800 hours. Finally, Khoub bakht et al. (2008) arrive at accumulated costs as high as 0.88, based on 102 (type MF285) tractors in Iran. All four analyses with substantially higher values either originate in a region with a different climate and agricultural scenario (Khoub bakht et al., 2008) or are older (i.e. date from the 1980s: Ward et al. 1985, Rotz 1987 and Morris 1988). Similarly, Bruhn (2000) stresses that – compared to older analyses – technical improvement has occurred in Germany, leading to lower repair costs.

For ploughs and mowers, a different definition of work units only allows for an indirect comparison with the ASAE (2003a). Assuming a slightly larger estimated service life, the ASAE gives repair and maintenance costs of 1.01 for mouldboard ploughs, which tallies with our estimates for annual utilisations of 33 and 40 hectares. As regards mowers, the ASAE's repair and maintenance costs are 1.49, a value corresponding to our results for annual utilisation of around 27 hectares. Here, we must mention that the ASAE uses an utilisation value more than twice that of the mowers in Switzerland.

The importance of annual utilisation as an explanatory factor for repair and maintenance costs has been reported in just one study. Applying a covariance analysis, Bruhn (2000, p. 72) reports a statistically significant correlation between per-hour repair costs and annual utilisation for German tractors. Consequently, annual utilisation is used to calculate repair costs per work unit, but omitted as an explanatory variable in the subsequent regression analysis.

6. Conclusions

In this paper, we analyse repair and maintenance costs for four agricultural machine types in Switzerland, applying a two-stage approach in order to derive repair and maintenance factors. Compared to the literature, we introduce two modifications: Firstly, we use cross-sectional data from a survey instead of accumulated data on repair and maintenance costs and working units, with the result that data requirements can be substantially lowered. Secondly, this approach allows the introduction of more than one influencing variable.

Although no more than one-third of the variances can be explained, the analysis reveals statistically significant influences. For all four machines analysed, both age and annual utilisation significantly influence annual repair and maintenance costs. In addition, the regression analyses show that machine-specific variables are also important, and must be taken into account when analysing repair and maintenance costs.

The marginal effect of an additional year in service is positive for all machines. Generally speaking, the older the machine, the higher the annual repair and maintenance costs. It is in line with the literature that repair and maintenance costs tend to increase with the age of the machine, possibly owing to material fatigue and the higher costs of spare parts for older machines.

The introduction of annual utilisation as an explanatory variable helps us understand that the intensity of machine usage plays a major role in repair and maintenance costs. A central conclusion of this paper is that the repair and maintenance factor depends not only on (accumulated) utilisation, as reported in the literature, but also on annual utilisation. Consequently, assuming that the machine's estimated service (or useful) life is completely exploited, repair and maintenance costs depend on the length of time during which the estimated service life is utilised, a fact which, to our knowledge, has so far not been taken account of in the literature. Accordingly, farm-management literature should also report machinery repair and maintenance factors along with the reference annual utilisation.

Because estimated exponents for annual utilisation are less than one, an increase in annual utilisation leads to a decrease in repair and maintenance costs per work unit. This effect is confirmed for all machinery types analysed. We therefore conclude that there is an economy-of-scale effect. Hence, at least some repair and maintenance costs are incurred by activities performed independently of annual utilisation. Consequently, Swiss agriculture could achieve substantial savings in repair and maintenance costs by increasing its annual utilisation of machinery. The higher the utilisation rate, the lower the repair and maintenance costs per work unit. This tallies with the above-mentioned influence of length of service life. From a repair-and-maintenance-costs perspective, a short length of service coupled with high annual utilisation is advantageous. Conversely, lowering annual utilisation and extending the length of service of a machine leads to additional repair and maintenance costs. In this respect, the inter-farm use of machinery may represent a promising strategy for Swiss agriculture.

According to the literature, annual utilisation has a similar effect on depreciation, at least for tractors. If the market price of second-hand tractors is used to determine the current value of the machine and hence depreciation, a high annual utilisation leads to lower depreciation and interest charges per work unit (Wilson and Davis 1998, Wilson 2010).

As regards the application of the repair and maintenance factors for farm-management literature presented here, it must be borne in mind that, owing to the limitations of the data used, the values are to be understood as minimum figures. Consequently, a rounding-up of these figures is recommended.

The suggested approach constitutes a useful tool for all agricultural machine types analysed, leading to repair and maintenance factors comparable to those in the literature. It also offers the possibility of broad application via cross-sectional data, which is less costly than the recording of accumulated repair and maintenance costs.

Further analyses of other machinery types must be carried out in order to update the repair and maintenance factor database of the Swiss report on machinery costs. In addition, an important question to be answered in future is whether technological improvement still leads to lower repair and maintenance costs, as claimed by Bruhn (2000). If so, a regular revision of repair and maintenance factors for farm management literature would be essential.

About the authors

Dr Markus Lips (markus.lips@art.admin.ch) is head of the research group farm management of the Agroscope Reckenholz Tänikon research station (ART, www.agroscope.ch) in 8356 Ettenhausen, Switzerland.

Dr. Frank Burose (burose@ernaehrungswirtschaft.ch) a former scientific collaborator of the farm management research group of ART is business manager of the "Food Industry Competence Network" (www.ernaehrungswirtschaft.ch) in 8570 Weinfelden, Switzerland.

Acknowledgements

The authors thank Pierrick Jan, Andreas Roesch as well as two anonymous reviewers for their very helpful comments.

REFERENCES

Agri Benchmark, 2009. *Cash Crop Report 2009: Benchmarking Farming Systems Worldwide*. Braunschweig: Agri Benchmark, von Thünen Institut (vTI).

Albisser, G., Gazzarin, Ch. and Gärtner D., 2009. *Maschinenkosten in der Praxis: Auslastung, Nutzungsdauer und Reparaturkosten ausgewählter Landmaschinen auf Schweizer Betrieben*. ART-Bericht No. 711, Ettenhausen: Agroscope Reckenholz-Tänikon Research Station.

ASAE, 2003a. Agricultural Machinery Management Data D497.4 FEB03. American Society of Agricultural Engineers. *ASAE Standards*, 2003, pp. 373–380.

ASAE, 2003b. Agricultural Machinery Management EP496.2 FEB03. American Society of Agricultural Engineers. *ASAE Standards*, 2003, pp. 367–372.

Bruhn, I., 2000. *Erhebung zu Reparaturkosten von Maschinen auf Grossbetrieben, dargestellt für Traktoren und Mähdrescher*. Forschungsbericht Agrartechnik No. 357. Dissertation, Christian-Albrechts-Universität zu Kiel.

Dumler, T. J., Burton, R. O. and Kastens, T. L., 2003. Predicting Farm Tractor Values through Alternative Depreciation Methods. *Review of Agricultural Economics, 25*(2), pp. 506–522.

Gazzarin, Ch. and Albisser, G., 2010. *Maschinenkosten 2010*. ART-Bericht No. 733, Ettenhausen: Agroscope Reckenholz-Tänikon Research Station.

Khoub bakht, G. M., Ahmadi, H., Akram, A. and Karimi, M., 2008. Repair and Maintenance Cost Model for MF285 Tractor: A Case Study in Central Region of Iran. *American-Eurasian Journal of Agricultural & Environmental Sciences*, 4(1), pp. 76–80.

KTBL, 1990. *KTBL-Taschenbuch Landwirtschaft*, 15th edition, Darmstadt: KTBL, Association for Technology and Structures in Agriculture.

Morris, J., 1988. Tractor repair costs. *Farm Management*, 6(10), pp. 433–441.

Rotz, C. A., 1987. A Standard Model for Repair Costs of Agricultural Machinery. *Applied Engineering in Agriculture,* 3(1), pp. 3–9.

StataCorp, 2007. *Stata User's Guide, Stata Statistical Software*. Release 10, College Station, TX: StataCorp LP.

Stiens, H. and Windhüffel U., 1990. Zur Kalkulation des Reparaturrisikos. *Agrarwirtschaft,* 39(5), pp. 148–154.

Ward, S. M., McNulty, P. B. and Cunney, M. B., 1985. Repair Costs of 2 and 4 WD Tractors. *Transactions of the ASAE*, 28(4), pp. 1074–1076.

Wendel, G., 1989. Reparaturkostenuntersuchungen an Ackerschleppern. *Grundl. Landtechnik,* 39(1), pp. 17–21.

Whitehead, E.N.C. and Archer, C.G., 2010. *Guide to Machinery Costs. Agricultural Development Support Services Directorate KwaZulu-Natal South Africa*, available at: <www.kzndae.gov.za/AgricultureDevelopmentServices/AgriculturalEconomics/GuidetoMachineryCosts.aspx>, [accessed 4 October 2011].

Wilson, P. and Davis, S., 1998. Estimating Depreciation in Tractors in the UK and Implications for Farm Management Decision-Making. *Farm Management*, 10(4), pp. 183–193.

Wilson, P. and Tolley, C., 2004. Estimating tractor depreciation and implications for farm management accounting. *Farm Management*, 12(1), pp. 5–16.

Wilson, P., 2010. Estimating Tractor Depreciation: The Impact of Choice of Functional Form. *Journal of Farm Management*, 13(12), pp. 779–818.

Wu, J. and Perry, G. M., 2004. Estimating Farm Equipment Depreciation: Which Functional Form is Best? *American Journal of Agricultural Economics*, 86(2), pp. 483–91.

CALL FOR PAPERS

International Journal of Agricultural Management (IJAM)

General

IJAM welcomes submission of articles of various types:

- Articles based on original research, submitted for peer-review (up to 6000 words);
- Reviews of 'state-of-the-art' of research in relevant arenas, again subject to peer-review (up to 6000 words);
- Reviews of 'state-of-the-art' in agricultural or related practice (up to 5000 words);
- Case Studies of innovative practice, including evaluation of results (up to 3000 words);
- 'Viewpoint' articles taking a particular standpoint on current issues, and encouraging response from readers (up to 1500 words);
- Professional updating pieces (e.g. in rural policy, market trends, managerial practice) (up to 3000 words);
- Book reviews (up to 1000 words).

Guidance for contributors can be found on the journal website at www.tinyurl.com/6cb3hmq

Themed issues

It is proposed to produce occasional special issues based on a particular theme relevant to agricultural management, the latter term including social, economic and environmental aspects of food production and rural development, but with a farm-level orientation. If you would be interested in being a Guest Editor for a themed issue of IJAM, please email the Editor at editor.ijam@gmail.com with an outline of your proposal. We would expect a Guest Editor to:

1. Identify potential authors who might be expected to write an article relevant to the theme, of the appropriate quality and rigour;
2. Invite those authors to contribute;
3. Identify reviewers with appropriate expertise for each paper;
4. Make judgements on inclusion of papers, in consultation with the IJAM editorial team.

The IJAM team would provide administrative support to minimise the workload on the Guest Editor. This might include, for instance, putting out a general call for contributions on the theme; communication with authors subsequent to submission, and with reviewers once identified.

Topic areas could include:

- business and commerce
- supply-chain management
- animal and crop husbandry
- farm diversification and pluriactivity
- governance, democracy, activism
- digital divides, alleviation of poverty
- internet-mediated co-operatives, joint ventures
- village and social enterprise
- crime
- health and rural services

Special Issue on Agricultural Marketing in a Globalized Economy

This issue will be edited by Dr. Sanzidur Rahman, a researcher in agricultural economics and development since the 1980s.

the term 'marketing' includes a wide range of issues and aspects related to market, such as:

- marketing channels
- marketing structures
- dimensions (e.g., wholesale, retail)
- futures markets
- spot markets
- export/import markets
- marketing efficiency
- price formation
- price discovery
- price transmission
- socio-economic as well as political issues/environment

Analytical procedures may encompass both quantitative and qualitative approaches depending on the requirement and justification provided for specific projects/papers.

Special Issue on internet and social media in agricultural management

This issue will be edited by Martyn Warren, a Board member of EFITA (The European Federation for Information Technology in Agriculture, Food and the Environment) and a researcher in this area since the 1990s.

The phrase 'internet and social media' is quite wide-ranging, including

- WWW, email, instant messaging
- Web 2.0

- social networking
- blogs
- mobile internet
- rural broadband
- interactive video games
- online television and radio
- voice-over-internet telephony
- virtual worlds
- interactive community radio
- converging technologies

Prospective authors are invited to submit an abstract to Dr Sanzidur Rahman or Martyn Warren via editor.ijam@gmail.com

CONFERENCE PAPER

Balancing agricultural production and conservation: setting out the production and environmental challenges facing farming[1]

MARTIN HARPER[2] and ELLIE CRANE[2]

ABSTRACT
Globally, agriculture is facing an unprecedented set of pressures over the coming decades. After a brief review of recent studies on the challenges facing the food and farming sector, the RSPB offers its views on approaches to balancing agricultural production and conservation in the UK, drawing on case studies from within the charity's own farming portfolio. There are decisions to be made on how we use our land in the future, including whether we follow the 'land sparing' model of intensive agriculture freeing up land for nature conservation objectives; or adopt a 'land sharing' approach where wildlife-friendly farming delivers both food and biodiversity. The RSPB conclusion is that there is no 'one size fits all' model for the future of farming. Intensive and extensive farms, conventional and organic, arable and livestock, lowland and upland can all form part of the mix. Government, scientists and land managers must focus on addressing the conflicts between farming and conservation to make all farming systems more sustainable. An evidence-based approach, building on sound scientific research and efficient dissemination of new knowledge to land managers, will be critical.

This paper was originally presented at The Oxford Farming Conference, January 2012, and is reprinted by kind permission of the author and the Conference Secretariat.

KEYWORDS: Farming; agriculture; conservation; environment; biodiversity; land use

1. Introduction

Globally, agriculture is facing an unprecedented set of pressures over the coming decades. Global population currently stands at seven billion people, and is predicted to rise to over nine billion by 2050. Global demand for food will increase while competition for land, water and energy intensify. Farming will have to adapt to climate change, while reducing its own contribution to greenhouse gas emissions, and playing its part in enabling the adaptation of wildlife and society to changing climate conditions. The production and environmental challenges facing farming are inextricably linked: the natural environment provides the resource base on which production is completely dependent, and farming itself plays a major role in shaping the environment.

2. Production

The UK's Government Office for Science published its Foresight report on "The Future of Food and Farming" in 2011 (Government Office for Science, 2011). This major piece of work explores the pressures on the global food system between 2011 and 2050. The report emphasises that, to date, the food system continues to provide plentiful food for the majority of the world's population. However, the system is failing in two major ways: hunger remains widespread, while simultaneously a billion people are risking damage to their health by *over*-consuming. Secondly, many systems of food production are unsustainable, degrading the environment and compromising the world's ability to produce food in the future.

The Foresight report states that in future more food will need to be produced *globally* to feed the growing population. However, this is far from being the full story. The report stresses that food production systems must be *sustainable*, and must also address climate change: "Nothing less is required than a redesign of the whole food system to bring sustainability to the fore". The report also recommends "sustainable intensification": what the authors define as increased production without the use of substantially more land and with diminishing overall impact on the environment. This

[1] This paper was originally presented at The Oxford Farming Conference, January 2012, and is reprinted by kind permission of the author and the Conference Secretariat.
[2] Royal Society for the Protection of Birds (RSPB)

raises the question of *where* in the world and *how* this 'intensification' can and should take place. While future advances in science and technology may be able to raise the upper limits of sustainable production, it is estimated that simply applying existing knowledge and technology could increase average yields two- to threefold in many parts of Africa. In developing countries, increasing the productivity of agriculture through sustainable farming systems using appropriate technology has the potential to lift people out of poverty through creating jobs, increasing incomes, reducing food prices and empowering socially excluded groups, as well as improving physical access to food. Although the term ''intensification'' is usually associated with high-input, high-technology farming, it can equally well be applied to an increase in yields through intensification of *knowledge* and *labour* input (an approach advocated by the Food and Agriculture Organisation (2011) and referred to by Phalan *et al* (2011)).

Tackling food security will require addressing issues of waste and consumption. If current estimates are correct, halving the amount of waste we currently produce could reduce the food required by 2050 by an amount approximately equal to 25% of today's production. Changing people's diets through policy mechanisms is acknowledged to be difficult, but not impossible, and could play a significant role in achieving food security because different foods vary in the resources required for their production.

The Foresight report sets out the challenges facing the food system, and makes an extensive set of policy recommendations. As stated in the report: ''The solution is not *just* to produce more food, or change diets, or eliminate waste.'' *Sustainable intensification* (where this term is not restricted to increasing artificial inputs but can include a shift to more knowledge- or labour-intensive systems) certainly seems to be a desirable approach in those parts of the world where productivity is currently extremely low. Many more expert than I have questioned whether there is any real potential to *sustainably* increase yields further in high-input systems such as those dominant in many parts of the UK, or indeed whether this is necessary to improve global food security, certainly in the next 20 years.

3. Environment

The Government Office for Science (2011) highlighted that ''many systems of food production are unsustainable''. The National Ecosystem Assessment, also published in 2011, paints a more detailed picture of the condition of the UK's ecosystems, including agricultural habitats. It states that enclosed farmland is a vital habitat in the UK in terms of food production and provision of cultural benefits, but even at current levels of production imposes important negative effects including greenhouse gas emissions, diffuse water pollution and losses to biodiversity. Food production is just one of a range of ecosystem services farmland can provide. In the past, policies that encouraged farmers to maximise food production have led to an increase in external environmental costs and a decrease in the other ecosystem services provided. For example, levels of carbon stored in arable and horticultural soils fell between 1998 and 2007, while populations of some pollinating insects such as honeybees are known to have declined significantly. Some environmental impacts of farming, such as non-carbon dioxide greenhouse gas emissions, ammonia emissions and nitrate pollution of waterways have been reduced (but not eliminated) since 1990, due to both improvements in farming practices and to a slowdown in the increase in total agricultural productivity.

Rockström *et al* (2009) attempted to define the ''safe operating space'' for humanity with respect to the Earth's biophysical systems. The authors identified disruption to the nitrogen cycle and biodiversity loss as the two areas where we are most seriously exceeding our safe limits. Agriculture plays a key role in both of these areas and this needs to be addressed urgently.

The use of nitrogen fertilisers has allowed a growing world population, but has considerable adverse effects on the environment and human health. The European Nitrogen Assessment identified five key societal threats of reactive nitrogen: to water quality, air quality, greenhouse balance, ecosystems and biodiversity, and soil quality. A cost–benefit analysis concludes that the overall environmental costs of nitrogen pollution in Europe (estimated at €70–€320 billion[3] per year at current rates) actually outweigh the direct economic benefits of nitrogen in agriculture (Sutton *et al.,* 2011).

Declines in populations of wildlife associated with farmed land are well-documented. In the UK, as in Europe as a whole, farming is the dominant land use and biodiversity is inextricably linked with how this land is managed. Agriculture has shaped Europe's biodiversity over the centuries, with the result that many of Europe's most valued species and habitats today are dependent on the continuation of certain agricultural practices. Of the 231 habitat types of European interest targeted by the EU Habitats Directive, 55 *depend* on extensive agricultural practices or can benefit from them. Similarly, 11 targeted mammal species, seven butterfly species and 28 plant species depend on a continuation of extensive agriculture (Biala *et al*, 2010). All of these species will be detrimentally affected by further intensification of food production in these areas.

Changes in the countryside since the Second World War have been largely driven by policies targeted at increasing food production; in particular the Common Agricultural Policy. These changes can broadly be described as the intensification and specialisation of farms: removal of hedges, a shift from spring to autumn-sown crops, increased use of synthetic fertilisers and pesticides, and a decline in mixed farming (farms incorporating both livestock and arable crops). While these policies were highly successful in their aim of increasing food production, an unwanted side-effect was a decrease over time in the diversity and quality of wildlife habitats within the farmed landscape (Robinson and Sutherland, 2002). The Common Agricultural Policy has undergone successive reforms and now includes protecting the environment among its objectives. The shift away from production subsidies and the creation of a Rural Development funding strand represented significant steps towards a

[3] $95-$430bn, or £60-£270bn (approximate conversion, February 2010)

more environmentally sustainable policy. In particular, targeted agri-environment schemes have helped farmers and land managers to achieve great improvements for biodiversity and the wider environment in some places (see for example Birdlife International, 2011). However, to date these improvements have not been enough to compensate for the preceding decades of intensification. Some species in some regions are increasing in response to wildlife-friendly measures put in place by farmers, but well-studied groups such as farmland birds and butterflies continue to decline across the farmed landscape as a whole. Between 1970 and 2010, populations of breeding farmland birds across the UK declined by 50% (Defra, 2011a), while in England between 1990 and 2009 populations of specialist farmland butterfly species declined by 39% (Defra, 2011b).

Butterflies and birds are indicators of the state of wider biodiversity, so a decline in these groups is taken as indicative of a wider decline in the species that make up agricultural ecosystems. The decline in farmland biodiversity represents a long-term threat to the productivity of agriculture. Biodiversity provides numerous services to farming, including pollination, pest control and nutrient cycling. The value of insect pollination services alone to UK arable farming has been estimated at £400 million (€470m, US$635m)[4] per annum (POST, 2010). At least as important, although far less well understood, are the functions of soil. Soil is a living resource: its structure, organic content and fertility, its ability to store water or allow it to drain away, and its resistance to pest outbreaks, all depend on the organisms living in the soil. Agricultural management can have a profound effect on soil biodiversity. Inappropriate management such as overgrazing can damage soil biodiversity, with a resultant decline in the services provided by the soil, while good management practices like appropriate crop rotations can enhance soil biodiversity (Turbé *et al*., 2010). The precise relationships between biodiversity levels and provision of these ecosystem services are imperfectly understood, which makes it all the more important to halt biodiversity loss as a matter of urgency, rather than risk the collapse of agricultural ecosystems or the loss of key species if declines continue.

The extent to which biodiversity is valued by society, both for its economic and its intrinsic worth is reflected in policy. The UK Government has signed up to a series of legal commitments and policy aspirations regarding the protection and restoration of biodiversity. As a party to the Convention on Biological Diversity, the UK agreed in October 2010 to a new set of goals and targets for the protection of biodiversity globally (Convention on Biological Diversity Conference of the Parties 10, 2010). At the European level, a new target was adopted in March 2010: 'Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, and restoring them in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss.' EU biodiversity targets are partly delivered through a range of legislative measures, which place obligations on Member States to protect biodiversity and the natural environment. The Birds Directive (Directive 2009/147/EC) and Habitats Directive (Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora) provide a legally binding framework for the conservation and management of biodiversity in Europe. Government has set out its own ambitions for the UK in the Natural Environment White Paper: "We will work to improve the quality of our natural environment and will aim to halt the decline in habitats and species, degradation of landscapes and erosion of natural capital." (Defra, 2011c)

In summary, now is an extremely challenging time for agriculture. Many current food production systems are unsustainable, and the environmental degradation they are causing is in itself a critical threat to food security (Government Office for Science, 2011). Food systems must urgently be made more sustainable, and declines in farmland wildlife are one issue that must urgently be addressed.

4. Approaches to balancing agricultural production and conservation

A variety of tools is deployed in the UK to meet environmental objectives. These may involve designating areas where conservation objectives are to be prioritised (such as Natura 2000 sites, Sites of Special Scientific Interest, Local Wildlife Sites etc); or attempting to influence land management outside of these protected areas through mechanisms such as agri-environment schemes. In the latter case, these efforts may be targeted within certain geographic areas to address a particular environmental need. For example, Catchment Sensitive Farming is an English government initiative that delivers support and advice to farmers within priority river catchments to reduce diffuse pollution from agriculture[5].

To address resource protection issues, it is usually necessary to implement measures in specific places within the farmed landscape; such as bringing fragile soil under appropriate management, stopping a point source of pollution, or introducing buffer zones to protect a waterway from diffuse pollution. In the case of biodiversity conservation, there may be more choice about where and how to target action. If the UK is to meet the needs of both agricultural production and conservation, society will need to consider how to *optimise* its use of land.

One theoretical model of how to make land use decisions, that attempts to address both production and biodiversity needs with maximum efficiency, is "*land sparing*". The idea behind "land sparing" is that yields should be optimised on existing agricultural land, allowing other land to be "spared" for conservation objectives. This requires *sustainable intensification*, discussed above. The contrasting approach is known as "*land sharing*"; attempting to meet both agricultural and conservation objectives from the same parcel of land through 'wildlife friendly farming'. A recent study compared the two approaches at study sites in India and

[4] Approximate conversions, February 2012,

[5] See Natural England: http://www.naturalengland.org.uk/ourwork/farming/csf/default.aspx

The story of the turtle dove

Agri-environment schemes have brought some notable successes in reversing biodiversity declines in some places. For some species, however, populations have yet to show signs of recovery despite continuing efforts by farmers and conservation organisations. This could suggest that the right things are not being done for this species, they are not being done over a large enough area, or that there are other factors at work preventing population recovery. The turtle dove is one such species.

Turtle doves are birds of arable and mixed farmland, within the UK mostly seen in southern and eastern England. They have declined severely across Europe from the 1970s onwards, and have disappeared from many places where they had previously been common. The UK population declined by about 90% between 1967 and 2008 (Baillie *et al.*, 2010). Conservation effort in the UK has included maintaining the mature hedgerows and scrub they need for nesting. However, research has found that the breeding season is getting shorter, with about half the number of clutches and young produced per pair each year than formerly (Browne and Aebischer, 2004). It is likely that this drop in reproductive output is related to a shortage of favoured food – the seeds of certain weeds such as fumitory – that have declined in farmland and in the diet of turtle doves since the 1960s (Browne and Aebischer, 2003). Measures funded by agri-environment schemes exist to promote seed food availability on farmland, but these may not be providing the right kind of seed at the right time of year for turtle doves. Ongoing research is testing seed plots that provide key sources of food throughout the summer.

While the drop in young fledged alone is sufficient to explain the population decline, it may be only part of the picture. Turtle doves are migratory: they arrive in the UK in April to breed and leave by September. They winter in west Africa, gathering in huge roosts of up to 1 million birds. In Africa, as in the UK, they eat crop and weed seeds. Research shows that turtle doves are sensitive to agricultural changes in their wintering grounds: in years with high cereal production in west Africa, turtle dove survival rate was higher (Eraud *et al.*, 2009). During their migration, turtle doves can be shot by hunters as they travel through the Mediterranean region. Climate change may also be a growing threat, for example leading to more frequent and severe droughts in regions they migrate through, and changes in their wintering grounds. Conservation scientists do not yet understand the relative importance of each of these factors in driving turtle dove decline; scientific research (including satellite tagging of birds) is ongoing.The story of the turtle dove illustrates that, in some cases, conservation objectives for UK farmland species may be only partially achievable within our borders. Like food security, species conservation must be addressed at multiple scales from local to global.

Ghana, where remnants of the natural forest vegetation are surrounded by farmland (Phalan *et al*, 2011). The study concluded that in this particular situation, land *sparing* was the better strategy: ‘‘both countries could produce more food with minimal further negative impacts on forest species if they were to implement ambitious programs of forest protection and restoration alongside sustainable increases in agricultural yield.’’

As the authors state, this study ‘‘is not enough to argue that land sparing is the optimal strategy for reconciling food production and biodiversity conservation everywhere and for all taxa.’’ Indeed, even the theoretical applicability of the approach is entirely dependent upon what the starting point and specific species and habitat objectives are for biodiversity conservation. The authors are also at pains to point out that the success of the land sparing approach depends on proper implementation and systems to protect ‘conservation areas’ from both current and future production expansion: increasing yields on farmland does not in itself guarantee protection for other land against the expansion of agriculture. Other authors have raised further concerns about the land sparing model (Fischer *et al.*, 2011). Land sparing may not be appropriate in countries that lack the means to effectively protect wildlife areas but have a history of sustainable land sharing; in systems where both yields and biodiversity are high; where biodiversity depends on agriculture (a point also made by Wright *et al.*, 2011); or where agricultural land is only suitable for non-intensive use (for example because of low rainfall or shallow soil). Much of the work to assess the efficacy of ‘land sparing’ approaches has, to date, ignored wider aspects of environmental protection, such as soil and water quality. Furthermore, it is not the case that society must choose between land sparing and land sharing to feed the world’s population. There is a continuum of approaches to land management, and each situation should be assessed on its own merits rather than attempting to apply one particular model across the board.

Within the UK, it seems likely that a mixture of approaches will prove to be the most efficient use of land. Protected wildlife areas are a vital conservation tool, and if it is deemed necessary in future to increase agricultural production, this must not be achieved by expanding farming into wildlife areas. There would therefore be a case for increasing the productivity of existing farmland, *where this can be done sustainably.* However, there are sectors and areas where intensification would not be sustainable: in fact it would further exacerbate existing declines in environmental quality. For example, in the UK extensive livestock systems based on semi-natural grazing and low intensity grassland are associated with high levels of biodiversity (including species that are *only* found in these habitats) as well as providing other valuable services such as carbon sequestration in soils (RSPB, Birdlife International and European Forum on Nature Conservation and Pastoralism, 2011). Intensive livestock production, where livestock may be housed for a significant proportion of the time, does not provide these benefits. The negative environmental impacts of intensive systems may be significant and can extend well beyond the farm gate, in particular through growing crops for feed, both in the UK and abroad (Bartley *et al.*, 2009). This is a clear case for adopting the land *sharing* model, where extensively grazed land provides food alongside other benefits, rather than attempting to pursue intensification.

Organic farming is sometimes cited as an example of land sharing. In terms of agricultural yield, there is much debate over the performance of organic compared to conventional farming. In general, however, the yields of organic farms are expected to be lower than their conventional equivalents in intensively farmed regions such as the UK (it should be noted that in developing countries, the adoption of organic techniques could lead to a significant *increase* in yields) (Erb *et al.,* 2009). Organic farming can be beneficial for wildlife due to severe restrictions on the use of chemicals, and perhaps more importantly because of the emphasis on landscape diversity and the inclusion of fallow periods in rotations (Norton *et al.*, 2009). Organic farming methods can also have benefits for resource protection, and for climate change mitigation through increasing carbon stores in the soil (Smith *et al.*, 2011). Organic farming should be given consideration as one possible way of optimising production and environmental outcomes from the same land parcel.

Conventional farmland managed under 'broad and shallow' agri-environment agreements could be considered to fall somewhere between the 'land sparing' and 'land sharing' extremes. Some parts of the farm (for example hedgerows, field margins) are managed for biodiversity, while the majority of the land continues to be farmed with the aim of optimising agricultural yields (see the Hope Farm case study below). This approach can prove successful in delivering both food and biodiversity (as well as other benefits such as protecting water courses from pollution), particularly in an arable context, as demonstrated by Natural England (2009). Experience in the UK demonstrates that the success of this approach depends on appropriate management of the non-food producing areas to deliver optimum benefits for biodiversity: the *quality* of the habitat provided is important as well as the quantity.[6] This insight needs to be reflected in future agricultural policy. For example, one of the proposals currently being considered for the Common Agricultural Policy after 2014 is a requirement for arable farmers to keep at least 7% of their land as "ecological focus area". This could include land left fallow, terraces, landscape features and buffer strips.[7] Ecological focus areas could be considered as land sparing at a sub-farm scale. As with any application of the land sparing model, for this approach to be efficient it is vital to optimise the environmental benefits of the 'spared' land. In this case, this could be achieved by using agri-environment schemes to pay for positive management of the land designated as ecological focus area, rather than simply taking this land out of production and doing nothing further with it.

[6] See for example the 'Farm4bio' project: farm-scale management of uncropped land for biodiversity. Online at http://www.hgca.com/content.output/3323/3323/Environment/Biodiversity/Farm4bio%20farm-scale%20management%20of%20uncropped%20land%20for%20biodiversity.mspx.

[7] See Article 32 in Proposal for a regulation of the European parliament and of the council establishing rules for direct payments to farmers under support schemes within the framework of the common agricultural policy. European Commission, 2011. Online at http://ec.europa.eu/agriculture/cap-post-2013/legal-proposals/com625/625_en.pdf.

5. Case study: Hope Farm

Agri-environment schemes support land managers in delivering environmental objectives alongside food production. By applying an appropriate mix of agri-environment options, it is possible to provide sufficient high-quality habitat within the farmed landscape to allow wildlife to flourish, while keeping impacts on food production to a minimum. The RSPB has had some success in applying this approach on its own Hope Farm, an arable farm in Cambridgeshire. This case study demonstrates both what can be achieved within conventional farming systems, and the extent of the challenge still to be addressed.

The RSPB has owned Hope Farm since 1999. It is a 181 ha arable farm, managed using conventional (as opposed to organic) techniques, and in most respects is typical of farms in this part of Cambridgeshire. The farm is currently under a four-year rotation of wheat: spring beans: wheat: oilseed rape. It has been in an Entry Level Stewardship agreement since 2007. The agreement includes 1 hectare of wild bird seed mix, 0.9 hectares of nectar flower mix, 0.05 hectares of beetle bank and 100 skylark plots. In addition, the farm has 1.5 hectares of wild bird seed mix, 1 hectare of nectar flower mix, 2 hectares of sown wild flower headlands and an extra 20 skylark plots managed as Campaign for the Farmed Environment voluntary measures[8]. In all, about 8.5% of the arable area is currently out of production, under either agri-environment options or scientific research trials.

The RSPB's original objective in acquiring this farm was to develop, test and demonstrate farming techniques that produce food cost-effectively and benefit wildlife. Success to date has been encouraging. The farmland bird indicator, which continues to show a significant decline in farmland bird populations over the UK as a whole (Defra, 2011a), has increased by over 200% on Hope Farm since the RSPB took over management. In addition, ongoing monitoring suggests that butterflies, bumblebees, moths and fungi are benefitting from the way the farm is managed. Over the same period, crop yields have increased in line with other productive arable farms in the area, and compare very favourably with arable farms across England. The farm accounts, which are kept separate from the wider charity's accounts, are published annually on the RSPB's website and demonstrate that the farm is a profitable enterprise (RSPB, 2011).

Hope Farm's achievements to date demonstrate some success in delivering both food production and biodiversity objectives, through judicious use of agri-environment options combined with best practice in farm management. The RSPB, however, recognises that many challenges remain to be addressed to balance agricultural production and conservation on this farm. For example, the RSPB has assessed the ecological status of water bodies surrounding the farm as 'at risk', primarily from phosphate pollution. Measures are in place to reduce pollution in line with best practice for arable farms, but the RSPB is now investigating methods of further reducing diffuse pollution. In addition, the farm's carbon footprint was assessed in

[8] See Campaign for the Farmed Environment: http://www.cfeonline.org.uk/

2007. By far the biggest contribution to the farm carbon footprint arose from fertiliser applications, with emissions during both manufacture and application important. The report highlighted that cropping decisions made for both economic and biodiversity reasons in the past 10 years had the unintended positive consequence of reducing the farm's footprint. The RSPB has set an ambitious target of reducing emissions by 15% over 5 years.

Like all farmers, the RSPB is constantly faced with decisions on how to balance delivery of environmental public goods and yield – what is best for the farm's profit margin or production may not be best for the wider environment or food production over the longer term. The RSPB believes that agri-environment schemes, developed on the basis of sound scientific evidence, must continue to play a vital role in helping land managers to balance these objectives.

6. Case study: Tarnhouse Farm

A key finding of the UK National Ecosystem Assessment (2011) was that to maximise the value we gain from our land, society needs to consider the delivery of *all* ecosystem services. Focusing too exclusively on food production can mean we do not get the best from the land in terms of total services provided. On places like Hope Farm, food production is optimised while minimising conflicts with other objectives, like biodiversity and water quality. In other farming systems, the overall value of the land is increased by prioritising functions other than food production.

The RSPB purchased Tarnhouse farm in the North Pennines in 2001. It is a working organic farm of 2041 hectares, with 92 breeding suckler cows and around 500 breeding ewes, and is managed by a tenant farmer. The farm forms part of the Geltsdale nature reserve and has several national and European conservation designations.

Tarnhouse is a mosaic of upland heath, blanket bog and rough grazing habitats. Since taking the farm on, the RSPB has made various changes including introducing cattle (the farm previously had only sheep), decreasing the intensity of heather grazing and rewetting some habitats. So far, the more varied structure created by cattle grazing has led to increases in breeding wader numbers. Black Grouse populations have increased from none in 2003 to 23 males in 2011, bucking the trend of decline in the North Pennines generally. Habitats have become more botanically diverse. Wildlife on the farm now includes black grouse, lapwing, whinchat, cuckoo, grasshopper warbler, otter, red squirrel, green hairstreak butterfly, small pearl-bordered fritillary and dark-green fritillary.

Lying within the River Tyne catchment and with around two-thirds of the site based on peat soils, Tarnhouse is also important from both a water quality and carbon perspective. The site's heath and blanket bog is now recovering under current management, having been in unfavourable condition due to historic overgrazing with sheep.

By looking at *all* the functions this land can perform, it has been possible to increase the value of ecosystem services it provides. Although Tarnhouse is on land considered to be agriculturally marginal, it is now producing a wide range of valuable services including water quality, biodiversity and food, as well as being well on the way to becoming a net sequesterer and permanent store of carbon.

7. What can government, farmers and conservation organisations do now in the UK?

All stakeholders recognise the extent of the challenges facing farming, although they may place a different emphasis on which challenges are most pressing, and on how they can best be addressed. As stated at the start of this paper, it must be recognised that the challenges of production and conservation are completely interlinked and we cannot address either one in isolation from the other. The Government recognised this in its commitment within the Natural Environment White Paper to "bring together government, industry and environmental partners to *reconcile how* we will achieve our goals of improving the environment and increasing food production".

To meet the challenges facing us, it will be necessary to bring farms that are currently under-performing up to best practice standards. This requires much more investment into agricultural research, with more focus on increasing the sustainability of productive farming systems and, critically, better communication of both existing and new science and technologies to the land managers 'on the ground'. We need to be looking across the organic-conventional divide for existing practices that can help address environmental and production challenges over the long term. New knowledge will be needed just to keep pace with the growing challenges, particularly climate change and associated impacts like the spread of new pests and diseases (Government Office for Science, 2011). However, agricultural research and development is underfunded and public investment in particular has stagnated since the 1970s in most regions (World Bank, 2007), particularly the developing world (International Fund for Agricultural Development, 2010). Private sector spending on R&D tends to be commercially orientated rather than being focused on maximising the benefits from agriculture to people and the environment, and is not a substitute for public investment. New technologies must be focused not just at increasing yields, but at addressing environmental challenge, at local and global levels. Rigorous testing for unintended environmental impacts also needs to be part of the package. The International Fund for Agricultural Development's Rural Poverty Report (2011) concluded that "if sustainable intensification is to contribute effectively to increasing agricultural productivity, there needs to be greater research expenditure, and more of it needs to be spent on the challenges of sustainable intensification faced by smallholder farmers in countries dependent on agriculture." There is also concern from many quarters that current levels of investment in agricultural research in the UK and the wider EU are inadequate to address the challenges facing farmers in this region (House of Lords, 2011).

Future technologies should not be relied upon to provide a 'quick fix' to solve all of the production and conservation challenges. A variety of approaches will be needed, including better application and dissemination of existing skills and knowledge. This needs to happen *now*. It takes a long time for a new technology to develop from initial research to widespread adoption by farmers. Nevertheless, new technology will undoubtedly play a part in meeting future challenges, and investment in agricultural research and development, along with effective mechanisms for disseminating knowledge to land managers, should be a priority for governments.

In the meantime, there are already many excellent examples of farms where production and conservation challenges are being addressed in a holistic way. For example, in the Cambridgeshire Fens conservationists and farmers have come together to create a Farmland Bird Friendly Zone. The project involves at least 14 farmers, managing more than 3,700 hectares of high-grade arable farmed land, and is generating a lot of interest from other farmers in the area. Farmers participating in the project are using their Environmental Stewardship agri-environment agreements to implement land management options that meet all the needs of farmland birds, while balancing this with the needs of the farm businesses. As well as helping farmland birds and bringing farmers together to discuss future plans, this project is generating a lot of positive publicity for farming in a part of the country where intensive agriculture dominates the landscape.

Agri-environment schemes are one mechanism for providing land managers with the support they need to maximise the potential of their land to provide both food and biodiversity. Although agri-environment in the UK has brought some notable successes, it is argued by many that it is not yet meeting its potential. Some of the issues are now being addressed, for example by Defra's project in England "Making Environmental Stewardship More Effective". Other projects, such as the Campaign for the Farmed Environment, aim to encourage uptake of existing scheme options to maximise the benefit of these schemes.

UK agri-environment schemes operate within the context of the Common Agricultural Policy (CAP). This policy will enter a new period in 2014, and the reforms agreed between now and then will be critical in determining the future direction of travel for agriculture. It is the RSPB's opinion that the Commission's proposals for CAP reform fail to address adequately either the production or the conservation challenges facing farming in the EU, and would not represent an efficient or justifiable use of taxpayers' money. The RSPB, alongside its Birdlife partners and others including many farmers, is calling for a real shift towards a policy that supports farming to become more sustainable, and meet all the challenges facing it. This will mean, among other things, more funding for measures like agri-environment schemes that have been proven to deliver benefits for farming and wildlife; more environmental improvement achieved from direct payments, and a shift of support towards farming systems that are delivering a variety of services to society.

8. Conclusions

The pressures on land are many and increasing. We need to optimise our use of land by considering *all* the services any given parcel of land could potentially provide. This will mean some difficult choices. In some places, we will find there are win-wins: it will be possible to maintain or increase production while simultaneously increasing the delivery of other ecosystem services. This is what the RSPB is trying to achieve at Hope Farm. In other places, however, we will find that to secure the full range of ecosystem services we need it will be necessary to accept some *loss* of food production. It remains an open question as to how society can best optimise land use while respecting the rights of private land managers to take decisions on the use of their land. There is an urgent need for all stakeholders to discuss what approach to land allocation society wishes to adopt for the future.

The market alone will not deliver an optimum solution: history shows that short-term price signals generally override more strategic considerations in guiding decision making. Furthermore, the market does not adequately reflect the value of the public goods farming provides to society, nor the costs of negative impacts such as pollution and biodiversity loss.

As emphasised by the Future of Food and Farming Foresight report (Government Office for Science, 2011), meeting the challenges of making our food supply system more sustainable will require "interconnected policy-making". Many policy areas outside the food system have an impact on land use, including transport, energy, housing, employment, education, health, water management, biodiversity conservation and energy generation. The report highlights that achieving closer coordination of all these policies, at all levels from local to national, will be a major challenge but one that decision-makers must not duck.

The case studies (Hope Farm and Tarnhouse) described in this paper show two farming systems that are very different; however both make valuable contributions to UK agriculture. There is no one model for the future of farming. Intensive and extensive farms, conventional and organic, arable and livestock, lowland and upland can all form part of the mix. Government, scientists and land managers must focus on addressing the conflicts between farming and conservation to make all farming systems more sustainable. An evidence-based approach, building on sound scientific research and efficient dissemination of existing and new knowledge to land managers, will be critical.

About the authors

Martin Harper

Martin Harper (martin.harper@rspb.org.uk) has been the RSPB Conservation Director since May 2011 and oversees the Society's work on conservation policy and advocacy, research and acquisition of nature reserves. Prior to joining the RSPB in 2004 as Head of Government Affairs, Martin spent five years as Conservation Director at Plantlife International, having previously run Wildlife & Countryside Link. Educated at Oxford and University College London, Martin undertook fieldwork in the Comores and Mongolia before embarking on a career in policy and advocacy. Away from work, Martin enjoys family life in Cambridge and the North East coast with his wife and two children. He claims that running keeps him sane, while Arsenal FC and the England cricket team provide him with emotional highs and lows.

Ellie Crane
Ellie Crane (Ellie.Crane@rspb.org.uk) is an Agricultural Policy Officer at the RSPB, working as part of the team that brings together the Society's knowledge from its own research and advisory work to design and advocate policy solutions that will ensure birds and other wildlife are able to thrive within the wider countryside. Ellie joined the RSPB just over a year ago and has previously worked in a variety of roles, including at Natural England advising on Common Agricultural Policy reform, and at the Joint Nature Conservation Committee in the Sustainability Advice and Land Use Policy Teams. Ellie holds a BA in Natural Sciences from Cambridge University and an MSc in Applied Ecology and Conservation from the University of East Anglia.

REFERENCES

Baillie, S.R. *et al*., 2010. Breeding Birds in the Wider Countryside: their conservation status 2010. *BTO Research Report No. 565*. British Trust for Ornithology, Thetford.

Bartley, J., Hart, K., and Swales, V., 2009. *Exploring policy options for more sustainable livestock and feed production. Final report for Friends of the Earth*. Institute for European Environmental Policy. Online at http://www.ieep.eu/assets/419/sustainable_livestock_feed.pdf

Biala, K., Makarewicz, K., Zisenis, M. and Richard, D., 2010. *10 Messages for 2010: Agricultural Ecosystems*. European Environment Agency. Online at http://www.eea.europa.eu/publications/10-messages-for-2010-agricultural-ecosystems

Birdlife International, 2011. *Seeds of Success*. Online at http://www.birdlife.org/eu/pdfs/AEbrochurefinalpart1.pdf

Browne, S.J., Aebischer, N.J., 2003. Habitat use, foraging ecology and diet of Turtle Doves *Streptopelia turtur* in Britain. *Ibis* 145, 572–582.

Browne, S.J., Aebischer, N.J., 2004. Temporal changes in the breeding ecology of European Turtle Doves *Streptopelia turtur* in Britain, and implications for conservation. *Ibis* 146, pp 125–137.

Convention on Biological Diversity Conference of the Parties 10, 2010. *Decision X/2: Strategic Plan for Biodiversity 2011-2020*. Online at http://www.cbd.int/decision/cop/?id=12268

Defra, 2011a. *Defra National Statistics Release: Wild bird populations in the UK, 1970 to 2010*. Online at http://www.defra.gov.uk/statistics/files/Wild-bird-populations-in-the-UK-1970-2010-National-Statistics-Release.pdf

Defra, 2011b. *Indicator DE6: Farmland butterfly populations*. Online at http://archive.defra.gov.uk/evidence/statistics/foodfarm/enviro/observatory/indicators/d/de6_data.htm

Defra, 2011c. *Biodiversity 2020: A strategy for England's wildlife and ecosystem services*. Online at http://www.defra.gov.uk/publications/2011/08/19/pb13583-biodiversity-strategy-2020/

Eraud, C., *et al*., 2009. Survival of Turtle Doves *Streptopelia turtur* in relation to western Africa environmental conditions. *Ibis* 151, pp 186–190.

Erb, K-H. *et al*., 2009. *Eating the Planet: Feeding and fuelling the world sustainably, fairly and humanely – a scoping study*. Commissioned by Compassion in World Farming and Friends of the Earth UK. Institute of Social Ecology and PIK Potsdam. Vienna: Social Ecology Working Paper No. 116.

Fischer, J. *et al*., 2011. Conservation: Limits of Land Sparing. *Science* 334, p 593

Food and Agriculture Organisation, 2011. *Save and Grow*. Online at http://www.fao.org/ag/save-and-grow/

Government Office for Science, 2011. *Foresight: The Future of Food and Farming. Final Project Report*. London, Government Office for Science.

HM Government, 2011. *The natural choice: securing the value of nature*. Online at http://www.official-documents.gov.uk/document/cm80/8082/8082.pdf

House of Lords, 2011. *Innovation in EU Agriculture*, *House of Lords European Union Committee Nineteenth report*. Online at http://www.publications.parliament.uk/pa/ld201012/ldselect/ldeucom/171/17102.htm

International Fund for Agricultural Development, 2010. *Rural Poverty Report 2011*. Online at http://www.ifad.org/rpr2011/report/e/rpr2011.pdf

Natural England, 2009. *Agri-environment schemes in England 2009: A review of results and effectiveness*. Online at http://www.naturalengland.org.uk/Images/AE-schemes09_tcm6-14969.pdf

Norton, L. *et al*., 2009. Consequences of organic and non-organic farming practices for field, farm and landscape complexity. *Agriculture, Ecosystems & Environment* 129, pp 221–227

Phalan, B., Onial, M., Balmford, A. and Green, R.E., 2011. Reconciling food production and biodiversity conservation: land sharing and land sparing compared. *Science* 333, 1289

POST, 2010. *Insect Pollination POST Note 348*. Parliamentary Office of Science and Technology, London.

Robinson, R.A. and Sutherland, W.J., 2002. Post-war changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecology* 39, pp 157–176

Rockström, J. *et al*., 2009. A safe operating space for humanity. *Nature*, 461, pp 472–475

RSPB, 2011. *Hope Farm accounts*. Online at http://www.rspb.org.uk/ourwork/farming/hopefarm/accounts.aspx

RSPB, Birdlife International and European Forum on Nature Conservation and Pastoralism, 2011. *High Nature Value farming: how diversity in Europe's farm systems delivers for biodiversity*. Online at http://www.efncp.org/download/HNV-farming.pdf

Smith *et al*., 2011. *Soil Carbon Sequestration and Organic Farming: An overview of current evidence*. Organic Centre Wales. Online at http://www.organiccentrewales.org.uk/uploads/soilcarbonsequestration2011.pdf.

Sutton, M.A. *et al*., eds., 2011. *European Nitrogen Assessment*. Cambridge University Press, Cambridge, UK.

Turbé, A. *et al*., 2010. *Soil biodiversity: functions, threats and tools for policy makers*. Bio Intelligence Service, IRD, and NIOO, Report for European Commission (DG Environment).

UK National Ecosystem Assessment, 2011. *The UK National Ecosystem Assessment: Synthesis of the key findings*. UNEP-WCMC, Cambridge.

World Bank, 2007. *World Development Report 2008: Agriculture for Development*. Online at http://siteresources.worldbank.org/INTWDR2008/Resources/WDR_00_book.pdf

Wright, H.L. *et al*., 2011. Agriculture—a key element for conservation in the developing world. *Conservation Letters*, DOI: 10.1111/j.1755-263X.2011.00208.x

BOOK REVIEW

Unlocking markets to smallholders: Lessons from South Africa

Edited by: Herman D. van Schalkwyk, Gavin C.G. Fraser, Ajuruchukwu Obi and Aad van Tilburg

Published May 2011 by Wageningen Academic Publishers, 2012 (Mansholt publication series 10): Wageningen, The Netherlands. ISBN: 978-90-8686-134-7. Price: €39. Also available as free-access e-book (ISBN 978-90-8686-168-2) from www.wageningenacademic.com/Mansholt10. 268 pages, 12 illustrations, 2 in colour.

Overview

The book presents an excellent piece of work on an area that has been a major stumbling block to small scale farmers in Africa. The book assesses institutional, technical and market constraints as well as opportunities for smallholder farmers from previously marginalized areas in South Africa. Smallholder farmers in Africa face many challenges in their effort not only to produce marketable produce, but also to secure markets for their surplus produce. Although the book uses evidence from the black economic empowerment strategy in South Africa, the basic theoretical concepts and case studies used in the book are relevant in the rest of Africa and any emerging markets where a section of the population has been marginalized and denied full participation in economic activities.

The approach used by the book is commendable for first of all expounding the theoretical concepts in the selected topics before presenting case studies that facilitate a deeper understanding by the reader. This also creates a link between theory and application. The book further crafts a policy framework and suggests institutional responses for unlocking markets for smallholders. This makes the book not only readable by students and market specialists, but also policy makers who would find it handy for supporting decision making at policy levels in Africa.

The book is composed of eleven chapters. In Chapter 1, market access, poverty alleviation and socio-economic sustainability in South Africa is analyzed thus setting the theme and agenda for the study. Additionally, a historical and evolutionary overview of market policies shaping institutional environment for smallholder development in South Africa is discussed. Chapters 2–6, focuses on constraints in former homelands while Chapters 7–10 examine how constraints operating at micro level influence coordination of national and international food systems. Finally, Chapter 11 draws from theoretical and practical lessons learnt from various chapters of the book to generate stakeholder relevant recommendations.

Specific comments

More specifically key issues discussed by chapter are enumerated below:

In Chapter 2, strategies to improve smallholders' market access are discussed. Emerging issues from this chapter are:

- Models/examples exist in South African agriculture to show how smallholder farmers can be linked to markets in a sustainable way.
- Need to develop and implement high volume-low value and low volume-high value strategies for niche products.
- Intensified public and private support through initiatives and investments.
- Supportive financial institutions
- Intensification of sector organizations, agribusiness enterprises and member cooperatives.
- Multi-institutional task force required to monitor process of improving smallholder market access.
- The major weakness is the lack of comparison of these findings with occurrences in the rest of Africa to be able to come up with more inclusive policy framework for Sub Saharan Africa.

In Chapter 3, institutional and technical factors and market choices of smallholder farmers are discussed. Evidence from Kat River valley is used to confirm assertion by literature that smallholder and emerging farmers use informal markets to sell their produce. Some challenges that prevent farmers from using formal markets are identified; they include access to information, expertise on grades and standards, availability of contractual agreements, existence of social capital, availability of good market infrastructure, group participation and reliance on tradition. It concludes by suggesting several ways smallholder farmers can market their produce.

In Chapter 4, technical constraints to market access for crop and livestock farmers in Nkonkobe Municipality, Eastern province are discussed. It is concluded that income disparities are substantial even within a group that would ordinarily be considered homogenous. Access to information had the highest chance of influencing extent of smallholders' marketable surplus confirming expectations. Additionally, the limited scope of the present study calls for caution in generalizing results, but agrees with recent studies and viewpoints about progress in the sector. Restructuring programmes in the mid 1990's triggered dismantling of agricultural parastatals. It recommends that improvement of smallholders' market access must be framed around recent smallholders' developmental context. It is finally noted that the situation of smallholder farmers will be enhanced by arrangements that simultaneously address their skills gap and ensuring asset constraints are minimized.

In Chapter 5, smallholders and livestock markets are discussed. It concludes that there are severe weaknesses and challenges in smallholder livestock production and marketing in South Africa needing redress

In Chapter 6, unlocking markets to smallholder farmers: the potential role of contracting is discussed. It emerges that contract farming has a chequered history over the world. It argues that failures have been previously attributed to poor organization, opportunistic behavior and lack of trust. It highlights efforts that need to be taken to boost contract smallholder agriculture.

In Chapter 7, food retailing and agricultural development is discussed. It emerges that South Africa has a dynamic food retail industry characterized by competition, concentration and a unique South African customer base. It is noted that developing food retailing industry and concentrated supermarket industry reflects on different levels of industry.

In Chapter 8, a focus of the discussion is unlocking credit markets. It emerges that marketing of agricultural products is a field where both poor small scale farmers and small scale market operators have to cope with formidable impediments.

In Chapter 9, governance structures for supply chain management in the smallholder farming systems of South Africa are discussed. Evidence from Eastern Cape Province shows that substantial variability exists in product mixes, participant profiles, existing linkages and mechanisms for coordination and regulation of food systems. From the human dimension, the principal issue is the nature of needs and aspirations and fundamental values that drive economic participation. In addition, other key elements of the food system discussed are the nature of governance arrangements, composition of the food system, existing coordination and regulatory mechanisms as well as quality control.

In Chapter 10, smallholder market access and governance in supply chains is discussed. A number of governance structures are proposed namely: incentives for transport contractors, capacity building of smallholder farmers, encouragement of farmer organizations/associations, rebuilding support services and institutions. It basically identifies each important small holder and what role each one of them should play.

In Chapter 11, factors unlocking markets to smallholders: lessons, recommendations, and stakeholders are addressed. Major constraints are identified and remedial measures suggested. The merits of all the chapters is that theoretical concepts are discussed, followed by case studies which enhance the ability of the reader to link theory and reality. A major weakness of the book is that it puts case studies in the main body of the book which interferes with smooth flow of the text.

Overall the book is a true reflection of what goes on among smallholder farmers in emerging markets. It is easy to read and understand and can be used by different categories of users.

Dr. Philip M. Nyangweso[1]

[1] Chair, Agricultural Economics and Resource Management, Moi University, Kenya.

EDITORIAL

I don't really believe that anyone actually reads a journal editorial. Whether it is an opinion piece about current affairs which are no longer current by the time of publication, or a somewhat listless rehearsal of the contents list, the editorial is all too readily passed by on the way to the real meat of the journal – the articles. And for those of long memory, I do indeed remember that it was I who introduced editorials to the former *Journal of Farm Management*, after it had survived quite happily without for thirty-odd years.

In case I am mistaken, and do have one or two readers, let me firstly remind you of a couple of important events in the agricultural management world. The first is the UK National Farm Management Conference, '*New research, new technologies – giving farmers the tools to feed the future*', organised by the Institute of Agricultural Management. This will take place at the Royal Society in London on 21 November 2012, and has been chosen by the Technology Strategy Board as the launch-pad for its Agricultural Technology Road Map, an element of the Innovation Platform for Sustainable Agriculture and Food. Fine speakers are guaranteed, with the Chief Executive of the Royal Agricultural Society of England as the Chair. More detail from www.iagrm.org.uk/nfm.php

The second is the International Farm Management Congress '*Transforming Agriculture - Between Policy, Science and the Consumer*', taking place in Warsaw University of Life Sciences between 21 and 26 July 2013 (www.ifma19.org/). The biennial IFMA Congress is now established as one of the most influential events in the agricultural management world, with a large number of high-quality contributions from researchers, consultants and practitioners and excellent opportunities for networking. The call for papers and posters is already open, with a deadline of 31 January 2013, at www.ifma19.org/call-for-papers/ . IJAM will be hoping to publish a number of the contributions eventually, either as conference papers or developed into refereed articles.

Our Editorial Board is an essential resource of advice and, particularly, reviewers (all refereed papers published, and some of those rejected, have been reviewed by at least two people). I am very pleased to welcome two new members to the Board: Caroline Stanford-Billington, a strategic management specialist in the Land, Farm and Agribusiness Department, Harper Adams University College, UK; and Dr Karl Behrendt, Lecturer in Agribusiness and Director of the Asian Agribusiness Research Centre at Charles Sturt University, New South Wales, Australia. They have each done an excellent job as a reviewer, and will greatly strengthen the Editorial Board.

And so to our Journal contents. This issue opens with a flourish in the shape of George Magnus asking whether emerging markets have already emerged: a question given additional piquancy by global events occurring since he gave this paper at the Oxford Farming Conference in January 2012. Five excellent refereed articles examine specific aspects of food production, environmental management and land management, and Barrie Florey enthuses about a new book on farm management by Kent Olson.

If you have been, thank you for reading.

Martyn Warren

Have emerging markets already emerged?

GEORGE MAGNUS[1]

ABSTRACT
This Viewpoint article, based on a lecture to the 2012 Oxford Farming Conference, examines the rise in economic power of the so-called 'emerging markets' (EM) and its implications for agricultural markets in the so-called 'developed world'. In particular, the favourable demographic trends in EM are highlighted and contrasted to those in Western countries, creating a potential powerhouse of productive power. While it is easy to see the current impact on global markets, it is less easy to predict future effects of rapid growth either in the emerging markets themselves or on the economies of the rest of the world.

KEYWORDS: Emerging markets; financial crisis; economic outlook; demographic change; China; India; Brazil.

I'd like to begin by thanking the Oxford Farming Conference for inviting me here to give the Frank Parkinson Lecture[2]. But I do so with some anxiety. My experience of farming amounts to having a bolt-hole in rural Wiltshire and downing decent ale with some neighbourly farmers. With those credentials, I have hopefully deflated any expectations about my ability to enlighten this audience about the specific risks and opportunities presented by the rise of emerging markets (EM).

But the question posed for this session - whether EM have already emerged - is one where I can hopefully illuminate some key issues with important implications for global agriculture. EM will spawn the world's next billion consumers, continuing to underpin global demand for food and energy. But they will also be the focus for supply, because of the constraints that arise both from economic development and rapid urbanisation, and from climate change and new weather patterns, to which EM are especially vulnerable.

Some economists argue that the larger EM, such as China and Brazil, have already emerged, and visitor impressions of Shanghai, Mumbai or Dubai may be quite persuasive. At the very least, if 'emerged' simply means that EM have 'arrived on the global scene with the capacity to alter and influence life beyond their immediate borders', then some probably have already emerged. But this is a rather limited, and misleading, way to consider EM. The term 'emerging', itself, implies a process, and from this standpoint, there's a very long way to go, and it may punctuated by as much by successes as by slip-ups, or worse.

To help illuminate the opportunities and pitfalls in this process, we could choose from a seemingly endless list of topics, but space restricts me to a choice of three. I will look at the phenomenon of the rise of the EM; then I will outline the favourable demographics and population characteristics of EM - in stark contrast to our own; and finally, I will argue that although EM are every bit as significant as we think they are, we cannot draw straight lines into the future.

First though, a little perspective to put things into context. There is no question that we are living through an extraordinary epoch-changing phenomenon, in which EM are not just catching up with the West, but challenging its dominance for the first time in over 200 years.

Once upon a time, China really did rule the world. And India was no bystander. A kind of global system, with China at its hub, mapped the world from before the birth of Christ and until roughly the 17th century, when China's relative position, compared with Europe, started to weaken. How the world might have evolved, had China allowed its mariners and navigators, with superior ships, free rein to discover the Americas, we'll never know. But Europeans did, and in so doing, they helped to turn the world's centre of gravity to the West. There were many other factors that determined the rise of the West, and the steady and then precipitous decline in China - but from about 1800 onwards, human development in the West advanced faster than ever before, despite revolutions and wars. By the end of World War 2 and until the 1970s, China, the USSR, India and the bulk of what we now call EM were of no consequence economically, except to the extent that they were outlets for Western exports and or key producers of oil or other key commodities.

Although the so called Asian Tigers - South Korea, Taiwan, Singapore and Hong Kong - arrived on the scene in the 1970s, two significant developments really explain the rise of EM .

In 1978, under its leader Deng Xiaoping, China began a period of intense reform that set it on a path that has made the country what it is today. Deng had famously said in a party conference discussion on the economy that 'I don't care if it's a black cat or a white cat, so long as it's a cat that catches mice'. What he meant, of course, was that capitalism could work in China too, albeit under the strict and exclusive direction of the

[1] UBS Investment Bank

[2] This paper was originally presented at the 2012 Oxford Farming Conference, and is reproduced here by kind permission of the Conference Secretariat.

Chinese Communist Party. And so it is today for the most part.

About 10 years later, in 1989, of course, the USSR collapsed, and the Berlin Wall was dismantled, opening the way to the most intense period of globalisation that we have seen since the end of the 19th century. A billion workers joined the global labour force as developed markets and EM became ever more closely intertwined in trade, international investment, and global finance.

China has become the hub of long and complex global manufacturing supply chains, initially based on toys and textiles, but now including higher value goods, technology, and alternative and clean energy products. Russia has emerged from its communist past as a major oil and raw materials producer. Brazil went through a huge reform programme in the 1990s that brought first economic stability and then added energy exploration, and aircraft and high end manufacturing to its natural resource bow. And India also introduced extensive economic reforms at the time, allowing its services and limited manufacturing sectors to emerge from the shadows, especially in information communications and technology, steel and automobile engineering. Different routes and different strengths, but all with the same objectives: to develop, to become richer, and to stake a claim to power.

Much of this was well understood before the financial crisis struck in 2008, ending a 25 year long period of unfettered financial globalisation and credit expansion. We tend to call it the Global Financial Crisis, but in China, they call it the Western financial crisis - which indeed it was, and is. The consequences of this crisis are fattening the wedge between EM and developed markets, and accelerating divergent trends in economic development.

EM now account for about 40% of world GDP, and perhaps four fifths of global GDP growth. China's GDP will surpass America's in the next decade, while India, and Brazil will be bigger than any European country by the 2030s. Global trade is being boosted by rising transactions between EM themselves, an interesting anecdote being the Singapore Port Authority's current programme to double capacity in what is already the world's largest trans-shipment port. Over 20% of the Fortune 500 global companies are now headquartered in EM, many of them in China, Korea and Brazil. Of the $10 trillion[3] of global foreign exchange reserves, EM account for about 77%, with China's alone standing at over $3 trillion, and a further $2.5 trillion owned by Russia, Saudi Arabia, Taiwan, Korea, Brazil and India. Increasing economic weight has inevitably lead to greater EM representation and influence in international bodies, such as the G20, the International Monetary Fund, World Bank and World Trade Organisation. And it has spawned new rivalries both with the West and among EM themselves over secure access to raw materials, export markets, shipping routes, food and in some cases, water.

The power that is accruing to EM is of course the same power that is draining away from the US and Europe. And there's no doubt that the financial crisis has weakened us severely and is obliging us to reduce bloated levels of public and private debt, prepare for the financial consequences of rapid population ageing, and explore new growth drivers and technologies. The current sovereign debt crisis in Europe which threatens the very existence of the Eurosystem, is bound to keep Europeans engaged for a considerable period of time.

But it is the threat to America's capacity to set and implement agendas in everything from global monetary governance to international security, from the rules of trade and commerce to climate change, and from global food security to the application of science and productivity in agriculture that is the most worrying. The failure of the Doha Round of trade negotiations, for example, after 10 years of trying to reach a deal, of course reflects conflicts of interest, in which China, Brazil and India have understandably become more vocal and demanding, but I think you still need a leader, someone trusted and willing to broker compromises and solutions, to make global negotiations work.

It just seems unrealistic to expect Americans or Europeans to waver from their preoccupations with home-grown political and economic issues. Mind you, you could say the same about EM too.

I don't want to dwell here on the short term outlook, which actually doesn't bode that well for EM. But many EM are still experiencing relatively high rates of inflation, partly commodity price-related, to which they have responded by tightening interest rate and credit policies. Growth in Brazil has stalled, proved disappointing in India, and seems to be slowing significantly in China, where there are growing signs of disquiet in the export industries, and in the real estate sector, which accounts for about 10% GDP and which is arguably the most important sector on the planet because of its copious consumption of iron ore, steel, cement, copper, lumber, energy and an array of other construction materials. If China experiences a property and credit bust in 2012 or perhaps a bit later, there would be dramatic consequences for global industrial commodity prices and for the principal producers.

These issues will continue to command a lot of attention in China and in EM during the next 1-2 years. But my second topic is about the longer-term, in which the single biggest economic advantage - or Malthusian problem, depending on your point of view - that many EM have is their populations and demographics. In the next 40 years, world population will increase by 2.4bn to 9.3bn, of which all but 100m will be born in EM and less developed countries. Population size in China, Russia and Eastern Europe will decline, but there will be an additional 1bn in both the rest of Asia (half of which will be in India and Indonesia alone) and Sub Sahara Africa. A lot more mouths to feed, you may say, quite correctly. But the age structure of EM is the really important issue here, and this has the potential to be a magic bullet.

Most EM are in a phase which demographers call the demographic dividend. This is when fertility rates decline and the working age population expands from previous higher fertility, rising faster than the population of older citizens. In other words as the productive 15-64 year olds increase, the dependency of children and older citizens on them declines. This phase is generally associated with rising levels of incomes and savings, jobs and output, and prosperity generally - as Western

[3] In early June 2012, $US1 was approximately equivalent to £0.64 and €0.80.

countries themselves experienced with the baby boomers in the 1980s and 1990s.

Now there are some exceptions to this in EM, China and Russia among them. China in fact is the fastest ageing country on Earth, today with 10 workers per citizen aged over 60, but by 2050 there will only be 2.5 per citizen. And China will be considerably older than the US by that time. Weak fertility is an almost universal phenomenon that is about economics, child-care, contraception and literacy, and is therefore not unique to China.

But the critical issue for China is really the speed of ageing, set against low income levels and weaknesses in social insurance and pension systems. And it's this that has given rise to the now common mantra of 'getting old before getting rich'. In fact, the speed of ageing in China is such that it will take 20 years for the share of the over 60s to reach levels that took between 70-100 years in the UK, France and other Western nations. And again China isn't unique. Except for the very poorest nations, the same rapid speed of ageing is occurring throughout the emerging world though the full impact won't start to be felt until roughly the 2030s and later.

If China is a demographic hare, the most significant tortoise is surely India. Here a third of the population is aged less than 14, and the working age population is going to grow by more in the next 20 years than the entire working age population of Europe today. This really is a sweet spot to be in. More labour means more incomes, consumption, and tax revenues, higher standards of living, and presumably better human capital as education systems and attainment levels improve.

But to succeed in harvesting your demographic dividend, you have to educate people, give them work, and equip them with capital. Take India again. For all its output of scientists, doctors and IT specialists, India's illiteracy rate is 40%. School enrolment and drop-out rates are low and high, respectively. The official unemployment rate is 7% but there's a 25% incidence of poverty among anyone that has any type of work, suggesting that the real unemployment rate is much more Asian, that is, around 25-30%. So, India and its peers can only look forward to rising wealth, prosperity and productivity if they are able to put their growing numbers of young people to work, allowing them to aspire to economic and political opportunities. Without this - well you only need to think about the blanket coverage of the Arab Spring, to see, in extremis, the consequences.

But given adequate job creation, we can say that from the standpoint of EM demographics, emerging countries still have a lot of emerging still to do, with profound implications, including for their agriculture. As incomes per head rise, of course, so will per capita demand for food, animal protein consumption, agricultural commodities, and of course, energy.

But this is bringing problems too. According to the World Bank, only about 11% of the world's land surface is used for crop production at a time when arable land acreage is under pressure from soil erosion, flooding or desertification and urbanisation. China's urbanisation rate of 47% is expected to reach 70% by 2050, India's 55%, and Brazil's 90%. Water scarcity is becoming a significant issue, partly because of intensive absorption by agriculture and partly because of climate change effects. Small wonder that the expected 70% increase in food demand by 2050, or over 100% in EM and less developed nations, is making food security and access a leading global issue. Unresolved, this could even brake the emergence of EM.

My final point is about drawing straight lines into future - which is something we all do, and my profession in particular. But there's something really important that you can't plug into an economic model or forecast, or classify under breaking news - and that is the quality of institutions. What I mean by this is the economic and commercial, social and political, and importantly legal, institutions that embody the successful pursuit of initiative, ingenuity, enterprise and creativity.

Institutions matter to human development, for the same reasons they do to a small business or farmer. First, they matter because there's only so much you can do with physical labour and capital. Ultimately, you get more bang for your buck if you combine and organise them efficiently, and improve the quality of both. In my nerdy world, this bang for the buck is called total factor productivity - it is the part of economic growth that can't be accounted for by physical inputs. This is about things such as education and training, organisational methods, incentives, the rule of law and independent enforcement of contracts, the regulatory environment, levels of corruption and so on.

Second, they matter because the need for countries to adapt and refresh their institutions is directly related to the level of development and economic complexity.

Perhaps you can see where this is going. Countries such as Brazil, Argentina, Venezuela, Chile, Poland and Turkey are middle income. But Argentina, Venezuela and to a degree, Brazil have been middle income for a very long time, and haven't been able to jump out of what we call a middle income trap. Brazil may have a fresh chance now, along with others that are trying for the first time. We shall see. The former USSR got to this stage too in 1982 before stumbling - and that was three years before Gorbachev came to power. Russia today has an income per head roughly the same as the USSR's peak - and so here too institutional change will be key, as you may have gathered from the recent public protests over rigged elections. Good institutions, commanding the faith and respect of citizens, matter.

India has phenomenal potential. But if it can be a nuclear power, why can't it improve the lot of its hundreds of millions of rural inhabitants and address urban poverty? If it can become a world leader grains, ICT, and medical services, why can't the whole economy be lifted more rapidly? Again, I refer you to the weighty institutional obstacles that retard or hinder development, including corruption, and note in passing that the Indian upper house recently failed to agree important anti-corruption legislation, which the lower house had already passed.

And finally, of course, China, which has trebled its income per head over the last 25 years to about $4,500, and is on course to treble it again by 2020. We know China will soon have the largest GDP in the world, but it will take many decades, if ever, to close the gap on the West in terms of per capita income.

I don't think this is going to happen without extensive political changes - and it's a moot point whether the Chinese Communist Party is willing to cede power to the point where it undermines its own *raison d'etre*. Rapid economic development is already generating strains in China which are raising the demand for change and flexibility.

Incidents of social unrest, for example, numbering about 120,000 in the last year, are no longer confined to disco brawls and small local disturbances, but characterised by large protests over job losses, and wages and conditions, and well-supported campaigns against political corruption, the suppression of political rights, land expropriation and environmental degradation.

The major economic issue for the next several years is rebalancing China's chronically unbalanced economy away from an excessive reliance on savings and investment, and especially in property. A more consumer and private sector-oriented economy is going to be key to China's future success but rebalancing requires contentious economic, financial, legal and social reforms, which will draw political power away from vested interests that have been major financial beneficiaries in the last 20 years, and redistribute it to those that have been left behind. In other words, a power shift from state owned companies and banks, local and provincial governments, and coastal regions - sure to be resisted - to private enterprise, consumers, rural migrants and the countryside, and the 6-7 million new college graduates each year, whose aspirations to good jobs and houses are already under some pressure.

Summing up, we can look in the rear-view mirror and out of the side windows and appreciate how far and impressively EM have emerged to date. The effects of the rise of EM are clear for all to see locally, in world markets, and through their interactions with us.

Out of the front window though, things are more blurred than they sometimes appear. On the one hand, modernity, rising incomes, and rapid population growth create major opportunities for EM, and for global companies: Nestle and Danone, for example, get 40-50% of their sales from EM already. On the other hand, successful human development needs change that is often disruptive to economies and societies.

Think of your own sector. Strong demand and structural and water supply problems in agriculture are already compromising the ability of EM to follow stable fiscal and monetary policies because of the food price inflation risks, for which these policies are poorly designed anyway. Over time, EM will need to ensure that the declining agricultural weight in GDP is also a much more productive weight with new initiatives to improve yields, and resource and water allocation efficiencies. Otherwise, agriculture, itself, could brake economic development, and along with other pitfalls, keep many EM firmly behind what we could call a BRIC Wall.

About the author

George Magnus (georgemagnus17@gmail.com) is Senior Economic Adviser at UBS Investment Bank. Previously he was the Chief Economist from 1997-2005, and before this he held senior economic positions with S.G.Warburg and Bank of America.

He is the author of *Uprising: will emerging markets shape or shake the world economy?,* published in 2010, and of The Age of Ageing: how demographics are changing our world, published in 2008.

He is a regular contributor on contemporary economic issues in the media, including the Financial Times, the Times and the BBC. All his public commentaries are available at www.georgemagnus.com. He is married with four children and lives in London.

Application of an optimisation model for analysing production seasonality in the Irish milk processing sector

KARIN E. HEINSCHINK[1], LAURENCE SHALLOO[2] and MICHAEL T. WALLACE[1]

ABSTRACT

Ireland's dairy sector is characterised by pastoral spring-calving systems and seasonal milk production at national level. This production seasonality initiates various implications at processor level, such as poor plant capacity utilisation in the off-peak season or a requirement for seasonal labour, which impose extra costs on the processor and limit their options as to which markets can be serviced. An optimisation model was developed to analyse the impact of production seasonality on the Irish dairy processing industry regarding processor gross surplus (*Surplus*), costs of milk collection and handling, processing, product storage and labour as well as on product mix, plant and labour capacity utilisation and the marginal producer milk price (*MPMP*). Three scenarios with differing milk intake curves were examined whereby it was found that a flatter intake pattern incurred less variation in the *MPMP* and capacity utilisation in addition to a higher *Surplus* and a larger proportion of more profitable products in the product mix *vis-à-vis* seasonal patterns. As expected, these results suggest that a producer supplying milk in line with a nationally seasonal production pattern receives lower milk payments since the seasonality-related costs are fed back from the processor to the producer via a lower producer milk price.

KEYWORDS: Milk production seasonality; processor profitability; dairy product mix; marginal producer milk price; optimisation model; linear programming

1. Introduction

In pastoral milk production systems, the dairy herd's calving dates are matched with the grass-growing season's start in order to maximise the intake of cost-efficient grazed forage, effectively resulting in a seasonal milk production pattern. The producer benefits from reduced feed costs and thus lower production costs per kg of milk, however the production system needs to be flexible to ensure adverse climatic conditions can be managed through the use of diet supplementation by means of more expensive concentrates. Seasonal supply at producer level initiates a variety of challenges in dairy processing and auxiliary activities, resulting in implications for milk transport, storage and financing. For the off-peak season, implications include persistent plant and labour capacity underutilisation which potentially necessitates the closing down of plants for a part of the year, as well as higher raw milk collection and product storage costs (Downey and Doyle, 2007, Hennessy and Roosen, 2003, Prospectus, 2003, Quinlan et al., 2011). Since output capacities of more lucrative products are usually fully exploited during peak months, the 'excess' milk supplies in those months are typically manufactured into less profitable commodities that involve reduced market returns and increased finance and storage costs. In addition, milk composition changes in the course of lactation; the suitability of some late-lactation milk for various products, particularly cheese, is limited with respect to processability, storability and desired product properties (Guinee et al., 2007, Downey and Doyle, 2007, Phelan et al., 1982).

Ireland's dairy industry has the highest production seasonality within the EU with a peak-to-trough ratio (PT ratio) of 4.9:1 in 2009. The vast majority, namely 21 EU member states, ranged from 1.1:1 to 1.3:1 (EC, 2010b). In Ireland, 18 processing enterprises (derived from DAFF, 2010b) purchased approx. 5.2m tonnes of raw milk, of which 92% were produced domestically (CSO, 2011) in 2009. Of the total domestic raw milk produced, 10.3% were manufactured into liquid milk (509,600 tonnes), the remainder of the national product mix consisted mainly of cheese (157,500 tonnes), butter (126,000 tonnes), skim milk powder (SMP) (113,000 tonnes), chocolate crumb (40,500 tonnes), proteins (30,000 tonnes) and whole milk powder (WMP) (25,000 tonnes) (IDB, 2010, National Milk Agency, 2010). Dairy exports accounted for €2.7bn[3], or 30% of agri-food and drinks exports in 2009 (DAFF, 2009). In the same year, an estimated 5,000 persons were employed in the dairy processing sector (CSO, 2011).

Due to the progressing deregulation of EU dairy markets, competitive pressures are expected to increase as national milk output will no longer be limited by milk

[1] School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Dublin, Co. Dublin, Ireland.
[2] Livestock Systems Research Department, Animal and Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland
[3] In July 2012, €1 was worth approximately £0.79 and $US1.22

production quota post 2014/15 and prices are assumed to settle closer to world market prices. In this context, Ireland has been recommended to examine the implications of milk production seasonality and the future structure of the processing sector (Teagasc, 2009). However, there are contrasting financial implications of seasonality for producers and processors. On the one hand, seasonal milk production is favoured at farm level because it allows producers to minimise production costs by optimising the use of grazed pasture. On the other, seasonality imposes extra costs on milk processors in terms of additional plant capacity to handle peak supplies, poor off-peak capacity utilisation and reduced product mix flexibility. A key challenge concerns how to reconcile these divergent producer-processor interests to formulate a more cohesive strategy that maximises returns to the industry as a whole.

Addressing such issues becomes more urgent in the context of abolition of the milk quota. With expected expansion of milk supplies processors must decide whether investments should be made to further support a seasonal milk production, or whether present capacities could be used more efficiently by means of smoothing milk intake pattern.

The economic sustainability of seasonality in dairy markets has been studied (FAO, 2010, Keane and Killen, 1980) and 2 fundamentally different strategic options with important consequences for the entire value chain have emerged for processors: accepting or evening out a seasonal milk intake curve (Keane, 2010). Maintenance of a seasonal supply profile results in a 'production-led', price-sensitive, commodity-based dairy industry with lower milk production costs on the one hand, but a variety of inefficiencies in the processing and marketing of dairy products on the other. In contrast, a flat milk supply curve facilitates the design of a 'market-led' product mix comprising less price-sensitive, value-added items throughout the year as well as better utilisation of fleet, plant, storage and labour capacities (Downey and Doyle, 2007). This can be achieved by encouraging producers to ensure year-round dairying particularly with the aid of milk price incentives (Harte and O'Connell, 2007) or, where geographically feasible, through imports of raw milk during months of low intake. Both measures raise the costs of raw milk.

The usefulness of optimisation models to solving problems in the agri-food industry has been widely acknowledged. Optimisation techniques have been used at milk processor level for analysing milk pricing mechanisms, the value of milk components, product mix and profitability in dairy processing (Bangstra et al., 1988, Breen et al., 2003, Burke, 2006, Papadatos et al., 2002). However, there has been little, if any, research that has modelled the implications of production seasonality for a milk processor. A few studies have used optimisation techniques to analyse milk production seasonality at farm level. For example, Davis and Kirk (1985) and Killen and Keane (1978) used farm level linear programming models to analyse the economic aspects of changing seasonal milk production patterns in Northern Ireland and the Republic of Ireland, respectively. They concluded that the interdependencies of milk production, collection and processing should be accounted for and that changing the distribution of milk production is justified only if this resulted in lower costs for the entire system. For example, a flatter milk intake curve may improve the processor's capacity utilisation and profitability throughout the year; however, if the additional production costs caused thereby at farm level exceed the economies at processor level, the authors recommend not to pursue seasonality changes.

Given this context, the objective of this paper is to analyse the financial consequences of seasonality for the Irish milk processing industry. A milk processing optimisation model is presented in which the objective function maximises a dairy processor's annual gross surplus subject to processing capacity and milk intake profile. Scenario analysis provides the opportunity to evaluate the impact of changes in milk production seasonality on processor profitability, seasonality costs, product mix, plant and labour capacity utilisation, marginal milk solids values and marginal producer milk price.

2. Method

Model output

A milk processing model was developed for the analysis of profitability based on various milk intake patterns or processing capacities.[4] The model was formulated as a single-criterion, multi-period linear programming problem which identifies the maximum annual processor gross surplus (*Surplus*, €) and a corresponding optimum production plan at monthly intervals for a time horizon of one calendar year. The optimum production plan maximises the processor's annual *Surplus* subject to its resource constraints comprising monthly raw milk supplies and processing capacities. Furthermore, the model solution illustrates the impact of milk production seasonality on selected costs (€), including raw milk collection and handling, product processing, labour, storage and product mix, as well as the marginal values of the milk solids (*SolidsMV*, €/kg solid) fat, protein and lactose. The *SolidsMV* allow for calculating the marginal producer milk price (*MPMP*, €c/kg raw milk). It should be noted that the price payable to the milk producers is covered by *Surplus*. The surplus-maximizing product mix is subject to a set of technical constraints addressing, for instance, milk solids contents and output capacities (Figure 1).

Processor gross surplus, product gross margin and milk collection and handling costs

The objective function (1) calculates *Surplus* (€) as the product gross margin generated from the production plan (*Margin*, €), reduced by the variable costs arising from raw milk collection and handling activities (*CollHandVC*, €) and total fixed costs (*FC*, €).

$$\text{Max.}\, Surplus = Margin - (CollHandVC + FC) \qquad (1)$$

The *CollHandVC* comprise the costs of all raw milk collection, assembly, separation and standardisation activities for the total raw milk volume processed.

[4] A technical annex providing a more detailed description of variables and equations is available from the corresponding author upon request.

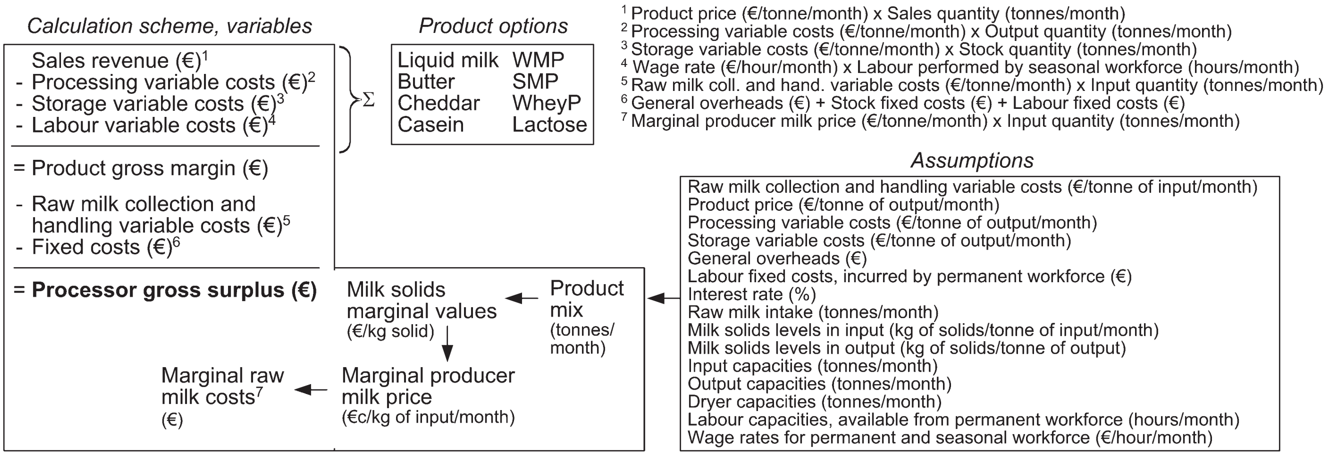

Figure 1: Conceptual framework

Margin is defined as sales revenue (*SalesRev*, €) less variable costs of processing milk into the final product (*ProcessVC*, €), labour (*LabourVC*, €) and product storage (*StorageVC*, €); where t =monthly time period (2). In the equations listed in this section a subscript t is used to denote variables or parameters that are defined on a monthly basis in the model. Omission of the t subscript denotes that the variable is determined at the annual level.

$$Margin = \Sigma_t\ SalesRev_t - (ProcessVC_t + StorageVC_t + LabourVC_t) \quad (2)$$

Milk solids, input and output capacities

Product yield (*Output*, tonnes) is limited by product composition (SolidsO, milk solids levels in output, kg solids/tonne of output) as well as by the quantity (*Input*, tonnes) and quality (SolidsI, milk solids levels in input, kg solids/tonne of input) of raw milk available for processing.

For each unit of milk solid allocated to a product, the amount of solids available from the milk pool is reduced by 1 unit. SolidsI are determined on a monthly basis in order to reflect the variability of raw milk composition which naturally occurs in the course of lactation. This is particularly relevant in an environment characterised by a seasonal milk supply profile as a dairy processor's production possibilities change during the year due to fluctuating quantities of milk components available for processing and the ability to process some of those components into certain final products.

Furthermore, the model predefines maximum input capacities (tonnes/month) depending on raw milk availability or intake capacity, and output capacities (tonnes/month) for individual products as determined by product processing capacity and marketing considerations.

Sales, stock levels and storage-related costs

Due to the perishable nature of milk, a seasonal intake curve will result in a seasonal production of dairy products which is in conflict with a relatively constant demand throughout the year (Killen and Keane, 1978). By dividing total annual output by 12 it is assumed in the model that product sales (*Sales*, tonnes/month) are constant throughout the year.

Any mismatch between monthly product yield and sales has implications for stock levels and stock-related costs. When product manufacture exceeds *Sales*, the unsold quantity is put on stock (*Stock*, tonnes/month), and when product manufacture falls short of demand, the quantity required to satisfy demand is taken from *Stock*. To account for the opportunity costs of resources tied up in output on *Stock* (*StockFC*, stock fixed costs, €), interest is charged based on the variable costs of processing, storage, labour, the value of milk components and the length of storage; where o = output, product line; s = type of milk solid; ProcessUVC[5] = variable costs of processing input into output per unit of output (€/tonne); LabourUVC = variable costs of labour per unit of output (€/tonne); StorageUVC = variable costs of storage per unit of output (€/tonne); IR = annual interest rate (%) (3).

$$StockFC = \Sigma_t\, \Sigma_o\, \Sigma_s\, (\mathrm{ProcessUVC}_{ot} + \mathrm{StorageUVC}_{ot} + \mathrm{LabourUVC}_{ot} + \mathrm{SolidsO}_{os} \times SolidsMV_{st}) \times Stock_{ot} \times (\mathrm{IR}/12) \quad (3)$$

Labour capacities and costs

The optimum product mix determines the total number of labour hours required, and the work hours available from permanent workforce are specified prior to running the model. When the permanent workforce cannot cover the workload required for the optimum production plan, seasonal staff are hired. Labour by seasonal workforce is all labour required for the product mix less the hours contributed by the permanent staff. Whereas wages paid to the permanent workforce qualify as fixed labour costs (*LabourFC*, €), those payable to the seasonal workforce are considered variable labour costs (*LabourVC*, €).

[5] UVC denotes 'Unit Variable Cost'.

Fixed costs

FC (€) are the total of *LabourFC* (€), *StockFC* (€) and general overheads (OverhFC, €, such as depreciation of plant and equipment, administration, managerial salaries).

Milk solids marginal values and marginal producer milk price

The marginal value (MV), or shadow price, of a limiting resource expresses how much can be spent on an extra unit of the resource without reducing the objective value, i.e. the *Surplus*, when other model specifications remain unchanged. The *MPMP* (€c/kg raw milk) is computed from the *SolidsMV* as indicated in the model solution, multiplied by the milk solids in raw milk (SolidsI, kg solids/tonne of input), divided by 1000 to scale to kg, and finally reduced by a volume charge (*VolCharge*, €c/kg input) based on *FC* plus *CollHandVC* (4a, 4b):

$$MPMP_t = \Sigma_s\,(SolidsMV_{st} \times \mathrm{SolidsI_{st}}/1000) - VolCharge_t \tag{4a}$$

$$VolCharge_t = (CollHandVC + FC)/\Sigma_t\,Input_t \tag{4b}$$

Seasonality costs

A seasonally operated dairy processing plant registers additional costs that could be avoided or reduced with a smooth production profile. These seasonality costs (*SeasonalityC*, €) are calculated as the difference between key financial results for a scenario with a seasonal milk intake curve and a reference scenario with a smooth milk intake curve (Δ). In this paper, *SeasonalityC*, which were computed post-optimisation, comprise (a) certain costs arising from the processor's activities (*SeasonActivC*, €), i.e. raw milk collection and handling, processing, storage and labour, and (b) *Surplus* foregone due to a less profitable product mix (product mix costs, *SeasonMixC*, €) imposed by seasonality of raw milk supply. In other words, *SeasonActivC* stem from the output produced in the individual scenarios (5a), whereas *SeasonMixC* originate from the output *not* produced in the seasonal scenarios *vis-à-vis* a smooth raw milk intake pattern (5b):

$$SeasonActivC = \Delta\,(CollHandVC + ProcessVC + StorageVC + StockFC + LabourVC + LabourFC) \tag{5a}$$

$$SeasonMixC = \Delta\,(Surplus - SeasonActivC) \tag{5b}$$

3. Data

Financial data

Collection and handling costs per unit of raw milk (€/tonne) (Table 1) were taken from a milk transport model developed by Quinlan (2011) for Ireland whereby the transport model was run for each scenario as specified in this paper.

Product prices were obtained from price records on national (EC, 2010a) and international (Productschap Zuivel, 2010) markets. An annually standardised wholesale price was computed for manufactured dairy output as the 36 month average from January 2008 to December 2010. The liquid milk price (Young, 2009) was estimated as a percentage of the retail milk price reported for 2009 (63.9%) (derived from Young, 2009, CSO, 2011, National Milk Agency, 2010) (Table 2).

Product variable costs comprised (a) processing: fuel and power, added ingredients, packaging, transport, losses, effluent, interest and other direct expenses, (b) labour and (c) storage. Historical processing cost data (Breen, 2001) were updated for inflation, and, where applicable, adjusted for productivity increases (EC, 2010b, IPCC reports, processor annual reports, CSO, 2011) to 2009 level, and validated via industry consultation. The hourly wage rate of €21 charged for both permanent and seasonal workforce was taken from CSO (2011). Storage costs were derived from consultations with milk processors and storage companies (industry consultation).

The interest rate applied to calculating interest on bank loans and opportunity costs of storage was set to 6.8% per annum (derived from processor annual reports).

Overhead costs of the representative processing plant were €3.99m per annum in all three scenarios. This was equivalent to €c1.46 per kg of raw milk processed which was regarded as typical for Irish milk processors in 2009 (industry consultation). Overhead costs included depreciation, insurance, rent, R&D, interest, management, quality control and central IT and administration (industry consultation).

Plant scale

It was decided to specify a synthetic plant for the scenarios modelled which processes the national average of domestic raw milk intake (2009: 273,746 tonnes) while availing of processing capacities which were calculated as product-line averages. For this purpose, the milk pool was specified as total domestic milk intake divided by the total number of processors, and each

Table 1: Raw milk collection and handling costs

CollHandUVC[a]	Baseline €/tonne	Smooth €/tonne	Seasonal €/tonne
Jan	21.83	9.73	51.45
Feb	15.71	9.86	50.01
Mar	9.42	8.63	11.67
Apr	7.98	8.45	7.82
May	7.50	8.26	7.33
Jun	7.63	8.44	7.64
Jul	7.92	8.49	7.94
Aug	8.48	8.68	8.38
Sep	9.05	8.64	8.78
Oct	10.81	9.74	10.38
Nov	14.66	9.90	11.77
Dec	21.19	9.90	52.44
W.avg.[b]	9.73	9.01	10.01

[a]CollHandVC = collection and handling costs per unit of raw milk (€/tonne/month), adapted from Quinlan (2011).
[b]W.avg. = weighted average.

Table 2: Product prices per month, variable costs of processing, labour and storage per unit of output and month; output capacities per month

Output	Product price €/tonne/month	Processing costs ProcessUVC €/tonne/month	Labour costs LabourUVC €/tonne/month	Storage costs StorageUVC €/tonne/month	Processing capacities tonnes/month
Liquid milk	627[b]	200	24	0.00	2,831
Butter	2,620[c]	258	12	8.13	1,050
Cheddar	2,759[c]	306	36	5.80	1,875
Casein	6,480[d]	241	154	5.80	357
WMP[a]	2,471[e]	265	71	3.14	Dry[g], 298
SMP[a]	1,973[c]	217	71	3.14	Dry[g]
WheyP[a]	535[e]	216	71	3.14	Dry[g], by-prod[h]
Lactose	577[d]	250	71	3.14	By-prod[h]

[a]WMP = whole milk powder, SMP = skim milk powder, WheyP = whey powder.
[b]Derived from Young (2009), NMA (2010) and CSO (2011).
[c]Prices for the Ireland, average Jan 2008 to Dec 2010 (EC, 2010a).
[d]Prices for the USA, average Jan 2008 to Dec 2010 (Productschap Zuivel, 2010).
[e]Prices for the Netherlands, average Jan 2008 to Dec 2010 (Productschap Zuivel, 2010).
[f]Breen (2001), adjusted for inflation and productivity increases (EC, 2010b, IPCC reports, processor annual reports, CSO, 2011) and validated by industry consultation.
[g]Products utilising drying capacity: WMP, SMP, WheyP.
[h]By-products: WheyP, Lactose.

product's processing capacity was computed as national output divided by actual number of processors manufacturing the product in question. This approach was chosen to ensure that production capacities would be representative of typical production scales for individual products within the industry.

Input: Raw milk quantity and composition

The monthly milk volume available for processing was calculated as Ireland's creamery domestic milk intake at national level in 2009 (CSO, 2011) and divided by the number of processors in 2009. The lactation curves (Olori et al., 1999) were applied in order to estimate milk volume and milk composition according to seasonal calving pattern. To accommodate the fact that these levels vary according to stage of lactation and month of calving, a dynamic link was established between milk pool, calving pattern and lactation curves, ensuring that the amount of milk solids available for the production plan was automatically recalculated as soon as the monthly calving distribution changed.

The milk solids types considered in the milk pool and products were fat (FAT), protein (PRO) and lactose (LAC). PRO was further subdivided into casein protein (CPRO) and whey protein (WPRO); non-fat solids (NFS) were the aggregate of PRO plus LAC. The item NFS was introduced to allow for flexibility in product composition where FAT levels are standardised while PRO and LAC levels vary in line with raw milk composition (see milk powders). Hence, total NFS allocated to 1 unit of output remained unchanged while the proportion of PRO or LAC within the NFS collective corresponded to actual levels contained in the milk pool. PRO was subdivided into CPRO (82% of PRO) and WPRO (18% of PRO) (Fox and McSweeney, 1998).

Output: Product types and composition

A catalogue of 8 product options was specified, including those which are particularly important in Ireland's national product mix: liquid milk, butter, cheddar cheese (Cheddar), casein, whole milk powder (WMP), skim milk powder (SMP), whey powder (WheyP) and lactose (Table 3). PRO and LAC levels in liquid milk, WMP and SMP were allowed to fluctuate in line with monthly raw milk composition as opposed to a standardised product composition for all other items (Breen, 2001; IDB, Dublin, Ireland, personal communication, McCance and Widdowson, 2002) throughout the year. The logic is that, although FAT contents are standardised in the manufacture of liquid milk and milk powders in Irish dairy processing facilities, PRO and LAC levels typically are not; instead, the amount of PRO and LAC contained in the milk pool goes unaltered into the final product (Teagasc, Fermoy, Ireland, personal communication). Unlike the other product options, cheese and casein products only utilise the CPRO component of milk protein only; the remaining WPRO goes into whey, which, is subsequently manufactured into the by-product WheyP (Southward, 1998).

Input and output capacities

The volume of raw milk to be processed was constrained by the milk pool available (tonnes/month). Likewise, a monthly upper limit was determined for selected manufactured outputs (Table 2). Liquid milk output (tonnes/month) was determined not to exceed 10.3% of the annual milk pool, which corresponds to the proportion of Ireland's liquid market based on domestic milk intake in 2009 (National Milk Agency, 2010), and divided by 12. Butter, cheese and casein were assumed to be constrained by processing capacity which was computed as national product-line average where total output at national level (IDB, 2010) was divided by the number of plants manufacturing these items (derived from DAFF, 2010b), and subsequently divided by 12. WheyP was treated as a by-product of cheese and casein output and thus limited by the volume of whey resulting from cheese and casein manufacture. Monthly WMP capacity was calculated as national WMP output

Table 3: Product composition

Output	SolidsO[a] kg solids/tonne of output					
	FAT	PRO	LAC	NFS	CPRO	WPRO
Liquid milk[b]	35.0			79.0		
Butter[c]	800.0	4.0	3.0			
Cheddar[c]	320.0		1.9		260.0	
Casein[c]	9.0		1.9		900.0	
WMP[c,d]	280.0			630.0		
SMP[c,d]	8.0			875.0		
WheyP[c,e]	13.0		780.0			122.0
Lactose[b]		2.0	946.0			

[a]SolidsO = milk solids levels in output: FAT = fat, PRO = protein, LAC = lactose, NFS = non-fat solids, CPRO = casein protein, WPRO = whey protein.
[b]Breen (2001).
[c]IDB, Dublin, Ireland, personal communication.
[d]WMP = whole milk powder, SMP = skim milk powder, WheyP = whey powder.
[e]McCance and Widdowson (2002).

divided by the number of WMP-producing plants, and divided by 12. Total output of WMP, SMP and WheyP was capped by drying capacity. Lactose output was restricted by the solids available from the milk pool. All items were allowed to be produced year-round except for cheese: Due to unsatisfactory processability characteristics of some late lactation milk, cheese and its by-product were automatically excluded from the list of product options in months where the raw milk pool's LAC levels fell below 4.3% (Guinee et al., 2007).

Labour capacities

The monthly labour pool from all permanent staff was estimated from Smooth and specified as 11,520 labour hours. For this purpose, the annual labour requirement was divided by 12 and calibrated to identify 72 full-time equivalents per month. One full-time equivalent amounted to 48 work weeks per year at 40 hours per week, equalling 1,920 labour hours per worker per year (Oireachtas, 1997). Smooth was selected for the labour pool estimates as this scenario indicates the work requirement that would be sufficient for processing in a situation with a smooth pattern of milk deliveries. To facilitate additional labour requirements associated with seasonal variation in milk deliveries it was assumed that casual labour (hours) could be hired without restriction.

Validation

Model structure and assumptions were reviewed in two independent face validation exercises by dairy technologists at Teagasc Moorepark, Ireland's national dairy research centre. A plausible imitation of real-world decisions and processes in Irish dairy manufacturing enterprises received particular attention.

Furthermore, processing cost data were validated in a two-stage process. Firstly, preliminary unit variable processing costs for each product were prepared in consultation with Moorepark dairy technologists based on figures from a survey conducted by Breen (2001). Next, dairy co-operative production managers and management accountants were consulted in order to calibrate the cost data for each product. The experts revised the cost estimates to reach a consensus on a representative set of unit-based costs for each product in and iterative process.

4. Scenarios

Three scenarios representing different milk intake profiles were run for a 12-month period from the perspective of a single dairy processing enterprise (Figure 2). In order to identify seasonality-related effects resulting from shifts in the distribution of raw milk intake occurring within one plant, the same plant equipment and labour pool were imposed on all 3 scenarios. Whereas the Baseline scenario reflects a distribution of milk intake typical for the average processor operating in Ireland in 2009, the other scenarios aim at illustrating how a smoother (Smooth scenario) or a more seasonal (Seasonal scenario) pattern affect the processing enterprise's performance. To ensure comparability of the different situations examined, only selected key variables as outlined below were altered from Baseline.

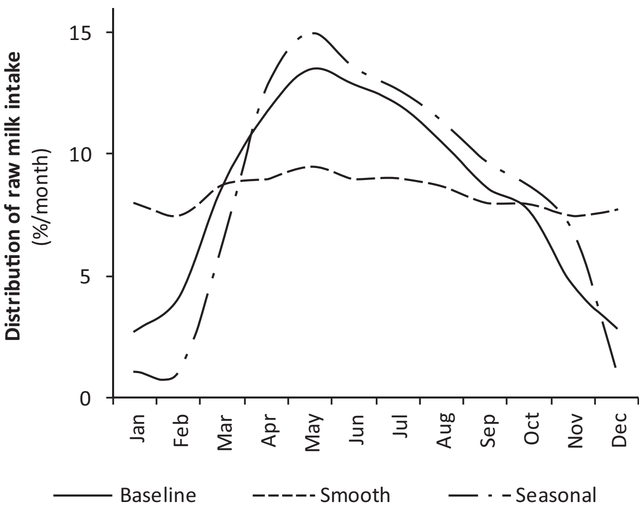

Figure 2: Distribution of raw milk intake

Baseline

The Baseline scenario was characterised by an intake pattern derived from the monthly distribution of domestic milk intake at national level (derived from CSO, 2011) with a PT ratio of 4.9:1 and an annual intake of 273,746 tonnes.

Smooth

In the Smooth scenario, monthly milk intake varied little (PT ratio: 1.3:1) due to an all year round even calving pattern, allowing for a better utilisation of equipment and workforce in the trough months while deteriorating capacity utilisation in the peak months.

Seasonal

It has been suggested that Irish dairy farmers should aspire a more compact spring calving pattern, thus reducing feed costs and improving competitiveness (Teagasc, 2009). An intensified calving compaction could result in a more extreme milk supply curve to dairy processors. In Seasonal, milk intake increased more steeply than in Baseline while total milk intake and processing capacities remained unchanged. A sufficient amount of raw milk was available to secure year-round liquid milk production; however, limited milk volumes permitted only minimal production of manufactured dairy products in the trough period (December, January and February).

5. Results

Product mix and processing capacity utilisation

Liquid milk was identified by the model as the most financially rewarding product, followed by casein, cheddar cheese, WMP and SMP, respectively. Butter and lactose came into the solution with the manufacture of the aforementioned products. WheyP varied proportionally as a by-product of casein and cheese output. The full product portfolio was manufactured in the months of higher intake, i.e. in two months in Seasonal and one month in Baseline whereas Smooth engaged in the manufacture of all products but SMP in three months. Annual results show that the seasonal scenarios included a higher tonnage of milk powders (Seasonal: 1,886 tonnes; Baseline: 1,422 tonnes) as opposed to Smooth (83 tonnes), which manufactured the largest quantity of the most profitable manufactured product casein (Table 4).

Liquid milk capacity was entirely filled in all scenarios and casein capacity was exploited at 75% (Seasonal) and above (Baseline: 87%; Smooth: 100%). Other than that, capacity utilisation was poor in the trough periods; much less output was manufactured in Baseline's and Seasonal's trough periods as opposed to Smooth. It is also shown that during the peak month of May, Seasonal required 1.9 times the dryer capacity as compared to Smooth (Table 5). Overall, the plant modelled in Smooth would manage with considerably smaller capacities due to the absence of milk supply peaks (see discussion).

Milk solids marginal values and marginal producer milk price

The *SolidsMV* changed throughout the year due to variations in the product mix and raw milk composition. The minimum to maximum ranges for *FATMV* and *LACMV* were similar in Baseline (FAT: €2.85-€2.99; LAC: €0.23-€0.36), Seasonal (FAT: €2.86-€2.99; LAC: €0.23-€0.36) and Smooth (FAT: €2.84-€3.02; LAC: €0.24-€0.36). Larger variations in the *PROMV* were apparent when juxtaposing the seasonal scenarios and Smooth. Compared to Smooth (€4.47-€5.08), the difference between the lowest and the highest value was larger in Baseline (€4.21-€5.72) and Seasonal (€4.24-€5.73). This reflects that throughout the year, there were periods in the seasonal scenarios in which the capacities were less utilised (i.e. higher MV) or better utilised (i.e. lower MV) (Table 6).

Smooth achieved an annual weighted average *MPMP* of €c24.71 followed by €c24.15 in Baseline and €c23.33 in Seasonal. Historical data on the manufacturing milk price indicates similar values of €c28.15 (3-year weighted average 2008 to 2010) or €c22.44 (weighted average 2009) per kg (CSO, 2011). The *MPMP* is broken down into four elements, i.e. a reward for the FAT, PRO and LAC components and a volume deduction. In all scenarios, the PRO element fluctuated more than the FAT and LAC elements. Also, the PRO element was approx. 60% higher in value than the FAT element (weighted average), and the LAC element was negligibly small. *VolCharge* (€c/kg raw milk) was lowest in Smooth (€c3.47), higher in Baseline (€c3.73) and highest in Seasonal (€c3.85) (Table 6). Furthermore, the seasonal scenarios displayed a *MPMP* curve countercyclical to the milk intake pattern, i.e. lower prices in peak months and higher prices in trough months. There was notably less *MPMP* variation in Smooth than in the seasonal scenarios (Figure 3).

Financial performance and seasonality costs

Smooth (€103.4m) achieved the highest annual *SalesRev*, followed by Baseline (€102.2m) and Seasonal (€101.7m). Thus, *SalesRev* increased with a smoother distribution of milk intake, but differed only to a modest extent. The highest annual *Surplus* was realised in Smooth (€78.0m), followed by Baseline (€75.5m) and Seasonal (€74.2m). Logically, the surplus per unit of raw milk (€c/kg) was higher in Smooth (€c28.48) as opposed to the seasonal scenarios (Baseline: €c27.56; Seasonal: €c27.11). *FC* amounted to €7.0m in Smooth, followed by €7.5m in Baseline and €7.8m in Seasonal. The per kg of raw milk equivalent was €c2.57 (Smooth), €c2.75 (Baseline) and €c2.85 (Seasonal) (Table 6).

The model results show that across all scenarios, the costs in question correlated positively with an increasing degree of milk intake seasonality (Tables 6 and 7).

Table 6 documents that *CollHandVC* amounted to €2.47m in Smooth, €2.66m in Baseline and €2.74m in Seasonal. *ProcessVC* totalled €15.87m in Baseline and were similar in Smooth (€15.81m) and Seasonal (€16.03m). The model reported total labour costs (*LabourVC* + *LabourFC*) of €2.97m for Smooth, followed by €3.31m for Baseline and €3.43m for

Table 4: Product mix by month

Output[a] tonnes	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
Baseline													
Liquid milk	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	33,972
Butter	255	405	611	569	590	534	567	571	570	580	524	285	6,061
Cheddar			745	1,489	1,875	1,847	1,624	1,529	1,100	801			11,010
Casein	140	234	357	357	357	357	357	357	357	357	329	167	3,726
WMP			108	298	298	298	298						1,300
SMP					122								122
WheyP	226	378	927	1,275	1,455	1,442	1,338	1,294	1,093	953	533	270	11,184
Lactose	40	97	221	272	297	281	246	181	93	73	25	15	1,841
Dry	226	378	1,035	1,573	1,875	1,740	1,636	1,294	1,093	953	533	270	12,606
Smooth													
Liquid milk	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	33,972
Butter	634	619	615	564	534	540	565	572	574	593	610	628	7,048
Cheddar	684	527	855	1,033	1,203	1,054	1,039	962	826	795	628	650	10,256
Casein	357	357	357	357	357	357	357	357	357	357	357	357	4,284
WMP			69	7	7								83
SMP													
WheyP	898	825	978	1,061	1,141	1,071	1,064	1,028	964	950	872	882	11,734
Lactose	171	166	180	168	171	166	174	155	124	129	126	151	1,881
Dry	898	825	1,047	1,068	1,148	1,071	1,064	1,028	964	950	872	882	11,817
Seasonal													
Liquid milk	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	2,831	33,972
Butter	32	19	587	587	751	588	567	574	576	591	595	32	5,499
Cheddar			124	1,768	1,875	1,875	1,767	1,747	1,388	1,092	617		12,253
Casein	6	<1	357	357	357	357	357	357	357	357	357	5	3,224
WMP			108	298	298	298	298						1,300
SMP					464	122							586
WheyP	9	<1	636	1,405	1,455	1,455	1,405	1,395	1,227	1,089	867	9	10,952
Lactose	1	<1	143	296	313	306	275	213	122	89	36	<1	1,794
Dry	9	<1	744	1,703	2,217	1,875	1,703	1,395	1,227	1,089	867	9	12,838

[a]WMP = whole milk powder, SMP = skim milk powder, WheyP = whey powder, Dry = dryer output; results rounded to the nearest whole number.

Table 5: Capacity utilisation – minimum, maximum, average

Cap.Ut.[a]	Baseline			Smooth			Seasonal		
% Output[b]	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
Liquid milk	100	100	100	100	100	100	100	100	100
Butter	24	58	48	51	60	56	2	71	44
Cheddar	0	100	49	28	64	46	0	100	54
Casein	39	100	87	100	100	100	0	100	75
WMP	0	100	36	0	23	2	0	100	36
Dry	10	83	47	37	51	44	0	99	48

[a]Cap.Ut. = capacity utilisation; Min = minimum, trough month; Max = maximum, peak month; Scenario: Min/Max of raw milk intake = Baseline: Jan/May, Smooth: Nov/May, Seasonal: Dec/May; Avg = Output p.a. / (Output capacity p.m. × 12).
[b]WMP = whole milk powder, SMP = skim milk powder, WheyP = whey powder, Dry = drying capacity; SMP is limited by the dryer capacity, WheyP is limited by the dryer capacity, cheddar and casein output; Lactose is limited by its availability from the raw milk pool.

Seasonal. Not only did a more seasonal milk intake curve result in higher total labour costs, but also in a higher proportion of labour costs incurred by seasonal workforce (*LabourVC*; Seasonal: 15.4%; Baseline: 12.4%; Smooth: 2.3%). Analogously, stock holding costs (*StorageVC* + *StockFC*) in Smooth (€0.20m) were considerably lower than in Baseline (€0.91m) and Seasonal (€1.27m). *StockFC* accounted for the larger proportion of stock holding costs (Seasonal: 71.0%; Baseline: 71.1%; Smooth: 69.7%).

Table 7 shows how Baseline and Seasonal results deviate from Smooth. *SeasonActivC* amounted to €2.02m in Seasonal and €1.32 in Baseline and are broken down into *CollHandVC*, *ProcessVC*, stock holding costs and total labour costs. *CollHandVC* in Smooth undercut Baseline by 8.0% (−€0.20m) and Seasonal by 11.1% (−€0.27m). Smooth's *ProcessVC* varied very little compared to Baseline (−0.4%) and Seasonal (−1.4%). Stock holding costs in Smooth were 78.3% (−€0.72m) below those in Baseline and 84.3% below those in Seasonal (−€1.07m). Finally, Smooth's total labour costs fell short of Baseline by 10.4% and of Seasonal by 13.5%.

In total, Smooth surmounted the *Surplus* realised in Baseline by €2.51m and in Seasonal by €3.75m (*SeasonalityC*), which equals *SeasonMixC* of €1.19m in Baseline and €1.73m in Seasonal.

Discussion

Financial performance and seasonality costs

The *SeasonalityC* arising to a dairy processing business were subdivided in this paper into costs arising from (a) activities related to the processor's production plan, which include raw milk collection and handling, processing, stock holding and labour, and (b) a product mix which is less profitable than the Smooth scenario's mix. A higher degree of milk intake seasonality resulted in higher *SeasonalityC* and a lower *Surplus*.

The *Surplus* figure represents the amount available for covering the milk payments and the retained processor profit. Smooth registered the highest *Surplus* followed by Baseline and Seasonal, respectively. The main reason for these variations is a different distribution of milk intake caused by the underlying calving pattern which determines product mix choices and the *SeasonalityC*. However, the financial net benefit of smoothing out the milk intake curve was relatively minor: *SeasonalityC* resulted in €2.5m less for Baseline and €3.8m less for Seasonal when compared to Smooth which registered a *Surplus* of €78.0m. In practice, switching to an even supply would involve milk price adjustments to incentivise non-seasonal production by which the reported benefits may quickly dissipate.

Regarding the *SeasonActivC*, *CollHandVC* were lower in Smooth compared to the seasonal situations as the fleet was used more efficiently off the peak periods, which is reflected in the lower raw milk collection and transport costs. Despite *ProcessVC* similar across the scenarios, underutilisation of processing capacities in the seasonal situations were apparent; this is explained by low milk supplies in the winter months. Total labour costs (*LabourVC*, *LabourFC*) were also comparable, whereas abundant milk supplies in the summer months required the processor to hire casual workforce (*LabourVC*). Extra stock holding costs (*StorageVC*, *StockFC*) were caused by the disparity between production (*Output*) and sales (*Sales*) levels in the peak season caused by larger output quantities to be put on stock (*Stock*). The stock holding costs accounted for the second largest item in the *SeasonalityC* calculation. Overall, however, the variation of the *SeasonActivC* across the scenarios was modest and the advantage of Smooth over the other scenarios (−€1.3m relative to Baseline; −€2.0m relative to Seasonal) is not likely to justify a massive restructuring of the entire industry. *SeasonMixC* emerged as the single largest seasonality-related cost. The *SeasonMixC* could be reduced by aiming at a product mix more similar to the Smooth scenario's production plan but this was not possible due to the seasonal distribution of raw milk intake. Implications of potential product mix and plant capacities changes are addressed below. Overall, whereas the *SeasonalityC* are small in a quota-constrained market, it should be noted that they may become a rather critical issue in a liberalised milk market which may give impetus for a strategy change towards a smoother milk intake curve.

Processing capacities and fixed costs

A processing business aligned to a smooth milk intake curve generally requires less processing capacity and

Table 6: Financial results summary

Results	Variable		Baseline	Smooth	Seasonal
Annual totals, €'000					
Sales revenue	*SalesRev*	Year	102,200	103,389	101,664
Variable costs – Output			−16,547	−15,937	−16,922
of which Processing	*ProcessVC*	Year	−15,872	−15,809	−16,025
of which Storage	*StorageVC*	Year	−264	−61	−367
of which Labour	*LabourVC*	Year	−411	−67	−530
Product gross margin	*Margin*	Year	85,653	87,452	84,742
Variable costs – Input					
Raw milk coll. and hand.	*CollHandVC*	Year	−2,664	−2,467	−2,741
Fixed costs	*FC*	Year	−7,541	−7,029	−7,791
of which Stock	*StockFC*	Year	−650	−138	−900
of which Labour	*LabourFC*	Year	−2,903	−2,903	−2,903
of which Overheads	*OverhFC*	Year	−3,988	−3,988	−3,988
Processor gross surplus	*Surplus*	Year	75,448	77,956	74,210
Marginal raw milk costs	*MPMP* × *Input*	Year	−66,118	−67,656	−63,852
Per unit, €c/kg raw milk					
Fixed costs	*FC*	Year	−2.75	−2.57	−2.85
Gross surplus	*Surplus*	Year, W.avg.[a]	27.56	28.48	27.11
Marginal producer milk price	*MPMP*[a]	Year, W.avg.[a]	24.15	24.71	23.33
Marginal producer milk price	*MPMP*[a]	Min-Max[a]	21.02–31.32	23.60–26.24	20.80–31.75
of which Volume charge	*VolCharge*	Year	−3.73	−3.47	−3.85
Per unit, €/kg milk solid					
Marginal milk solids values	*SolidsMV*				
Fat	*FATMV*	Min-Max[a]	2.85–2.99	2.84–3.02	2.86–2.99
Protein	*PROMV*	Min-Max[a]	4.21–5.72	4.47–5.08	4.24–5.73
Lactose	*LACMV*	Min-Max[a]	0.23–0.36	0.24–0.36	0.23–0.36

[a]W.avg. = weighted average, Min = minimum, Max = maximum; results rounded to nearest whole numbers.

Table 7: Seasonality costs

Annual results, €'000	Variable	Baseline[a]	Seasonal[b]
Activity costs	*SeasonActivC*	1,319	2,021
of which Raw milk collection and handling[a]	*CollHandVC*	197	274
of which Processing	*ProcessVC*	63	216
of which Stock holding	*StorageVC* + *StockFC*	715	1,068
of which Labour	*LabourVC* + *LabourFC*	344	463
Product mix costs	*SeasonMixC*	1,189	1,725
Seasonality costs, total	*SeasonalityC*	2,508	3,746

[a]Seasonality costs of Baseline = Baseline results – Smooth results
[b]Seasonality costs of Seasonal = Seasonal results – Smooth results

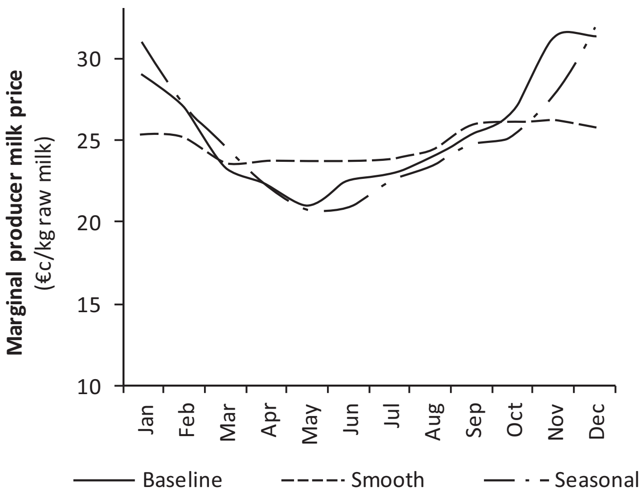

Figure 3: Effects of production seasonality on the marginal producer milk price

thus has lower overhead costs due to the absence of major milk production peaks. In the case of Smooth, dryer capacity could nearly be halved, butter (–40%) and cheddar cheese (–36%) capacities could also be reduced substantially. However, the Smooth scenario presented in this paper examined a plant which converted from operating in a seasonal milk market to a flat milk intake curve. Thus it was assumed that the business observed in Smooth had the same plant structure and fixed costs as Baseline. The fixed costs imposed on Smooth were seen as 'sunk costs' which means that the overheads incurred by the plant in Baseline were irreversible, so that no fixed costs savings were realised when switching to a flat intake curve.

Nonetheless, there is scope to improve processing capacity utilisation and financial performance when smoothing out the milk supply curve, i.e. when simultaneously increasing annual milk intake volume. Thus, additional raw milk is processed in what previously qualified as trough periods, and *FC* are spread over a larger milk pool which effectively decreases the *VolCharge* and increases the *MPMP* per kg of raw milk. The removal of the milk quota regime effective from 2015 could facilitate such a strategic new positioning: By 2020, Irish milk producers are expected to increase milk production between 30% (Keane, 2010) and 50% (DAFF, 2010a), provided economic and climatic circumstances are favourable. In this context, processors must decide whether to further support a seasonal milk production by building additional capacities for the peak period or whether present capacities could be used more efficiently by means of smoothing out the milk intake pattern.

A move to less seasonal milk production systems will involve higher costs for producers which must be set against the potential benefits that will accrue to processors. On the other hand, continuation of seasonal production coupled with expansion in milk output will necessitate additional investment in peak processing capacity, the cost of which will be passed back to producers through lower milk prices. This raises important questions about whether these costs will be shared by all milk producers or only by those who actually expand their peak season milk production. Further considerations about investment into processing equipment concern product mix decisions, e.g. if the portfolio were to be changed from focusing on milk powder output towards more profitable or value-added products. Smooth focused on manufacturing the more profitable products throughout the year and consequently differed from the seasonal scenarios with respect to the product portfolio. Smooth showed a far higher casein output (+33%) than Seasonal and little milk powder output. However, the market capacity for the products to be introduced may be limited. Similarly, where the markets for the presently produced goods are saturated, processors need to seek sales opportunities for additional output resulting from an increased raw milk volume in a liberalised market. Consequently, the marketability of the targeted products in existing geographical markets, the requirement for entering new markets, and the costs entailed by finding or creating additional demand would need to be taken into consideration when opting for product mix changes and output increases.

Milk solids marginal values and marginal producer milk price

Marginal values are affected by the production and marketing capacities relative to the availability of raw materials. In the case of a milk processing plant, it is optimal for the processor to first allocate its raw materials (i.e. milk solids) to the most profitable product until the capacity or market constraint for that product is reached. Milk solids are then allocated to the next most profitable product and so on until the milk supply is exhausted.

Consequently, in a month of high milk supply, capacities for the higher-margin products are exhausted and milk must be allocated to lower-margin products, thereby driving down the shadow price (marginal value) for extra units of purchased milk. However, if the processor has a small volume of milk supply relative to a large processing capacity for a high margin product, both *SolidsMV* and *MPMP* in that month will be high if the processor has scope to allocate additional milk to the high margin product. Thus in a market with seasonal milk supply, *SolidsMV* and *MPMP* are likely to be higher in trough months and lower in peak months of supply. This was evident in the model results where the monthly *MPMP* curve was more stable in the Smooth scenario than in Baseline or Seasonal. The weighted average annual *MPMP* per kg raw milk was highest in Smooth (€c24.71), followed by Baseline (€c24.15) and it was lowest in Seasonal (€c23.38). These differences reflect the fact that in the Baseline and Seasonal scenarios a greater proportion of raw milk was processed into lower margin milk powders (SMP, WMP) and it was these commodities that effectively set the marginal milk price in peak months of raw milk supply. *MPMP* was further supressed in the Baseline and Seasonal scenarios due to seasonality elevating key processing costs in areas such as product storage, especially interest on working capital, and labour utilisation.

Nevertheless the model results suggest that the benefits to Irish producers in terms of higher *MPMP* per kg of raw milk from switching to a smoother production profile are relatively modest (€c0.56 relative to Baseline; €c1.33 relative to Seasonal). This is especially relevant since the potential producer price enhancement must be weighed against the extra production costs, higher feed costs in particular (Dillon et al., 2008), of non-seasonal dairy systems.

6. Conclusions

This paper examined a plant operating three differing intake patterns in a milk-quota constrained environment. However, Irish milk producers are expected to significantly increase supply post milk quota abolition in 2015, which in turn requires a strategy for processors dealing with this larger milk pool in a liberalised market. This strategy could encourage, for instance, a smoother milk supply curve or an altered structure of the processing sector. In this context, future research could address the key questions of (a) whether the plant capacities available at present suffice to cover the extra raw milk volume provided the national milk supply curve is flattened or (b) whether substantial investment should be made so as to be able to maintain the traditional pasture-based dairy production which is seasonal in nature. Alternatively, new markets could be targeted which would entail considerable expenses for establishing logistics, business relations, a marketing strategy etc. Operating a seasonal dairy industry is a strategic choice which implies servicing different market segments (i.e. commodities) and being exposed to other risks (i.e. price fluctuations on international markets).

In a quota-constrained environment, the model results suggest that efforts to aggressively reduce seasonality are unlikely to significantly enhance the profitability of the Irish dairy industry. Specifically, the financial gains to the processor from pursuing non-seasonal production appear to be relatively modest since the capacities required for current production peaks are in place. Capacity-related sunk costs such as depreciation cannot be reduced through smoothing production. Moreover, the farm-level production costs (esp. concentrate feed) of switching to year-round dairying are likely to be substantial necessitating considerable milk price premiums to encourage greater off-peak production (Davis and Kirk, 1985).

An important caveat is that the above conclusions are based on the current quota constrained environment and with the proposed removal of milk quotas the optimum strategy for processors may change. The industry will need to decide if it is better to incur investment costs for additional peak processing capacity or to incentivise less seasonal production to handle extra supplies through better year-round utilisation of existing plant. This is a crucial strategic decision for Irish milk processors which is being analysed in an extension of the present study.

It has been demonstrated in this paper that the multi-period optimisation model as discussed above proves to be a useful tool for analysing the effects of seasonal milk production at processor level especially with respect to financial performance, product mix, capacity utilisation and operational aspects of seasonality, such as product storage and labour utilisation. It is proposed that a natural extension to the work reported in this paper would be an integrated producer-processor model providing a more holistic industry-level perspective. An integrated approach would allow for a more detailed examination of potential strategies to dampen production seasonality such as seasonal supply contracts and milk pricing incentives. Such an approach would necessarily estimate the likely trade-offs between farm-level production costs versus processor benefits arising from improved market returns and reduced seasonality costs. The objective should be to identify strategies that sustainably enhance the financial performance of the dairy industry as a whole.

About the authors

Karin E. Heinschink (karin.heinschink@gmail.com) studied International Business Administration at the Vienna University of Economics and Business Administration in Austria. Her master's thesis examined "The production of cattle and cattle meat in Austria and the USA" (2008). Today she works as a PhD student at University College Dublin, Ireland under the supervision of Dr. Michael T. Wallace in the field of Agricultural Economics. Her principal research interests include the production and processing of livestock and its products as well as mathematical modelling.

Dr. Laurence Shalloo is a senior research officer at the Animal & Grassland Research and Innovation Centre, Teagasc, Moorepark, Fermoy, Co. Cork, Ireland. His research interests include farm systems and milk processing sector modelling.

Dr Michael T. Wallace is a lecturer in agricultural economics at University College Dublin. He completed his PhD at Queen's University of Belfast on the use of multiple criteria decision making models in agricultural management. He currently teaches in the areas of farm business management, production economics, and business modelling. His principal research interests are in the application of mathematical modelling techniques to the study of agricultural systems and business decision making.

Acknowledgements

The authors gratefully acknowledge financial support of the Department of Agriculture, Fisheries and Food through the Research Stimulus Fund. They would also like to thank the two anonymous reviewers for their helpful comments.

REFERENCES

Bangstra, B. A., Berger, P. J., Freeman, A. E., Deiter, R. E. and La Grange, W. S. 1988. Economic value of milk components for fluid milk, cheese, butter, and nonfat dry milk and responses to selection. *Journal of Dairy Science,* 71, 1789–1798.

Breen, J. 2001. *A new direction for the payment of milk: Technological and seasonality considerations in multiple component milk pricing of milk (liquid and manufacturing) for a diversifying dairy industry*. M.Agr.Sc., University College Dublin.

Breen, J., Wallace, M., Crosse, S. and O'Callaghan, D. 2003. *A new direction for the payment of milk: Technological and seasonality considerations in multiple component milk pricing of milk (liquid and manufacturing) for a diversifying dairy industry. End of project report*. Dublin/Fermoy, Ireland: University College Dublin, Teagasc Dairy Products Research Centre Moorepark.

Burke, J. A. 2006. Two Mathematical programming models of cheese manufacture. *Journal of Dairy Science,* 89, 799–809.

CSO 2011. Main Data Dissemination Service. Central Statistics Office Ireland, Dublin, Ireland.

Daff. 2009. *Fact sheet on Irish agriculture – December 2009* [Online]. Dublin, Ireland: Department of Agriculture, Fisheries and Food. Available: http://www.agriculture.gov.ie/media/migration/publications/2009/Fact%20Sheet%20on%20Irish%20Agriculture%20Dec%202009.pdf [Accessed March 10, 2010].

Daff 2010a. Food harvest 2020. A vision for Irish agro-food and fisheries. Dublin, Ireland.

Daff 2010b. Milk and dairy establishments approved under the hygiene regulations, quarterly verification. Dublin, Ireland: Department of Agriculture, Fisheries and Food.

Dillon, P., Hennessy, T., Shalloo, L., Thorne, F. and Horan, B. 2008. Future outlook for the Irish dairy industry: A study of international competitiveness, influence of international trade reform and requirement for change. *International Journal of Dairy Technology,* 61, 16–29.

Downey, L. and Doyle, P. T. 2007. Cow nutrition and dairy product manufacture – Implications of seasonal pasture-based milk production systems. *Australian Journal of Dairy Technology,* 62, 3–11.

EC 2010a. EU market prices for representative products (monthly), PRODCOM.: European Commission.

EC 2010b. Statistics on the production of manufactured goods (annual 2009), Eurostat. European Commission.

FAO 2010. Greenhouse gas emissions from the dairy sector. A life cycle assessment. Rome, Italy: FAO Animal Production and Health Division.

Fox, P. F. and Mcsweeney, P. 1998. *Dairy Chemistry and Biochemistry,* London, UK, Blackie Academic and Professional.

Guinee, T. P., O'Brien, B. and Mulholland, E. O. 2007. The suitability of milk from a spring-calved dairy herd during the transition from normal to very late lactation for the manufacture of low-moisture Mozzarella cheese. *International Dairy Journal,* 17, 133–142.

Harte, L. and O'Connell, J. J. 2007. European dairy cooperative strategies: Horizontal integration versus diversity. *In:* Karantininis, K. and Nilsson, J. (eds.) *Vertical markets and cooperative hierarchies. The role of cooperatives in the agri-food industry*. Dordrecht, Netherlands: Springer.

Hennessy, D. A. and Roosen, J. 2003. A cost-based model of seasonal production with application to milk policy. *Journal of Agricultural Economics,* 54, 285–312.

IDB 2010. Annual report 2009. Dublin, Ireland: Irish Dairy Board.

Keane, M. 2010. Potential investment costs in milk processing and transport to 2020. Report for ICMSA. *Report for ICMSA*. Farran, Ireland: MJKeane Agribusiness Services.

Keane, M. and Killen, L. 1980. Seasonality and the Irish dairy industry. *Irish Journal of Agricultural Economics and Rural Sociology,* 8, 1–26.

Killen, L. and Keane, M. 1978. A linear programming model of seasonality in milk production. *The Journal of the Operational Research Society,* 29, 625–631.

McCance and Widdowson 2002. The composition of foods integrated dataset (CoF IDS). Food Standards Agency, London, UK.

National Milk Agency 2010. Annual report and accounts 2009. Dublin, Ireland: National Milk Agency.

Oireachtas 1997. Organisation of working time act. *20/1997*. Dublin, Ireland: Office of the Attorney General.

Olori, V. E., Brotherstone, S., Hill, W. G. and Mcguirk, B. J. 1999. Fit of standard models of the lactation curve to weekly records of milk production of cows in a single herd. *Livestock Production Science,* 58, 55–63.

Papadatos, A., Berger, A. M., Pratt, J. E. and Barbano, D. M. 2002. A nonlinear programming optimization model to maximize net revenue in cheese manufacture. *Journal of Dairy Science,* 85, 2768–2785.

Phelan, J. A., O'Keeffe, A. M., Keogh, K. and Kelly, P. 1982. Studies of milk composition and its relationship to some processing criteria: IV. Factors influencing the renneting properties of a seasonal milk supply. *Irish Journal of Food Science and Technology,* 6, 39–47.

Productschap Zuivel 2010. Market prices by country – 2008, 2009, 2010. Zoetermeer, Netherlands: Productschap Zuivel (Dutch Dairy Board)

Prospectus 2003. Strategic development plan for the Irish dairy processing sector. Department of Agriculture and Food, Enterprise Ireland, Irish Co-operative Organisation Society, Irish Dairy Industries Association of IBEC.

Quinlan, C., Keane, M., O'Connor, D. and Shalloo, L. 2011. Milk transport costs under differing seasonality assumptions for the Irish Dairy Industry. *International Journal of Dairy Technology,* 64, 22–31.

Southward, C. R. 1998. Casein products. *Chemical processes in New Zealand.* 2nd ed. Christchurch, New Zealand: Consumer and Applications Science Section, New Zealand Dairy Research Institute.

Teagasc 2009. Irish dairying: New thinking for challenging times. *In:* Buckley, F. (ed.). Fermoy, Co. Cork, Ireland: Moorepark Dairy Production Research Centre, Teagasc.

Young, P. 2009. Supplying liquid milk locally. *Irish Farmers Journal*, October 24.

Can rent adjustment clauses reduce the income risk of farms?

HENNING HOTOPP[1] and OLIVER MUßHOFF[1]

ABSTRACT

Risk management is gaining importance in agriculture. In addition to traditional instruments, new risk management instruments are increasingly being proposed. These proposals include the rent adjustment clauses (RACs), which seem to be an unusual instrument at first sight. In contrast with conventional instruments, RACs intentionally allow fixed-cost 'rent payments' to fluctuate. We investigate the whole-farm risk reduction potential of different types of RACs via a historical simulation. The change in standard deviation and the value at risk (VaR) of the total gross margin (TGM) measure risk reduction potential. Our results revealed that RACs contribute to farm risk management. However, the trade-off between moral hazard and basis risk must be considered. Our proposal of weather index-based RAC seems to be a 'good compromise': the problem of moral hazard is completely eliminated by objectively measuring weather data. At the same time, the risk reduction potential of precipitation-based clauses, for example, is comparatively high.

KEYWORDS: Risk management; rent adjustment clause; moral hazard; basis risk; weather index; value at risk

1. Introduction

Farms must face various types of risk. Agricultural enterprise risks are expected to continue to increase due to the elimination of subsidies, the liberalisation of the European market (Serra et al., 2006) and global climate change (Olesen and Bindi, 2002). Moreover, the proportion of external production factors in general and rented land in particular has recently increased in agricultural enterprises creating financial risk. For example, only 54% of the total agricultural area in Germany was rented in 1991; this proportion rose to 62% in 2007. In some parts of Eastern Germany, the rent share was approximately 80% in 2007 (Federal Statistical Office of Germany, 2011). Given these increasing risks, the relevance of risk management has increased.

In recent years, so-called rent adjustment clauses (RACs) have been proposed as an interesting alternative risk management instrument (Langemeier, 1997; Fukunaga and Huffman, 2009; Breustedt et al., 2010). At first glance, RAC are unusual risk management instruments. They adjust the cost factor 'rent' based on the economic situation of the farm. In contrast with traditional risk management instruments, a usually fixed cost factor is intentionally brought to vary. In this context, the crucial question is how these fluctuations affect the distribution of farm income.

On the one hand, there is empirical evidence that there is a very pronounced potential for RAC acceptance among farmers (Breustedt et al., 2010; Plumeyer et al., 2010). On the other hand, RACs are not common practice in many nations (e.g., in Germany). This contradiction may be due to farmers still not being familiar with these clauses. Furthermore, it is still unknown whether and to what extent RACs reduce the income risk of farms. Various types of RACs have been discussed in the literature that couple rent payments with the development of national price indices or operationally realised income, prices, or both. The choice of indicators underlying an RAC determines its risk-reducing effect. Thus far, studies have focused on the change in the expected rent payment for using various clauses (Plumeyer et al., 2010). Breustedt et al. (2010) investigate the change in the distribution of rent-adjusted revenue for using clauses based on different farm-specific price data. To the best of our knowledge, investigations that determine the risk reduction potential of RACs that account for cost risk have not been conducted. Therefore, the suggested risk reduction potential of RACs may be too low to cover all the costs associated with it. Moreover, there has been no systematic comparison of the risk reduction potential of different RACs.

This paper aims to determine how different RACs reduce the income risk of farms. Furthermore, we propose and examine an RAC based on the objectively and easily measurable weather indices that weather index insurances, which has been intensively discussed in recent years, are based on (Turvey, 2005; Chen et al., 2006; Berg and Schmitz, 2008; Norton et al., 2010). The calculations are conducted using a historical simulation of an exemplary German farm. To our knowledge, we are the first who quantify the overall operational risk reduction potential of different types of RACs in general and an RAC based on a weather index in

[1] Department of Agricultural Economics and Rural Development, Farm Management Group, Georg-August-University Goettingen, Platz der Goettinger Sieben 5, 37075 Goettingen, Germany. Email: henning.hotopp@agr.uni-goettingen.de

particular. The results allow us to conclude as to whether a risk-reducing effect explains the low acceptance of RACs. We do not investigate whether landowners and farmers will accept RACs.

2. Rent adjustment clauses (RACs)

Systematisation of RACs

There are two major types of compensation for rented land: natural and monetary rent payments. Today, the fixed-rent payment is the most common type of monetary rent payment in Germany and in many other countries (Otsuka et al., 1992; Barry et al., 2000; Fukunaga and Huffman, 2009). 'Fixed rent' denotes that a fixed payment must be made to the landowner independent of the farm's performance. However, crop-yield-dependent rent payment systems are still widespread in many developing countries, such as Ethiopia and Madagascar (Kassie and Holden, 2007; Bellemare, 2009). Moreover, this method of payment still plays an important role in the agricultural sector of the USA (Allen and Lueck, 1999).

The RAC recently discussed therefore are not based on a completely 'new' idea. With an RAC, the annual rent payment is contractually linked to the development of a particular indicator. The contracting parties can freely decide on these indicators and the design of the contract. Some types of RACs that use on-farm indicators are similar to sharecropping contracts in the USA (Langemeier, 1996) and contract farming in the UK (Stockdale et al., 1996). Figure 1 classifies various types of RACs.

In principle, RACs can be divided into two groups of clauses: performance and sliding. Performance clauses allow the landowner and the farmer to renegotiate the rent when a measurable event (e.g., under- or above-average yields in crop production) occurs before the end of the regular lifetime of the contract. The possible rent adjustment, upon which the landowner and farmer agree, must be communicated to the respective parties. In addition, new negotiations must be scheduled and conducted. Therefore, this type of RAC is relatively expensive. In addition to renegotiations, the relationship between landowners and farmers can be negatively influenced. Accordingly, the practical applications of performance clauses appear to be limited.

Sliding clauses do not necessitate renegotiations after the conclusion of the contract; rather, the rent payment is adjusted automatically depending on the performance of a predetermined indicator (Langemeier, 1997; Plumeyer et al., 2010). The indicator upon which the sliding clause is based is measured either externally or internally (Langemeier, 1996; Breustedt et al., 2010). For example, the external group includes the 'price index clause' in which the rent adjustment is based on national and objectively measured price indices. The internal group includes a clause in which the rent adjustment depends upon the on-farm revenue generated from crop production.

One can expect that the clauses based on external indicators have smaller risk-reducing effects than clauses based on internal indicators. The indices applied in the price index clause aggregate data at a national or regional level and the overall success of an individual farm makes only a small impact. In addition, price indices are only available with a certain time delay; therefore, the rent may be based on data from a previous period. Thus, situations emerge in which rent payments increase due to developments in aggregated product price indices, although the success of single farm may have deteriorated. The remaining risk for the farmer that an RAC cannot eliminate is referred to as 'basis risk'. On the cost side, the RACs based on external indicators have a relative advantage over internal indicators.

The price index clause only determines small costs for information and control because the Federal Statistical Office transparently and objectively set external price indices. Furthermore, in most cases, these indices are freely available. However, the risk of rent adjustment operator manipulation emerges in clauses based on internal indicators. The key term here is 'moral hazard' (Ghatak and Pandey, 2000; Allen and Lueck, 1999). Moral hazard describes a situation in which the landowner cannot be sure that the farmer has not manipulated the rent-adjustment-relevant indicator.

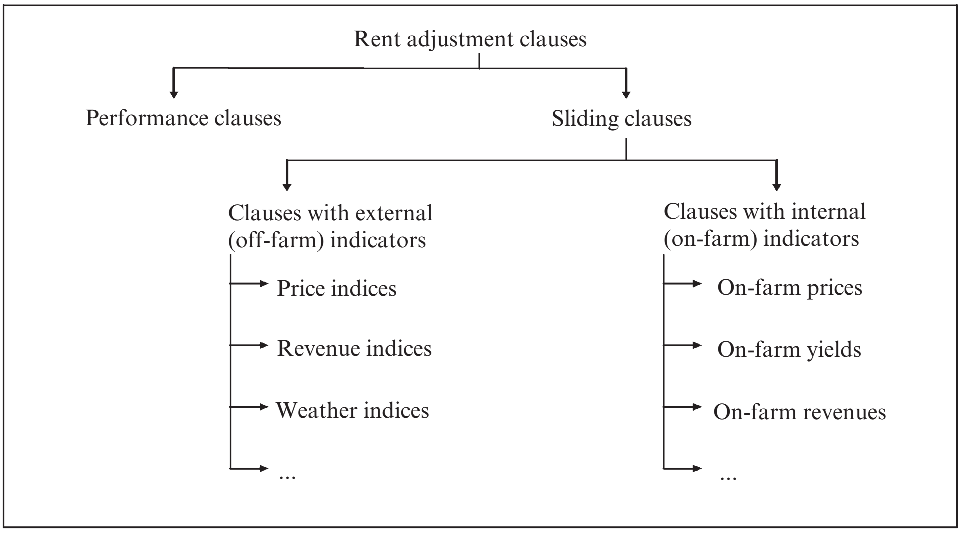

Figure 1: Classification of RACs

Instead, the landowner must either trust that the farmer has not manipulated the indicator values used for the RAC (Allen and Lueck, 1999) or he or she must conduct a high control effort. The costs of moral hazard include increased monitoring costs for the landowner and the farmer's unavoidable self-serving manipulation of his or her success.

A promising alternative to the aforementioned RAC is the use of a weather index as an external indicator for an RAC. For example, weather indices are used to underlie so-called weather derivatives (Turvey, 2005; Musshoff et al., 2011). In this situation, the total precipitation of the main growing season measured at an official weather station affects rent adjustment. When comparing the weather index clause with the previously discussed RAC, the following picture emerges. First, a weather index clause is advantageous because there is no risk of tampering with data (in contrast to internal indicators). Second, the required weather data can be obtained without a time delay, especially compared with the price index clause. Third, the risk reduction potential should be higher than the price index clause because the national indices are 'further away' from single-farm success than weather events such as rainfall. In summary, the cost of a weather index clause should be lower than that of clauses with internal indicators. The expected risk reduction potential, however, is higher in weather index clauses compared with clauses including external indicators (e.g., a price index clause).

The basis risk is the residual risk that remains with the farmer when an RAC is used. Three different sources can be distinguished from each other:

- The geographical basis risk arises when there is a geographical difference between the location at which the externally measured value and the corresponding indicator value on the farm are measured. This risk results in an imperfect correlation (Vedenov and Barnett, 2004; Xu et al., 2008). With regard to weather index clauses, an imperfect correlation means that weather patterns can vary between the reference weather station and the location of agricultural production. In terms of the revenue index clause, the rent adjustment will be determined based on average prices and the returns of several farms in a region. Depending on the size of the reference region, the economic success of an individual farm may differ greatly from the average success of the other farms in the region.
- The basis risk of production emerges when one indicator measured at the place of production is not perfectly correlated with the overall success of the farm (Musshoff et al., 2011). For example, wheat revenue may represent the economic success of a farm depending on the actual production of wheat and the correlation of the individual gross margins of different production methods.
- Another basis risk arises when the indicators of a previous period are used to determine rent adjustment due to a lag in data availability. Therefore, the RAC may be based on external revenues that require the actual production period data that is not available at the time of the rent payment determination. If the yield data of a previous period has a lower correlation to the current farm success than to that of the current production season, then a loss in the risk reduction potential may emerge.

The implementation of an RAC comes with a trade-off between risk reduction potential, on one hand, and moral hazard as well as information and monitoring costs, on the other.

Description of the analysed RAC

No rent adjustment (fixed rent)

A fixed rent does not require a rent adjustment. A payment at time t (R_t) is defined in the rent contract as the basic rent (R_B) and remains constant over time:

$$R_t = R_B \tag{1}$$

The fixed rent is generally widespread and occurs in Germany in particular because the rent payment is easy to administer and communicate (Stockdale et al., 1996; Sanjuán et al., 2009; Plumeyer et al., 2010).

RAC based on revenues

A rent adjustment in the amount of the percentage of change in the observed value of a revenue index (RI_t) compared with the base value of the revenue index (RI_B) is made for the RACs based on revenues. The observed revenue index value is the product of current crop prices (p_t) and yields (y_t) and moreover is derived from a contractually agreed base crop price (p_B) and a base yield (y_B), which may correspond with the long-term average values (Langemeier, 1996; 1997). The annual rent is calculated as follows:

$$R_t = R_B \cdot \frac{RI_t}{RI_B} = R_B \cdot \frac{(p_t \cdot y_t)}{(p_B \cdot y_B)} \tag{2}$$

Many design variants are conceivable for revenue-based rent adjustment. In addition to the choice of the revenue index base value, the following fundamental questions must be answered:

- Should the revenue relate to a particular crop or a mix of crops?
- Should the database be measured internally or externally?
- If the internally measured revenues are relevant, then should the RAC include a deductible?
- If the externally measured revenues are relevant, then which data aggregation level should be used?

To achieve the highest possible risk reduction, first it is reasonable to weight the revenue of each production process with its respective share in the production program. However, individual components of the production program may change over time. Such an RAC would involve a corresponding adjustment effort and could possibly be more difficult to communicate to (non-agricultural) landowners. Therefore, implementing an RAC that is based purely on the revenue of a dominant reference crop would be easier than using a RAC based on a crop mix.

The use of internally measured revenues is connected with the problem of moral hazard, which can be counteracted in two ways: by implementing a deductible or with externally measured revenues. A deductible means that a margin is set within which the indicator value may fluctuate without a rent adjustment. Because the portion of risk that is passed on to landowners decreases, incentives exist such that the farmer must seek to maintain a successful farm despite the RAC. Moral hazard can be completely avoided with external revenues. The risk reduction potential of the RAC is expected to decrease as the aggregation level increases. Note that the receipt of external relevant data can be delayed.

Thus far, we have focused on RACs based on revenues. Note that rent adjustments can be coupled with the development of a more disaggregated variable such as prices or yields (Langemeier, 1997). This coupling makes a clause easier to communicate and reduces the problem of delayed data availability. At the same time, however, the risk reduction potential is negatively affected (Langemeier, 1996).

Price index clauses

The price index clause uses national indices to derive rent adjustments. In this case, the determination of the RAC is based on three external indices (Plumeyer et al., 2010) published by the Federal Statistical Office of Germany. These include a Consumer Price Index (CPI), a Producer Price Index (PPI) and an Input Price Index (IPI). The percentage change in the indices with respect to the previous year (ΔCPI_t; ΔPPI_t; ΔIPI_t) is required to determine the rent adjustment. The annual rent is calculated as follows:

$$R_t = R_B \cdot \left(1 + \frac{\Delta CPI_t + \Delta PPI_t - 0{,}5 \cdot \Delta IPI_t}{2}\right) \tag{3}$$

It is necessary to individually clarify to which index one refers. For example, it is possible to revert to the national producer price index for industrial products but the national producer price index for agricultural products (which is specific to agriculture). Moreover, it would be conceivable to use regional-specific indices rather than national-specific ones (Plumeyer et al., 2010). When using price indices, the problem of delayed data availability is particularly relevant.

Weather index clauses

In a weather index clause, the rent is linked to one or more weather variables. The rent adjustment is calculated as the percentage deviation of the measured weather index (WI_t) in the respective production season from the contractual base weather index (WI_B). The annual rent payment is calculated as follows:

$$R_t = R_B \cdot \frac{WI_t}{WI_B} \tag{4}$$

There are various design options for weather index clauses. In addition to the choice of the base weather index, the following fundamental questions must be answered:

- Which weather variable is the base of the rent adjustment?
- Which weather station is the reference weather station?

The average temperature, precipitation, or both during a specific period of time is a plausible choice for a weather variable. A composite index derived from various weather variables can account for the small amounts of precipitation that lead to higher yield losses at high temperatures compared with low temperatures. Therefore, a composite index is expected to have a greater risk reduction potential than a weather index that only refers to the total precipitation of the main growing season. At the same time, a composite index is more difficult to communicate to contract partners because its calculation is more complex (Turvey, 2005). For this reason, it is reasonable to remain with a single index.

Initially, the farm's weather station, which is in close proximity to its agricultural land, is an interesting choice for a reference weather station. The weather data measured from the land should correlate with the success of the farm better than the weather stations that collect data from a distance. However, moral hazard accompanies the use of internally measured weather data. This problem can be avoided by using externally and objectively measured weather data from commercial weather stations.

3. Database and methodological approach

Gross margin time series for the sample farm

We investigated the risk-reducing effect of various RACs for an exemplary arable farm using the research farm at the University of Goettingen. The research farm is interesting for several reasons. First, the percentage of the rented area that comprises the arable land is relatively high (98%); thus, financial risk is particularly relevant. Second, it is a purely arable farm; therefore, its success is entirely dependent on fluctuations in cash crop production because land-based production is its only source of income. Other farming systems (e.g., animal husbandry or pasture farming) generate additional income that is not directly associated with land management. These systems might create a 'natural hedge' through the diversification of production that would reduce the risk of the farm. In addition, the relevant data is well documented. The farm has 420 hectares (ha) of arable land with an average of 69 soil quality points[2]. The soil types range from chalk to clayey loams. The farm's primary crops are winter wheat, winter barley, winter canola and sugar beet. On average, they are grown on 55%, 15%, 10% and 20%, respectively, of the arable area. Our analysis does not consider crops grown on an area of less than 5 ha and those grown on experimental areas. The long-term average annual rent paid is $351[3] per ha. The rent payments account for approximately 20% of the total operating costs.

The total gross margin (TGM) is the relevant business performance indicator whose volatility is reduced. No differences arise with respect to the risk reduction potential of the RAC when we use a profit or cash flow instead of the TGM because the difference is located

[2] According to the relative German soil quality classification scheme, which ranges from zero to 100 points.

[3] At the time of writing (late 2011) €1 was approximately equivalent to £0.88 (pound sterling) and US$1.40 (European Central Bank).

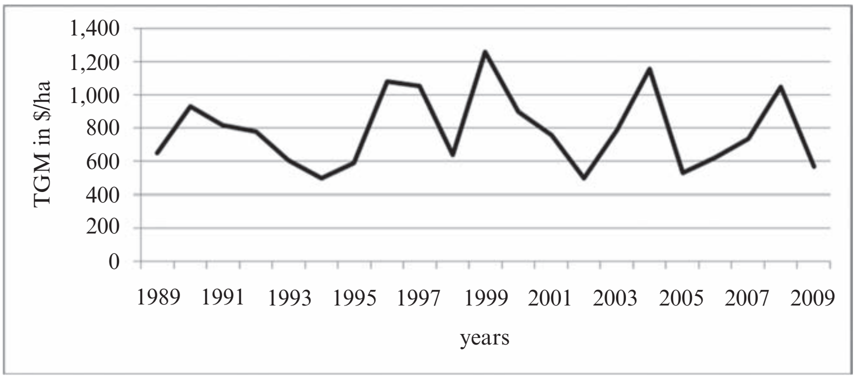

Figure 2: Time series of the TGM

only in constant fixed-costs or constant depreciation. Therefore, we determine a TGM time series for the sample farm (see Figure 2). The market prices and physical yield of the main crops were obtained from the appendix of the balance sheet from 1989 to 2009. Because research projects might distort the cost sections of these balance sheets, we used the variable costs that are published in the annual benchmark gross margins (Chamber of Agriculture, Lower Saxony (FID), different volumes) by the Agricultural Chamber of Lower Saxony, the federal state where the farm is located. The costs include expenses for fertiliser, pesticides, and machinery costs; rent costs are not included. The mean annual TGM before considering the rent payments was approximately $427,214 or $1,017 per ha. With regard to Figure 2, it becomes clear that TGM is subject to significant fluctuations over time.

The time series of the TGM without rent payment has a minimum of $570 per ha and a maximum of $1,490 per ha.

Relevant data for implementing an RAC

This section focuses on the data necessary to determine the risk-reducing effect of the following types of RACs:

The fixed-rent payment provides a reference. In the following section, we describe the data used to calculate RACs. The data were collected for a period corresponding with the considered gross margins.

Internal price and yield time series

For the RAC based on product prices and crop yields (see Equation 2), each of the grown cultures can be considered as base. We linked the rent adjustment to the prices and yields of winter wheat because it was grown in each of the past years and has the largest share of cultivated cropland on the research farm (on average 55%). Furthermore, winter wheat is very common in many parts of Germany. In 2010, approximately 28% of German agricultural land was used for its cultivation (Federal Statistical Office of Germany, 2011). The long-term average sales price of wheat was $20.88 per decitonne (dt), which formed the base crop price (p_B). The base yield (y_B) was the long-term average yield of wheat, which was 80.3 dt/ha.

External price and yield time series

Externally measured product prices and yields are needed for RACs based on external revenues. As in the case of the RAC with internal data, we used wheat prices and yields because of the aforementioned advantages and the easy access to the necessary long-term off-farm product prices and yield data.

To show the effects of the geographical basis risk associated with the revenue index clause, the required off-farm data was analysed using two aggregation levels. State-level data (Food and Agriculture Organization of the United Nations (FAOSTAT), 2011; Federal Statistical Office of Germany, 2011) as well as the federal state level data of Lower Saxony are used (FID, different volumes; Lower Saxony Statistical and Communication Technology Centre (LSKN), 2011). An additional reduction of the data aggregation level is not practical for several reasons. First, such data is not often published on the community level. Second, arrangements between farmers can occur on community level. Therefore, moral hazard cannot be excluded. In contrast, the data on the state and federal state levels are not related to moral hazard and are often accessible free of charge. However, they are only available after a time delay.

We considered two situations with regard to this time delay. First, if there is no time lag, then the rent adjustment is based on the price and yield data of the same year. Second, the price and yield data of the previous year must be used. Therefore, we revert to the external price and yield data of 1988 to 2009.

Price index time series

In accordance with Plumeyer et al. (2010), we chose the time series for three indices calculated by the German Federal Statistical Office (see Equation 3) to determine the risk-reducing effect of the price index clause. Specifically, we chose the following indices:

- The consumer price index for Germany (CPI);
- The index of producer prices for vegetable agricultural products (PPI);
- The index of purchase prices for agricultural inputs (IPI).

The CPI measures the trends of prices for German goods and services annually (Federal Statistical Office of Germany, 2011). The CPI should account for the landowner's perspective. Not all goods and services in this price index are directly related to agriculture (e.g., the cost of movie tickets). The PPI describes the development of the prices of vegetable products (Federal Statistical Office of Germany, 2011). In addition, we used the IPI index to indicate the development of the purchase prices of agricultural inputs such as fuel or fertiliser (Federal Statistical Office of Germany, 2011). The PPI and IPI should display the farmer's situation.

Weather time series

Weather data was required to determine the hedging effectiveness associated with weather-related index RACs (see Equation 4). At a weather station in Goettingen, 5 km away from the farm, average daily temperature and daily precipitation were measured. Data are available for the period from 1988 to 2009 (Institute of Soil Science, 2011). Average temperatures were calculated monthly, whereas rainfall sums were calculated for periods of one and two months (Itoh et al., 2009). Subsequently, we examined whether the weather variables are strongly correlated with the operational TGM.

The highest correlations between TGM and single-month precipitation were 0.30 for the 'February of the harvest year' and 0.28 for the 'October of the sowing year'. The two-month total precipitation of these months combined has the strongest positive correlation with the TGM (0.36). This strong correlation is because the arable land has soil with a high capacity for holding water. Thus, the rainfall in the aforementioned months is needed for soil 'water storage' and replenishes the plants in the spring. Only March had a monthly average temperature that was positively correlated with the TGM (0.26). This finding may be because the early warming of the soil extends the growing season and positively affects plant growth.

We compared the single-month precipitation of October and February with their sum to examine the basis risk of production. Furthermore, we used the average temperature of March as a weather index clause indicator.

We examined data from different weather stations to investigate the geographical basis risk. In addition to data from Goettingen, we used data from weather stations in Hanover and Magdeburg (German Meteorological Service (DWD), 2011) that are located 104 linear km and 135 linear km away, respectively. The correlation between the TGM and the rainfall in October and February was 0.22 for the weather station in Hanover and 0.17 for the weather station in Magdeburg.

Historical simulation

A historical simulation was performed to determine the risk reduction potential of the RAC in the sample farm (Dowd, 2002; Turvey, 2005). This simulation is a numerical, non-parametric method that uses historical data rather than estimated distributions. We sought to determine the values that target variable would have had in the past based on a particular decision (e.g., implementation vs. non-implementation of an RAC). The two crucial questions were

- How high was the risk of the TGM from 1989 to 2009, during which a fixed rent was paid?
- How high would the risk of the TGM have been if the farm had used an RAC?

The variation in the TGM risk triggered by the RAC is the risk reduction potential. The historical simulation included the following procedural steps:

1) The starting point was the TGM time series before rent payments, from 1989 to 2009 (see Figure 2). The historical simulation results are distorted when the stochastic variables include trends (Goodwin and Ker, 1998). A linear regression with a constant shows that the historical TGM had a significant trend (coefficient of time variable = 16.43, p-value = 0.0131, R^2 = 0.28). Therefore, we conducted a trend adjustment to the year 2009. The average trend-adjusted TGM before the consideration of rent payments was approximately $330,120 for the farm or $786 per ha.
2) The TGM time series after rent was determined by accounting for the trend-adjusted TGM time series using a fixed-rent payment of $351 per ha. The average trend-adjusted TGM after accounting for the fixed rent was approximately $182,700 or $435 per ha.
3) Statistical parameters were calculated that allowed us to quantify the TGM risk associated with the payment of a fixed rent.
4) To determine the risk-reducing effect of a RAC, the amount of rent payment from 1989 to 2009 was calculated under consideration of the development of the indicator of the relevant clause.
5) The TGM time series after rent payment was determined by accounting for the trend-adjusted TGM time series (see Step 1) and the rent according to the RAC (see Step 4).
6) Statistical parameters were calculated that allowed us to quantify the TGM risk associated with the rent payment derived by an RAC.
7) The comparison of statistical parameters calculated in Step 6 (with an RAC) and Step 3 (with fixed rent) allowed us to examine the risk-reducing effect of an RAC.

Furthermore, the following must be considered: We assumed that the percentage of rented land is 100% (not 98% as in the case of the real farm). Because we are solely concerned about analysing the risk-reducing effect of the RAC, we took a suitable precaution with our calculations such that the average annual rent payment was equal for all RAC. Therefore, we assumed that the implementation of an RAC does not cause an additional cost for the farmer (e.g., setup costs for contracts) or the landowner (e.g., cost control). Furthermore, we assumed that landowners are risk-neutral and that they would not demand a risk premium for receiving time varying rent payments rather than fixed ones. Any tax implication resulting from the introduction of the RAC, such as the potential impact on the marginal tax rate or the co-entrepreneurship of the landowner, was ignored.

Risk measures

Various risk measures were used to calculate the whole-farm risk reduction potential of the RAC. We determined the percentage of change in the standard deviation of the TGM time series caused by the RAC. The assumption of a normally distributed TGM cannot be rejected based on the Anderson-Darling or the Kolmogorov-Smirnov test. However, there are parametric distributions (e.g., the Weibull distribution) that describe our empirical TGM data distribution better than the normal distribution.

Because the standard deviation is of limited use for asymmetrical distributions (see Dowd, 2002), we calculated the percentage of change in the value at risk (VaR) compared with the reference scenario 'fixed-rent payment' to describe the risk reduction potential of the RAC. The VaR describes the loss of a particular risk position not exceeded by a given probability (confidence level) and within a given time horizon (Jorion, 2002). Although the VaR is often applied in the financial sector (see Jorion, 2002), it is increasingly used to measure agricultural risk (Odening and Hinrichs, 2003; Chen et al., 2006, Berg and Schmitz, 2008). Our calculations focused on the 90% confidence level (i.e., the expected loss at a maximum probability level of 90%). A VaR with a higher confidence level was less meaningful because we had annual data only and, therefore, a limited number of observations. We denote the VaR with 90% confidence level '90%-VaR'. The standard deviation provides information regarding the 'general variations' of the TGM. The VaR provides information regarding the left tail of the distribution.

Furthermore, we indicated the probabilities by which a TGM of less than \$295 per ha (approximately 50% of the expected TGM) and TGM of less than \$224 per ha (approximately 33% of the expected TGM) was achieved.

4. Results

Table 1 shows the risk reduction potential of various RACs compared with a fixed rent payment.

Line 1 refers to the reference scenario 'fixed-rent payment'. An average TGM of \$435 per ha has a standard deviation of \$227 per ha. The 90%-VaR of \$254 per ha denotes that there is a 90% probability that the maximum expected reduction in annual TGM is not more than \$254 per ha and not less than (\$435–\$254) \$181 per ha. In the last two columns for fixed-rent payments, we see in 38% of all cases the TGM was below \$295 per ha and there was a 19% probability of being below \$224 per ha.

Line 2 shows that the standard deviation decreases by 12% (and the 90%-VaR decreases by 25%) with the introduction of an RAC based on internal revenues from winter wheat compared with the 'fixed-rent payment' reference scenario. The probabilities of a

Table 1: Risk-reducing effects of different RACs

	RACs		Standard deviation of TGM after rent in USD/ ha[b]	90%-VaR of TGM after rent in USD/ ha[b]	Probability in % of loss higher than...	
					50% of the mean of TGM	66% of the mean of TGM
1	Fixed-rent payment	(Reference scenario)	227	254	38	19
2	Clause based on the internal revenues	Without deductible	201 (−12%)	189 (−25%)	29	10
3	from winter wheat	With deductible	208 (−9%)	189 (−25%)	33	10
4	Clause based on the national average of	Without time lag	229 (0%)	208 (−18%)	33	10
5	winter wheat revenues	One-year time lag	255 (+12%)	274 (+8%)	29	24
6	Clause based on the regional average of winter wheat revenue	Without time lag	215 (−6%)	213 (−16%)	29	10
7	Price index clause	Without time lag	223 (−2%)	229 (−10%)	38	14
8	Weather index clause based on the weather	Sum of precipitation for October and February	203 (−11%)	212 (−17%)	29	14
9	station in Goettingen	Average monthly temperature of March	244 (+7%)	219 (−14%)	33	19
10		Monthly sum of precipitation for October	213 (−6%)	213 (−16%)	33	10
11		Monthly sum of precipitation for February	210 (−7%)	226 (−11%)	24	14
12	Weather index clause based on the weather station in Hanover	Sum of precipitation for October and February	213 (−6%)	257 (+1%)	29	24
13	Weather index clause based on the weather station in Magdeburg	Sum of precipitation for October and February	222 (−3%)	239 (−6%)	33	39

Notes: a. The expected TGM value after the rent payment was \$435 per ha, independent of the respective RAC.
b. The percentage of change in the respective risk measure compared with the fixed rent (Line 1) is displayed in parentheses.

TGM less than $295 per ha and less than $224 per ha are decreasing by 24% and 47% in relative terms and by 9% in absolute terms. The percentage of change in risk measurement is different in each case, but the RAC based on internal revenues from winter wheat shows independent of the considered risk measure a substantial risk reduction potential. However, this RAC is associated with moral hazard.

One could try to mitigate this problem by introducing a deductible. With a deductible of 25% (Line 3), the risk reduction potential tends to decrease compared with Line 2. The 90%-VaR and the probability of the TGM below $224 per ha do not change. This finding is because these assessments are downside risk measures and because a deductible does not influence the rent adjustment when the TGM is low.

The clause based on the national average of wheat revenues represents a method of entirely avoiding moral hazard. Line 4 shows that this clause still reduces the 90%-VaR and the percentiles compared with the reference scenario. However, one also sees that the risk reduction potential is reduced considerably compared with the RAC based on internal wheat revenue (Line 2).

When one attempts to implement an RAC based on external average wheat revenues, the following must be mentioned with regard to the expected time lag in data availability and data aggregation level:

- The price and yield data from e.g. 2008 (Line 5) must be used to account for the one-year lag in data availability in the clause based on the national average of winter wheat revenues used to determine the rent adjustment in 2009. By doing so, the risk reduction potential will decrease substantially. The standard deviation and the VaR will increase compared with the reference scenario.
- When the RAC is based on a specific federal state average of wheat revenues, the risk reduction potential is slightly higher compared with the RAC based on national data (e.g., the change in the TGM standard deviation compared with the reference scenario is 6% in Line 6 and 0% in Line 4). Because only the aggregation level changed for the rent-adjustment-related data, an improvement in the risk reduction potential may be due to the smaller geographical basis risk when using small-area data.

The price index clause (Line 7) is clearly inferior (in parts) to the clauses based on internal or external wheat revenues. The standard deviation was reduced by 2% compared with the reference scenario; the 90%-VaR was reduced by 10%. The probability of a TGM lower than $295 per ha has not changed.

Line 8 displays the results concerning the RAC based on a precipitation index of 'October of the sowing year' and 'February of the harvest year'. By comparing all risk measurements with the reference scenario, one can notice a reduction in risk. Although this RAC was based on an external indicator, the standard deviation was reduced to $203 per ha (11%), and the 90%-VaR was reduced to $212 per ha (17%).

Lines 9 to 13 display the results for the alternative RACs; thus, they are not well-suited weather indices for the TGM. The results can be summarised as follows:

- In Line 9, the risk reduction potential of the RAC refers to the average temperature of March in Goettingen. Despite the fact that March has the highest positive correlation with temperature and the TGM, this clause has a lower risk reduction potential than the clause based on rainfall data in October and February (Line 8). The standard deviation of the TGM increases compared with the reference scenario. The risk reduction potential of the weather index clause in Line 8 and Line 9 is different due to a different basis risk of production because both rainfall and temperature are measured at the same distance from the place of production.
- Lines 10 and 11 refer to the RAC based on the total precipitation in October and February in Goettingen. They illustrate the basis risk of production and these results are similar to the temperature index clauses (Line 9). After comparing the one-month precipitation clauses with the two-month precipitation clause (Line 8), it becomes clear that combining the two months creates a greater risk reduction potential.

Lines 12 and 13 refer to the RAC based on the total precipitation in October and February measured at the weather stations in Hanover and Magdeburg. These data demonstrate the effect of the geographical basis risk. As the distance from the point of production in Goettingen (Line 8) increases from Hanover (Line 12) to Magdeburg (Line 13), the risk reduction potential of the respective RAC significantly decreases because the correlation with precipitation decreases as distance increases. The results of the temperature index clauses based on the weather data from Hanover and Magdeburg that are structured like those in Line 9 are not listed in Table 1. A similar pattern is observed with variations in the rainfall index: as the distance increases, the RAC risk reduction potential decreases. However, this decrease in the risk reduction potential is smaller because temperatures are more strongly spatially correlated with the agricultural production than precipitation (Norton et al., 2010).

5. Conclusion

The proportion of rented land has recently increased in the agricultural sector in general and in Germany in particular. Consequently, farm risk, especially financial risks, has also increased, which makes innovative risk management tools such as RACs more interesting. This paper aimed to determine the risk reduction potential of various RACs at the farm level.

Our calculations showed that the risk reduction potential of various RACs differ considerably from each other. In all, the achieved risk reduction level for all investigated clauses was not high. This result might explain why RACs have not been widely used thus far. However, RACs induce the fluctuation of only one cost factor. The much debated clauses based on internal prices or revenues are connected with moral hazard. Therefore, they are associated with high control and monitoring costs. The implementation of an RAC based on external and objectively measurable indicators is cost-effective. However, it is apparent that clauses based on national price indices are virtually ineffective. The weather index clause suggested in the present paper (which was based on rainfall data measured outside the farm) was many times more effective than the other clauses examined using external indicators. We conclude from our results that implementing RACs makes sense when they feature off-site measured weather-indices.

This paper is based on the data of one farm (i.e., the risk reduction potential was examined using an exemplary analysis). Investigating the extent to which our results can be replicated would be interesting, especially using farms in other countries or other types of farms to calculate the risk reduction potential. However, we would not expect qualitative differences because the nature of the RAC we examined does not change when other operational data are used.

Following an advice of a reviewer it is important to note that, in times of changing weather patterns due to global climate change, some farmland might become difficult to rent, if the landowner does not agree to an RAC. In addition, some landowners may find it beneficial to agree to an RAC to improve their risk management (e.g., when the RAC is negatively correlated with other income sources).

About the authors

Henning Hotopp is currently a research fellow and doctoral student at the Farm Management Group of the Department of Agricultural Economics and Rural Development of the Georg-August-University Goettingen (Germany) where he also studied Agricultural Sciences (B.Sc. and M.Sc.) with a focus on 'Economic and Social Sciences in Agriculture'.

Prof. Dr. Oliver Mußhoff is a professor of agricultural economics at the Georg-August-University Goettingen, Germany. In various publications he addressed issues of risk analysis and risk management. Research foci are on real options, weather derivatives and climate change.

Acknowledgements

The authors thank the two anonymous reviewers and the editor for their helpful comments. We also gratefully acknowledge financial support from Deutsche Forschungsgesellschaft. Furthermore, the authors wish to extend special thanks to Jessica Olbrich for language assistance.

REFERENCES

Allen, Douglas W. and Lueck, Dean. 1999. Searching for Ratchet Effects in Agricultural Contracts. *Journal of Agricultural and Resource Economics* 24 (2): 536–552.

Barry, Peter J., Moss, Lee Ann M., Sotomayor, Narda L. and Escalante, Cesar L. 2000. Lease Pricing for Farm Real Estate. *Review of Agricultural Economics* 22 (1): 2–16.

Bellemare, Marc F. 2009. Sharecropping, Insecure Land Rights and Land Titling Policies: A Case Study of Lac Alaotra, Madagascar. *Development Policy Review* 27 (1): 87–106.

Berg, Ernst and Schmitz, Bernhard. 2008. Weather-Based Instruments in the Context of whole-Farm Risk Management. *Agricultural Finance Review* 68 (1): 119–133.

Breustedt, Gunnar, Drepper, Christian and Latacz-Lohmann, Uwe. 2010. *Wie können Marktfrucht- und Veredelungsbetriebe auf zunehmende Ertrags- und Preisrisiken reagieren?* Auswirkungen der Finanzkrise und volatiler Märkte auf die Agrarwirtschaft, Schriftenreihe der Rentenbank 26, 89–120.

Chamber of Agriculture Lower Saxony (FID). *Richtwert-Deckungsbeiträge Landwirtschaftskammer Niedersachsen* (Benchmark Gross Margins). Hanover, different years.

Chen, Gang, Roberts, Matthew C. and Traen, Cameron S. 2006. Managing Dairy Profit Risk Using Weather Derivates. *Journal of Agricultural and Resource Economics* 31 (3): 653–666.

Dowd, Kevin. 2002. *An introduction to market risk measurement*. Wiley Finance, John Wiley & Sons, LTD.

European Central Bank. 2011. European foreign exchange reference rates. http://www.ecb.int/stats/exchange/eurofxref/html/index.en.html, Last Access: 27.10.2011.

Federal Statistical Office of Germany (Statistisches Bundesamt Deutschland). 2011. http://www.destatis.de, Last Access: 12.04.2011.

Food and Agriculture Organization of the United Nations (FAOSTAT). 2011. URL: http://faostat.fao.org, last Access: 14.04.2010.

Fukunaga, Keita and Huffman, Wallace E. 2009. The Role of Risk and Transactions Costs in Contract Design: Evidence from Farmland Lease Contracts in U.S. Agriculture. *American Journal of Agriculture Economics* 91 (1): 237–249.

German Meteorological Service (DWD). 2011. Weather data for Hanover and Magdeburg for 1989–2009; URL: http://www.dwd.de; Last Access: 14.04.2011.

Ghatak, M. and Pandey, P. 2000. Contract choice in agriculture with joint moral hazard in effort and risk, *Journal of Development Economics* 63, 303–326.

Goodwin, Berry K. and Ker, Allan P. 1998. Nonparametric Estimation of Crop Yield Distributions: Implications for Rating Group-Risk Crop Insurance Contracts. *American Journal of Agricultural Economics* 80 (1): 139–153.

Institute of Soil Science, University of Goettingen. 2011. Weather data for Goettingen from 1983 till 2010. (http://www.uni-goettingen.de/de/98158.html), Last Access: 14.01.2011.

Itoh, Hirotake, Hayashi, Shigeki, Nakajima, Takashi, Hayashi, Tomohito, Yoshida, Hozumi, Yamazaki, Koou and Komatsu, Teruyuki. 2009. Effects of Soil Type, Vertical Root Distribution and Precipitation on Grain Yield of Winter Wheat. *Plant Production Science* 12 (4): 503–513.

Jorion, Philippe. 2002. *Value at Risk. The New Benchmark for Managing Financial Risk*. Second Edition. McGraw-Hill Professional.

Kassie, Menale and Stein, Holden. 2007. Sharecropping efficiency in Ethiopia: threats of eviction and kinship. *Agricultural Economics* 37 (2): 179–188.

Lower Saxony Statistical and Communication Technology Centre (LSKN) (Landesbetrieb für Statistik und Kommunikationstechnologie Niedersachsen). 2011. *Erntestatistik online.* different years. (http://www.nls.niedersachsen.de), Last Access: 14.04.2011.

Langemeier, Larry N. 1996. *Crop-share or Crop-share/Cash Rental Arrangements for Your Farm*. North Central Regional Extension publication No. 105, Kansas State University, Distribution Centre.

Langemeier, Larry N. 1997. *Fixed and Flexible Cash Rental Arrangements for Your Farm*. North Central Regional Extension publication No. 75, Kansas State University, Distribution Centre.

Musshoff, Oliver, Odening, Martin & Xu, Wei. 2011. Management of Climate Risks in Agriculture-Will Weather Derivatives Permeate? *Applied Economics* 43 (9): 1067–1077.

Norton, Michael, Osgood, Dan and Turvey, Calum.G. 2010. Weather Index Insurance and the Pricing of Spartial Basis Risk. Selected Paper prepared for Presentation at the Agricultural & Applied Economics Association's 2010 AAEA, CAES & WAEA Joint Annual Meeting, Denver, Colorado 2010.

Odening, Martin and Hinrichs, Jan. 2003. Using Extreme Value Theory to Estimate Value-at-Risk. *Agricultural Finance Review* 63 (1): 55–73.

Olesen, Jørgen. E. and Bindi, Marco. 2002. Consequences of climate change for European agricultural productivity, land use and policy. *European Journal of Agronomy* 16 (4): 239–262.

Otsuka, Keijiro., Hiroyuki, Chuma and Yuriro, Hayami. 1992. Land and Labor Contracts in Agrarian Economies: Theories and Facts. *Journal of Economic Literature* 30(4): 1965–2018.

Plumeyer, Cord H., Becker, Martin and Theuvsen, Ludwig. 2010. Optionen der Pachtpreisanpassung: Ex-post-Analyse am Beispiel Niedersachsen. *Schriften der Gesellschaft für Wirtschafts- und Sozialwissenschaften* 45, 77–90. (http://www.gewisola.de), Last Access: 12.04.2011.

Sanjuán, Ana. I., Dawson, Philip J., Hubbard, Lionel J. and Shigeto, Sawako. 2009. Rents and Land Prices in Japan: A Panel Cointegration Approach. *Land Economics* 85 (4): 587–597.

Serra, Teresa, Zilberman, David, Goodwin, Barry.K. and Featherstone, Allen. 2006. Effects of decoupling on the mean and variability of output. *European Review of Agricutural Economics* 33 (3): 269–288.

Stockdale, A., Lang, A. J. and Jackson, R.E. 1996. Changing Land Tenure Patterns in Scotland: a Time for Reform?. *Journal of Rural Studies* 12 (4): 439–449.

Turvey, Callum. 2005. The Pricing of Degree-day Weather Options. *Agricultural Finance Review* 65 (1): 59–86.

Vedenov, Dmitry. V. and Barnett, Barry J. 2004. Efficiency of Weather Derivatives as Primary Crop Insurance Instruments. *Journal of Agricultural and Resource Economics* 29 (3): 387–403.

Xu, Wei, Odening, Martin and Musshoff, Oliver. 2008. Indifference Pricing of Weather Derivatives. *American Journal of Agricultural Economics* 90 (4): 979–993.

Selection indices offer potential for New Zealand sheep farmers to reduce greenhouse gas emissions per unit of product

CAMERON I. LUDEMANN[1,2], TIMOTHY J. BYRNE[2], JUDITH A. SISE[2] and PETER R. AMER[2]

ABSTRACT

The New Zealand Government is a signatory of the Kyoto Protocol which provides incentive for it to reduce its total greenhouse gas emissions (GHG). The sheep industry is a significant contributor to the total GHG in New Zealand. It also has widespread use of selection index technology which could be a potential GHG mitigation tool. This paper provides an assessment of the potential for New Zealand sheep farmers to reduce GHG using selection indices.

Trait weightings were altered in novel indices to facilitate greater reductions in GHG. These were compared to a conventional farm profit maximising index. Selection of sheep using the farm profit maximising index reduced GHG output in kilograms of carbon dioxide equivalent units (kg CO_2e) per kilogram of lamb carcase weight (kg cwt) by 0.59% of total methane and nitrous oxide emissions *per annum* (pa). Novel 'Dual Purpose Environment' indices (DPE) were developed to provide greater GHG reductions in kg CO_2e/kg cwt. A range of carbon prices were incorporated into the DPE. The study showed 96.6% of the potential farm profit (excluding emissions costs) and 69.8% of potential kg CO_2e/kg cwt improvements could be obtained using a carbon price of NZ$100/tonne CO_2e in the DPE. The corresponding figures for NZ$25/t CO_2e were 99.8% and 56%. The carbon price used in the DPE therefore influenced the trade-off between progress in traits which reduce GHG in kg CO_2e/kg cwt and those that improve farm profitability.

Selection indices are an option for farmers to reduce GHG in kg CO_2e/kg cwt in New Zealand sheep. However, farmers will need to consider the trade-off between improving traits which contribute to farm profit and those that reduce GHG.

KEYWORDS: Mitigation methods; genetic improvement; trait weightings

1. Introduction

Increasing concentrations of GHG in the Earth's atmosphere are a major challenge to humankind. The change in concentrations of GHG has been described as symptomatic of human activities '*stretching Earth's limits*' (Janzen, 2011 p. 785). The rise in GHG concentrations, as well as other waste products produced by human activity may put into jeopardy critical processes to the welfare of the biosphere and therefore the welfare of humankind (Kitzes *et al.*, 2008, Rockström *et al.*, 2009). Fortunately there have been efforts to reduce GHG at a global level (UNFCCC, 1998, UNFCCC, 2010). The Kyoto Protocol for instance was an agreement for signatory countries to measure their GHG and take steps to reduce them to negotiated levels.

Livestock is a significant contributor to global GHG with estimates of up to 51% of total GHG being attributed to this source (Herrero *et al.*, 2011). It has been claimed that livestock is one of the two or three biggest contributors to the most serious environmental problems (Steinfeld *et al.*, 2006). Energy losses through GHG are also significant inefficiencies in ruminant production systems (Eckard *et al.*, 2010). So regardless of their impact on the environment there is economic rationale for aiming to reduce these inefficiencies. Furthermore, any improvement in efficiency of production will enable more food to be produced on Earth's limited land resource. Efforts to improve the production efficiency of the major livestock groups will reduce environmental degradation through land use change (O'Mara, 2011).

A wide range of methods have been suggested as offering potential to mitigate the environmental impact of livestock in GHG terms (Eckard *et al.*, 2010, Moran *et al.*, 2011). However, genetic selection is a particularly feasible option because changes are permanent, cumulative and at relatively low cost (Wall *et al.*, 2010). Reductions in GHG may also occur in concurrence with

[1] Melbourne School of Land and Environment, University of Melbourne, VIC, 3010, Australia. Email: cludemann@abacusbio.com.au
[2] AbacusBio Ltd, 1st Floor Public Trust Building, 442 Moray Place, P O Box 5585, Dunedin, 9058, New Zealand.

improvements in farm profitability. This can improve the cost effectiveness of the genetic selection relative to other technologies (Moran *et al.*, 2011).

New Zealand is a signatory of the Kyoto Protocol and is relatively dependent on agriculture for its economic welfare. The agriculture sector for example contributed 5% of gross domestic product in the year ending 31 March 2009. Of New Zealand's gross agricultural production, sheep meat and wool contributed NZ$2.61 billion[3] or 11.3% to the total value in the same year (New Zealand Treasury, 2010). New Zealand's commitment to the Kyoto Protocol requires it to reduce its GHG to 1990 levels and take responsibility for any excess emissions (Ministry of Agriculture and Forestry, 2011). Of the total GHG produced by New Zealand in 2009, agriculture contributed 46.5% of New Zealand's total GHG. Methane from sheep alone made up 7.1% of total emissions (Ministry for the Environment, 2011). The potential costs of the agriculture industry exceeding its limit was estimated as being NZ$0.5 billion in the first commitment period (from 2008–2012) (Leslie *et al.*, 2008). The significance of the agriculture sector's contribution to the nation's total GHG therefore lead the New Zealand Government to propose including ruminant emissions in a regulatory framework to place a cost on producers of GHG by 2015. The framework was termed the Emissions Trading Scheme (ETS).

It is expected New Zealand farmers will generally not be the direct participants of the ETS. Rather, it will be the processors of the animal products who will be the participants (a processor point of obligation; (Ministry of Agriculture and Forestry, 2011)). Processors would deduct the costs of GHG from the value of each product. This would be based on New Zealand average emission factors (on a per head and per kilogram of product basis) on behalf of the Government.

The New Zealand sheep industry already has relatively widespread use of selection index technology and clearly has incentives to reduce GHG in order to contribute toward the nation's Kyoto Protocol obligations. This makes it an appropriate case study to assess selection index technology as a potential GHG mitigation tool for ruminants.

An update of the selection index for New Zealand sheep by Byrne *et al.,* (2012) provided an opportunity to incorporate GHG into indices which aimed toward mitigating GHG. No published studies have assessed the implications of including GHG in a wide range of traits in a selection index while taking into account the correlations between traits and the time it takes traits to be expressed. We therefore assessed selection index technology for its potential as a tool to mitigate GHG for the New Zealand sheep industry.

Research questions to answer this include:

- how would the relative weighting of traits differ between indices focussed on farm profit maximisation and indices which incorporate the goal of reducing GHG?;
- how would the genetic progress made in each trait respond to the changes in relative weightings?;
- how would the genetic progress made in each trait relate to GHG emissions?;
- what would be the effect of the novel indices in farm profit terms?

[3] In early June 2012, NZ$1 was approximately equivalent to US$0.75, €0.61, and £0.49 (sterling).

The analysis of genetic progress in this study will be limited to maternal (dual purpose) sheep in New Zealand farm systems for the production of meat and wool.

This introduction will be followed by a literature review which provides background on traditional economic selection indices (Section 2) as well as a review of studies which have assessed the potential implications of selecting for traits to reduce GHG (Section 3). The review will be followed by an explanation of the method we used to develop and assess novel selection indices for the New Zealand sheep industry (Section 4). Then the results (Section 5), discussion (Section 6) and conclusions (Section 7) will be explained.

2. Economic selection indices

Selecting the 'best' animals for breeding can be difficult when trying to take into account a range of traits. Selection indices can simplify the decision farmers make when selecting their 'best' animals. This is achieved by defining the relative weightings for a range of traits so that a fair comparison can be made between animals (Hazel, 1943).

Economic selection indices assign relative weightings to each trait based on how a unit change in the trait impacts on farm profitability. Each trait is generally defined per animal expressing the trait. Geneflow methodology can be used to account for the different timing and frequency of trait expression (McClintock & Cunningham, 1974). The longevity trait for breeding animals for instance will only be expressed once at the end of the life of the breeding animal. In contrast, a growth trait expressed in offspring may be expressed within a relatively short period of time, and by many offspring.

Genetic progress made in each trait is dependent on the relative weightings calculated for each trait. Altering the relative weightings in each trait can result in a re-ranking of individual selection candidates and impact on the overall trait progress made in a breeding programme (Simm, 1998). It is well established in the literature that selection of animals aided by a selection index can improve the production of offspring. Progress made using selection indices tend to range between 1 and 3% in relation to the mean of the trait being selected for (Simm, 1998). Furthermore, genetic progress has been an influential factor in the progress that has been made in livestock yield (Thornton, 2010). There are numerous examples where genetic progress has been made following the use of selection indices. Chickens in Tanzania for example obtained 70 to 81 gram per generation progress in 16 week body weight (Lwelamira & Kifaro, 2010) through genetic selection. European pig breeding programmes were stated by Merks (2000) to have contributed toward annual increases of 20g/day in daily gain and 0.2 piglets/litter in litter size from 1990–1999. Significant improvements in carcase weight and fertility traits in New Zealand sheep were also attributed to the use of a selection index (Young & Amer, 2009).

At an industry level genetic progress in traits can vary depending on the flow of information from elite breeders to commercial populations (Wall *et al.*, 2010). Genetic progress made in pig and poultry programmes for instance are generally greater than progress made in sheep and beef cattle breeding programmes. This is because the former industries tend to have fewer and larger seed stock companies in the market (Amer *et al.*, 2007). Nevertheless, genetic progress can bring about change to the economic welfare of farmers (Beard, 1988) with significant returns possible. The combined benefits from 10 years of genetic improvements made in the UK sheep and beef industry for instance was estimated as £110.8 million by Amer *et al.,* (2007). This represented an annual 32% internal rate of return on investment.

Industry incentive to maintain or improve farm profitability through the benefits genetic selection can deliver would partly account for the large number of studies which have developed selection indices across a broad range of species. De Vries (1989) for pigs; Beard (1988) for dairy cattle; McClintock & Cunningham (1974) for beef cattle and Byrne *et al.,* (2012) for sheep are just a few studies where selection indices were developed in order to optimise genetic selection for gains in farm profitability.

As a recent example from the literature Byrne *et al.*, (2012) updated the New Zealand sheep selection index termed the Dual Purpose Overall index (DPO) to reflect the maternal traits ram breeders select for in their maternal sire rams. The objective of the index was to maximise farm profit progress for farmers and is expected to be implemented by the New Zealand sheep industry in the near future. For the New Zealand sheep industry's selection index, farm profit was defined as the gross margin between before tax revenues and before tax costs for a typical sheep farm.

A further recent development in the literature is the uptake of selection index technology for ranking cultivars of perennial ryegrass (*Lolium perenne*) (DairyNZ, 2011, McEvoy *et al.*, 2011). McEvoy *et al.,* (2011) applied a selection index technique similar to that used for developing animal selection indices. They developed a model for an Irish dairy farm system to estimate the profit implications when perennial ryegrass traits changed by one unit. The subsequent ranking of perennial ryegrass cultivars will help optimise cultivar selection for the dairy industry (McEvoy *et al.*, 2011). The literature therefore highlights the flexibility the selection index method has to aid selection decisions across species and farm systems.

3. Selection to reduce GHG in livestock

Selection indices are not limited to just improving animal production and farm profits. Broader societal goals can also be aimed for. Other goals considered for inclusion in selection indices include: animal welfare; species biodiversity; safety of food; health properties of products and the environment (Wall *et al.*, 2010). However, some goals from society have a non-pecuniary aspect to them. This can make it more difficult to assign relative weighting to traits according to the contribution they make toward achieving those goals. Studies from the literature will be limited to the goal of improvements in the environment in relation to GHG as this is the focus of the review.

How reductions in GHG are measured is an important aspect to GHG mitigation through genetic selection methods. Therefore a brief background on ruminant GHG will be explained before studies pertaining to GHG mitigation through genetic selection are reviewed.

There are a range of GHG that contribute to climate change but methane (CH_4) and nitrous oxide (N_2O) are the two most significant from ruminant production systems. In a study of a New Zealand sheep system for instance approximately 90% of the GHG produced were either CH_4 or N_2O (Ledgard *et al.*, 2010). This is because CH_4 is inherently linked to the digestive system of ruminants (Janzen, 2011). Ruminants also excrete nitrogen which can contribute toward N_2O. The quantity of CH_4 or N_2O does not allow a fair comparison of their potential environmental damages to be made. Therefore a standard measure of the radiative forcing effect of a unit mass of each GHG is used (Casey & Holden, 2005). This measure is termed the Global Warming Potential (GWP). The GWP of GHG are calculated relative to carbon dioxide equivalent (CO_2e) values. The GWP of CH_4 for instance is 21 and for N_2O is 210 (Ministry for the Environment, 2010).

Furthermore, to calculate emissions from livestock, GHG emission factors (EF) need to be used. IPCC approved EF are used in order to create a fair and consistent quantification of total GHG between countries. EF can also be used to quantify the potential benefits of agricultural GHG mitigation methods such as how Alcock & Hegarty (2011) examined for sheep in Australia. Ruminant EF are primarily based on the quantity of energy consumed. These energy values can be converted into emissions per kilogram of dry matter consumed (Table 1) as reported in New Zealand's GHG inventory submission to the IPCC.

Although livestock produce GHG, the main aim of livestock systems is generally to produce food or fibre in a profitable manner (Janzen, 2011). However, countries signed up to the Kyoto Protocol also have obligations to take steps to reduce their total GHG. Increasing ruminant production per head could help reduce total GHG if there was a proportionate reduction in number of animals to maintain the same quantity of product. Intensification of agriculture (which genetic selection has contributed toward) has offset some GHG related to land use change (Burney *et al.*, 2010). Similarly, Wall *et al.,* (2010) mentioned improvements in per cow milk yield contributed to reductions in methane in the Canadian dairy industry (10%) and the European Union's agriculture sector (20%) following the reduction in number of cows. However, if the number of ruminants remains unchanged, an increase in per head production can result in higher per animal energy requirements hence higher total GHG. There appears to be a conflict in goals to reduce total GHG when there is selection for ruminants with higher production. A factor to explain why higher ruminant production is being targeted while countries have goals to reduce total GHG is the projected increase in the human population.

Table 1: Methane and nitrous oxide emission factors per kilogram of dry matter intake (kg DMI), based on the Ministry for the Environment (2010)

Class of stock	Grams of CH_4 per kg DMI	Grams of direct N_2O per kg DMI	Grams of indirect N_2O per kg DMI
Lambs (birth to slaughter)	16.8[1]	0.0489	0.0135
Replacement sheep (birth to maturity)	18.9[1]	0.0489	0.0135
Mature sheep	20.9	0.0489	0.0135

[1]Note: Lambs were assumed to not produce methane until they were 8 weeks of age as stated by Clark (2008)

The expected increase in human population will create greater demand for protein. Therefore McAllister *et al.,* (2011) proposed that GHG reductions be targeted per unit of product, termed the Emissions Intensity (EI). This assumed a global human population would continue to consume protein without a massive shift toward a vegetarian diet and that the world placed a priority on matching the increase in demand for food. Alcock & Hegarty (2011) and Beukes *et al.,* (2011) are recent examples of studies which included EI in their analysis. Alcock & Hegarty (2011) measured GHG per kilogram of live weight while Beukes *et al.,* (2011) measured EI per kilogram of milk solids. EI values can allow comparisons between systems and to gain perspective on the relative contribution a GHG mitigation technology might have. Ledgard *et al.,* (2010) for instance reported the most comprehensive calculation of GHG for New Zealand lamb production from the farm to the point of consumption. GHG relating to on-farm CH_4 and N_2O for lamb were estimated as 13.7 kg CO_2e/kg cwt. This was based on 72% of the 19 kg CO_2e/kg cwt total emissions (from farm to consumption) coming from on-farm emissions.

Variation in the production of GHG between ruminants has been long established (eg. Blaxter & Clapperton (1965)), but a focus on using genetic selection to reduce ruminant GHG is a relatively recent development in the literature. There have been an increasing number of studies which use farm system models to estimate the GHG implications of changing ruminant traits.

A New Zealand study of dairy cows by Beukes *et al*., (2010) estimated beneficial GHG and farm profit impacts of having higher genetic merit cows with improved milk yields (from 390 kg MS/cow pa to 430 kg MS/cow pa). They also suggested the increase in genetic merit could be a contributing technology to help New Zealand meet its Kyoto Protocol commitment. However, the 10–22% reduction in GHG in kg CO_2e/kg milk solids with an improvement in genetic merit did not account for the time lag for the assumed rates of change in production. Nor did it account for the correlations between traits, especially fertility and its effect on overall farm profitability and GHG.

In sheep in Australia, Alcock & Hegarty (2011) estimated reductions in total GHG of up to 18% were possible through 10% changes in a range of traits such as growth and fertility. Cottle *et al.,* (2009) examined what price of carbon was necessary in order for methane production and feed intake to be used as selection criteria in the future breeding programme for Australian merino sheep. In their study a carbon cost of over AU$400/t CO_2e was required to achieve 1% annual reductions in methane. In New Zealand, Cruickshank *et al*., (2008) estimated up to a 21% reduction in methane output per lamb sold through an increase in fertility. However, the GHG implications of changing one trait in isolation may not necessarily extrapolate to the field. This is because the heritability and genetic correlations between traits will have an influence on what changes in EI can be achieved at a farm level (Alcock & Hegarty, 2011). In particular, Alcock & Hegarty (2011) suggested the GHG benefits could be eroded to an extent by higher emissions from the heavier ewes when there was selection for higher growth rates in lambs.

There are limited published field trials to confirm the modelled studies which have estimated the potential GHG benefits of improving traits in livestock. Most field trials have been in dairy cows. For example field trials in Northern Ireland showed that dairy cattle high in genetic merit (for productive traits) had significantly lower urinary loss of nitrogen, hence lower nitrous oxide emissions per unit of nitrogen intake (Ferris *et al*., 1999). The high genetic merit cows also had lower methane energy lost in relation to gross energy intake.

The Langhill dairy research herd in Scotland analysed GHG from groups of dairy cows with different selection pressures. This included a group of dairy cows selected for increased milk fat and protein yield (select genetic line) and another selected to be close to the average genetic merit of dairy cows in the UK (control genetic line). Wall *et al*., (2010) reported the select line of dairy cows produced 21% less methane per unit of milk product in the first lactation compared to control dairy cows. However, it was suggested that body reserves were used to support the additional lactation energy requirements and this could have unfavourable impacts on other 'fitness' traits such as health and longevity. Bell *et al.,* (2011) later concluded that the select line of dairy cows had lower methane per unit of product up until their third lactation, but not over their lifetime. This highlights the complexity of trying to estimate the GHG implications of selecting for certain traits. This is particularly so if the higher production comes at a cost in the form of body reserves which can contribute negatively to health and fertility of livestock (Pryce *et al*., 1999).

It is therefore important to take into account the interactions between a full range of traits when analysing the effects of selection decisions on GHG at the farm level. Furthermore, the time lag effects of the rates of progress made in each trait need to be accounted for. There has been research on the Welsh sheep industry which has modelled the interactions between traits and time lag effects (Nakielny, C. personal communications, 2011). However, this was based on the current selection objectives to improve farm profits. It did not include analysis of scenarios where the objective was to obtain greater reductions in GHG. The current genetic improvement programme for the Welsh sheep industry was estimated to contribute a modest 0.03% reduction in methane per unit of carcase each year. Estimates of potential GHG reductions when selecting for a range of traits are therefore likely to be lower than when they are calculated as a trait changed in isolation.

To our knowledge no published study has estimated the GHG and economic implications of selecting for a broad range of traits in an index which has a primary objective to reduce GHG. Assessing the implications of indexes which have economic and GHG mitigation objectives for the New Zealand sheep industry will fill this gap in the literature.

4. Method

Approach

The recent development of New Zealand's DPO (Byrne *et al.*, 2012) calculated the energy requirement and economic implications of each trait of significance to the sheep industry. This study developed two GHG selection indices based on the same input assumptions as Byrne *et al.*, (2012). However, the relative trait weightings were different to the DPO as they were calculated to facilitate reductions in two measures of GHG. The Emissions Intensity index (EII) aimed to maximise reductions in terms of GHG/kg lamb cwt to align with the definition of EI described by McAllister *et al.,* (2011). The 'Total GHG' index aimed to maximise reductions in total GHG. GHG were limited to CH_4 and N_2O as these constitute the majority of emissions on a sheep farm in New Zealand (Ledgard *et al.*, 2010).

A third novel index was developed which aimed to facilitate selection of traits which provided a balance between genetic progress in traits that reduced EI and those that contribute positively to farm profitability. This index was termed the 'Dual Purpose Environment' index (DPE).

The aforementioned indices were assessed for their ability to maximise farm profit, reduce EI and reduce total GHG.

Assumptions

Index traits

Table 2 provides a description of the 15 traits used in the DPO described by Byrne *et al.*, (2012). The same traits and their units and definitions were used for the two GHG indices and the DPE.

Farm system assumptions

Sheep production and performance values used in the index models were estimated to reflect the New Zealand industry average. These align to those used by Byrne *et al.*, (2012) in the development of the DPO and are summarised in Table 3. Further assumptions and the sources of information for the estimates are detailed in Byrne *et al.*, (2012). As shown in Table 3 the base NLB was 1.45 lambs born per ewe lambing. Average lamb survival (0.91) was a function of the respective survival rates of each birth ranking (i.e. single, twin, triplet) weighted by the proportion of single, twin, and triplet lambs in the ewe litter. The survival rates (from birth to tailing) for single, twin and triplet lambs were 0.93, 0.88, and 0.60 respectively (Byrne *et al.*, 2012). Similarly, the number of days to slaughter for lambs was weighted by the proportion of each birth ranking of lambs in the ewe litter and their respective growth rates.

Table 2: Objective trait names, description and response units used in the modelling of responses to selection (Byrne *et al.*, 2012).

Name	Trait description	Response unit
NLB	Number of lambs born	Lambs
WWTd	Weaning weight (direct)	kg
WWTm	Weaning weight (maternal)	
CWT	Carcase weight	
LFW	Lamb fleece weight	
HFW	Hogget fleece weight	
EFW	Ewe fleece weight	
FEC1	Faecal egg count	eggs per gramme
FEC2		
AFEC	Adult faecal egg count	
SURd	Lamb survival (direct)	Lambs
SURm	Lamb survival (maternal)	
LeanYield	Carcase lean meat	kg
EweWT	Ewe mature weight	
Longevity	Ewe longevity	Replacement rate

Table 3: Performance parameters which form 'base' farm model assumptions for development of novel indices from Byrne et al., (2012)

Performance parameter	Assumption
Ewe prolificacy, number of lambs born (NLB)	1.45
Average lamb survival (birth to tailing)	0.91
Average lamb survival (tailing to slaughter)	0.98
Average weaning weight, averaged across sexes (kg)	28
Average lamb cwt (kg)	17
Average lamb dressing proportion	0.45
Ewe mature weight (kg)	65
Age at which mature weight reached (years)	2
Replacement rate (proportion of the flock as 2-tooths)	0.25
Average (across birth ranks) days to slaughter for lambs	157

Development of indices

GHG indices

Changes in energy requirements of sheep (in megajoules of metabolisable energy- MJME) for every unit change in traits from the DPO model described by Byrne *et al.*, (2012) were linked to the models which calculated the two GHG indices (EII and Total GHG) and the DPE.

For the GHG indices the change in MJME requirements per unit change in each trait were converted into GHG. To do this, an average pasture energy concentration of 10.4 MJME/kg DM (Litherland *et al.*, 2002) was assumed in the farm system to convert the change in MJME for each trait into a change in kg DM intake.

The change in kg DM intake was then multiplied by the respective EF shown in Table 1 to calculate the total GHG implications for each trait. These GHG values were used for the Total GHG index relative trait values.

In contrast, the EII needed to take into account not only total GHG but also the quantity of lamb cwt produced to formulate an efficiency measure. Appendix A describes the equation used to take GHG efficiency into account when calculating the EI implications of each trait.

As opposed to the trait relative values in the Total GHG index, those in the EII took into account the potential GHG 'dilution' effect of changes in traits. A trait with a GHG dilution effect was defined in this study as a trait which had a proportionately larger change in quantity of product produced for any change in total GHG. Increasing 'fertility' of a ewe may for example increase total GHG through greater energy requirements for the ewe. However, the EI value for the 'fertility' trait may decrease if the additional weight of lambs sent to slaughter dilute the additional total GHG attributed to extra energy requirements.

DPE

The DPE amalgamated both the farm profit economic values from the DPO and the EI values from the EII. EII values were chosen instead of the Total GHG index values as it was assumed EII values would align better to improving traits which contribute to enhanced farm profit. Furthermore, McAllister *et al.*, (2011) suggested EI should be emphasised in production systems in order to reduce GHG while ameliorating food availability problems associated with a growing human population.

The DPO values were in NZ cents/unit change in trait, while EII values were in GHG/kg lamb cwt per unit change in each trait. In order to add the trait values together in a combined DPE, EII values were converted into monetary values. EII values were monetised by multiplying them by carbon prices. This allowed them to be added to the DPO index to create the novel DPE trait values.

There is significant uncertainty in future carbon prices and there is a wide range of estimations for the cost of GHG (Watkiss, 2011). In a review by Watkiss (2011), the mode cost of GHG was US$2/t CO_2e and the median was US$14/t CO_2e. When the non peer-reviewed estimates were excluded the mean was US$50/t CO_2e. However, these estimates may not necessarily reflect the costs a New Zealand sheep farmer may incur in the short term. The Emissions Trading Scheme Review Panel (2011) for instance recommended the New Zealand Government ensure the cost of carbon was kept below NZ$25/t CO_2e in 2013 using a 'price cap'. Therefore DPE using a wide range of carbon prices were calculated including: NZ$15; NZ$25; NZ$50; NZ$75 and $NZ100/t CO_2e and were named the DPE15; DPE25; DPE50; DPE75 and DPE100 (indices) respectively. The NZ$15/t CO_2e carbon price represented a recent value of tradable carbon emission units in New Zealand's ETS (Point carbon, 2011) while the others provided sensitivity.

Conversion of trait values into trait weights

The trait relative values do not take into account the time it may take for a trait to be expressed on a farm, nor its importance to the industry in general. Therefore these factors needed to be taken into account before annual genetic progress was calculated for the different indices. Discounted genetic expressions (DGE) represent the timing and contribution of a selection candidate's (i.e. usually a ram when using a selection index) genes on farm profits over a 10 year investment period. Industry weighting factors (IWF) represent the proportion of New Zealand's sheep industry the change in the trait is relevant to. Both the DGE and IWF are further explained by Byrne *et al.*, (2012). Equation 1 shows how they were used in order to convert a trait value (i.e. an economic or EII value) into a trait weight.

Equation 1: Conversion of selection index trait values into trait weights:

$$Trait\ weight = Trait\ value \times IWF \times DGE$$

Trait values for all the indices were converted into trait weights before their genetic progress was calculated.

Estimation of genetic progress for each index

Genetic progress made in each trait was calculated for the range of selection indices. Genetic trends were predicted by using a model which followed Dekkers (2007) description of selection index theory and is described in more detail by Sise & Amer (2009). Predictions of the genetic progress made in each trait (in trait units per year) for each of the contrasting indices were calculated, and overall annual rates of genetic progress per lamb born for each index reported. Overall farm profit progress was in units of NZ$ per lamb born when selecting sheep based on each respective set of index weights.

5. Results

Selection index relative weights

Table 4 provides a comparison of the relative weights in each of the indices. DPE at two carbon prices are included in Table 4 to show the effect of a contrast in carbon prices. Compared to the DPO, the two DPE had greater absolute weightings on the NLB, CWT, SUR and Longevity traits. Increasing the carbon price increased the absolute weights for those traits. NLB for instance was 907 NZ cents higher in the DPE100 compared to the DPE25.

Trait responses

Annual trait responses estimated using relative weights from Table 4 are presented in Table 5. Higher relative weightings for NLB in the two DPE meant more genetic progress was made in this trait compared to when the DPO was used for selection. For example, genetic progress using the DPE100 index was 0.009 extra lambs per annum compared to the DPO index which gave 0.006 extra lambs per annum. Table 5 also highlights the contrast in relative progress made between the EII

Table 4: Relative trait weights for a range of indices

Index	DPO	DPE25	DPE100	EII	Total GHG
Units	NZ cents/lamb born	NZ cents/lamb born at NZ$25/t CO_2e	NZ cents/lamb born at NZ$100/ t CO_2e	kg CO_2e /lamb born	kg CO_2e /lamb born
NLB	1555	1858	2765	121	−118
WWTd	95	92	84	−1	−1
WWTm	84	82	75	−1	−1
CWT	260	274	313	5	1
LFW	182	182	182	0	0
HFW	79	79	79	0	0
EFW	228	228	228	0	0
FEC1	−3	−3	−3	0	0
FEC2	−3	−3	−3	0	0
AFEC	−2	−2	−2	0	0
SURd	6445	7733	11595	515	−160
SURm	5840	7007	10506	467	−145
LeanYield	324	324	324	0	0
EweWT	−104	−113	−141	−4	−4
Longevity	−11381	−11874	−13352	−197	−258

Table 5: Annual trait responses using relative trait weights

Index	DPO	DPE25	DPE100	EII	Total GHG
Trait	Genetic progress made (in trait units pa.)				
NLB	0.006	0.007	0.009	0.013	−0.015
WWTd	0.226	0.215	0.185	−0.009	−0.111
WWTm	0	0	0	0	0
CWT	0.168	0.161	0.141	0.005	−0.088
LFW	0.004	0.004	0.004	0.000	−0.001
HFW	0.028	0.027	0.024	0.003	−0.006
EFW	0.024	0.023	0.021	0.002	−0.006
FEC1	0.240	0.239	0.230	0.105	0.095
FEC2	0.276	0.274	0.264	0.121	0.109
AFEC	0.309	0.307	0.295	0.135	0.122
SURd	0.001	0.001	0.001	0.002	−0.001
SURm	0	0	0	0	0
LeanYield	0.020	0.020	0.019	0.007	0.009
EweWT	0.121	0.113	0.092	−0.030	−0.135
Longevity	0.000	0.000	0.000	0.000	0.000

and Total GHG indices. The EII made more progress in NLB than any other index.

Overall genetic progress

Overall annual progress made (in farm profit and EI terms) is shown in Table 6. Selection using the DPO was estimated to contribute to the highest overall farm profit response with 81.79 NZ cents/ lamb born. Table 6 also indicates that farmers who use the DPO will likely reduce EI by a cumulative 0.081 kg CO_2e/kg lamb CWT reduction each year. This is equivalent to 0.59% of the total on-farm methane and nitrous oxide emissions for lambs estimated by Ledgard *et al.*, (2010).

The EII was estimated to produce the greatest reductions in EI with annual reductions of 0.163 kg CO_2e/kg lamb CWT (or 1.19% of total emissions per kg of lamb cwt). Overall farm profit and EI responses when animals were selected using the two DPE were intermediary between responses from the DPO and the EII.

The Total GHG index was estimated to produce the greatest reductions in total GHG per ewe with a reduction of 0.140 kg CO_2e/breeding ewe. However, selection using the Total GHG index was predicted to facilitate genetic progress which contributed to a reduction in farm profits, equivalent to 47.79 NZ cents/lamb born.

The trade-off in the DPE25, when compared to the DPO was 99.8% of the farm profit progress (achieved by the DPO), and 56% of the potential reductions in EI (using the EII). If the cost of carbon was increased, the trade-off for the DPE100 index was 96.9% of potential farm profit progress while achieving 69.8% of the potential EI reductions (using the EII). Progress in traits that contributed positively to farm profit progress was estimated for the DPE100 with 79.30 NZ cents/ lamb born pa. The DPE100 was also estimated to achieve 0.033 kg CO_2e/kg lamb CWT greater reductions in emissions compared to the DPO.

Figure 1 illustrates the trade-off between farm profit and EI progress made under the full range of indices calculated (apart from the Total GHG index which was excluded due to the scale of its values). The figure graphically illustrates how the DPE across the full range of carbon costs were intermediary in terms of progress (profit and EI) between the DPO and EII. Placing a

Table 6: Overall farm profit and EI progress made using a variety of selection indices

Parameter	Index				
	DPO	DPE25	DPE100	EII	Total GHG
Farm profit response (NZ cents/lamb)	81.79	81.60	79.30	40.42	−47.79
GHG response (kg CO_2e/kg lamb CWT)	−0.081	−0.091	−0.114	−0.163	0.117
GHG response (kg CO_2e/breeding ewe)	0.084	0.089	0.099	0.101	−0.140
Farm profit response relative to DPO index (%)	100.0	99.8	96.9	49.4	−58.4
GHG emission efficiency gains relative to GHG Intensity index (%)	49.9	56.0	69.8	100.0	−72.0
GHG Intensity reduction as % of total lamb GHG[3]	−0.59	−0.67	−0.83	−1.19	0.86

higher cost of carbon in the DPE resulted in lower farm profit progress while the reductions in EI became greater (i.e. more negative).

6. Discussion

The New Zealand Government plans to include agriculture in the ETS. This may bring about a change in the goals farmers base their sheep selection decisions on, to include reducing GHG.

Previous studies have indicated that appropriate genetic selection of animals could contribute significantly to reducing GHG in livestock enterprises (Alcock & Hegarty, 2011, Beukes *et al.*, 2010, Wall *et al.*, 2010). However, these studies calculated the GHG implications of traits in isolation and did not fully account for the sometimes unfavourable correlations between traits or the time lag effect of trait expression.

Two contrasting methods for calculating the GHG implications of traits were used in the two GHG (EII and Total GHG) indices. The EII method aimed to reduce GHG per kg of lamb cwt while the Total GHG index method aimed to reduce total GHG. Selection of sheep using the EII had an opportunity cost of lost genetic gain in traits that contribute toward farm profits. For example the overall farm profit progress using the EII was NZ 41.37 cents per lamb born pa lower than the DPO (which optimised farm profit progress). A better balance between EI and farm profit progress was made using one of the DPE indices. The trade-off between EI and farm profit progress varied depending on the price of carbon used in the DPE. However, across the range of DPE there were greater reductions in EI compared to the DPO with greater progress in traits which contribute toward farm profits than the EII.

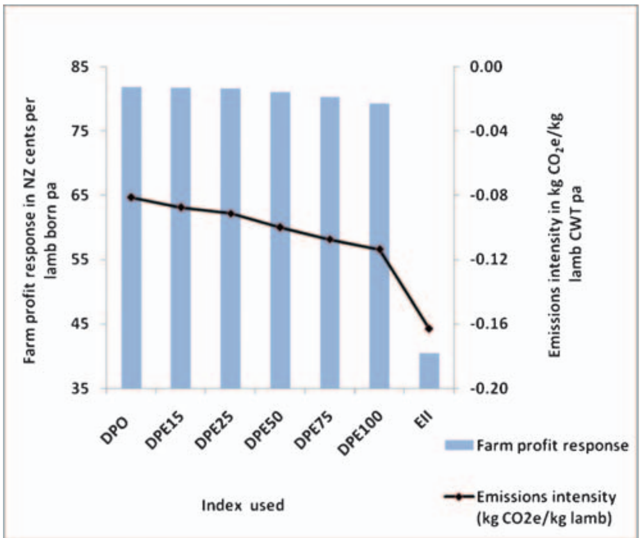

Figure 1: Farm profit and emissions intensity progress estimated using a range of selection indices

The DPE therefore offers a choice for farmers who wish to reduce their EI beyond that achievable using the DPO. It can also achieve farm profit progress greater than the EII. A higher cost of carbon in the DPE placed greater emphasis on traits that improve EI such as NLB. Although reducing EI can also improve farm profitability (as it also selects for efficiency of feed use), there is not a 1.0 correlation between EI and farm profit. Some traits which reduce EI will therefore be emphasised which do not provide optimal farm profit responses. Hence, lower farm profit progress is made as the carbon price in the DPE is increased. Farmers will therefore need to choose their preferred level of trade-off between farm profit and EI progress if they decide to use the DPE.

Reductions in EI through selection index technology can be put into perspective by relating it to total GHG for lamb production. Ledgard *et al.* (2010) reported the most comprehensive calculation of GHG for New Zealand lamb production from the farm to the point of consumption. The range of changes in GHG per unit of lamb product (using the estimate of total lamb GHG by Ledgard *et al.* (2010)) using selection indices ranged from a 0.86% per annum increase using the Total GHG index, to a 1.19% per annum decrease using the EII. Estimates of up to 22% reductions in GHG per unit product were calculated for dairy cattle through trait changes (Beukes *et al.*, 2010). Previous research has generally focussed on estimating the impact of changing traits in isolation to one another. Factors such as the correlated responses when selecting for more than one trait and the time it takes for a unit change in a trait to occur based on the heritability of traits were not taken into account. In contrast, modest (0.03% pa.) rates of reduction in methane intensity were estimated in the Welsh sheep industry (Nakielny, C. personal communications 2011) when more realistic rates of improvement were calculated. Estimates of EI for products can vary depending on the method of calculation and the inherent uncertainty associated with agricultural emission factors. However, these values still allow informative comparisons to be made. Results from New Zealand sheep in this study suggests that a breeding programme selecting for a range of traits may result in small but significant reductions in EI when compared to the overall lamb emissions. Nevertheless, genetic improvement provides permanent changes which cumulate over time (Simm, 1998) and this phenomenon could be exploited to reduce EI using a selection index.

Adoption of selection indices will be a key factor which determines the overall benefit of selection index technology on reducing an industry's GHG. An industry with a relatively high proportion of farmers who currently use a farm profit index will already have the infrastructure and knowledge of using selection indices. This will make it less costly and easier to implement a novel index which aims to provide greater reductions in GHG (such as the DPE). Industries which currently have low rates of adoption of selection indices may have higher costs to overcome to implement a DPE. However, compared to New Zealand, industries with currently low use of selection indices could receive greater marginal EI benefits from implementing either a selection index based on farm profit or one that also incorporates EI. For example, farmers who change from random selection (or selection on physical type characteristics that are not linked to farm profitability) to selection using the DPO would receive 0.59% pa greater reductions in EI. In comparison, farmers who already use the DPO would obtain 0.1% greater marginal reductions in EI if they adopted the DPE25 instead of the DPO. Therefore at an industry level there is greater potential for gains to be made in improving EI by increasing the proportion of farmers who choose to select animals based on a farm profit index (i.e. DPO), rather than alternative inefficient (or random) methods of selecting animals.

Although the New Zealand Government has a desire to reduce total GHG, the selection of sheep using an index with an objective to reduce EI would be desirable. This is because the index which aligns most closely to this goal (the EII) also selects for traits which contribute positively to farm profits. The index which aimed to reduce total GHG (Total GHG index) had selected traits which had a negative impact on farm profits. Farmers who desire improvements in farm profitability and greater reductions in EI are therefore more likely to adopt the EII compared to the Total GHG index.

A complication to the New Zealand situation for the adoption of the DPE is the incentives New Zealand farmers will have to reduce GHG. Under the proposed ETS, farmers may not receive any financial benefit for their reductions in ruminant emissions made at an 'on-farm' level. This is because the processor point of obligation used in the ETS will use New Zealand 'average' GHG emission factors rather than emission factors that alter according to changes made on individual farms.

Sheep selection using a DPE could be a management practice farmers use as evidence to negotiate lower emission factors for their sheep at the processor point of obligation compared to others in the industry. This could reduce a farmer's carbon costs when the ETS comes into effect. Alternatively, the use of a DPE could form part of a quality assurance programme in a 'low-carbon lamb' farmer supplier group. This could lead to innovative marketing strategies to extract greater value for lamb products. So the actual cost of carbon used in the DPE may not necessarily have to reflect the current market price. Farmers may choose to use a higher carbon price in their DPE if they believe they have an ability to counteract the reduction in farm profit progress by extracting benefit from elsewhere.

7. Conclusion

This study indicates there is potential to reduce GHG through the use of a selection index.

Including GHG in an index will result in less farm profit progress in traits compared to the DPO. However, the DPE can be used as a way to concurrently reduce EI and improve farm profit progress with lower opportunity costs than the EII or Total GHG index but greater reductions in EI compared to the DPO.

The trade-off between farm profit progress and reductions in EI using the DPE will depend on the cost of carbon used. Farmers who want to use the DPE may choose a cost of carbon to suit their preferred level of trade-off.

Consultation with the sheep industry could help ascertain farmers preferred level of trade-off between GHG reductions and farm profitability. Aligning farmer expectations with the index that is delivered to them would improve the level of adoption of the DPE. Discussions with farmers may also lead to the development of innovative ideas to capture greater value for their product using this technology in combination with other mitigation strategies.

About the authors

Cameron I. Ludemann

Cameron has been involved in on farm consulting and industry level research while working with AbacusBio Ltd for over two years in Dunedin, New Zealand. He is now at the Melbourne School of Land and Environment at The University of Melbourne studying for his PhD. The PhD involves modelling the impacts of forage innovations for the Australian dairy industry.

Timothy J. Byrne

Tim works as a genetics consultant with a range of technology, agribusiness and breeder clients. Tim specialises in providing advice on the development, implementation, and economic evaluation of breeding strategies. This includes development of multi-trait economic selection indexes for beef and dairy cattle, and sheep throughout New Zealand and internationally.

Jude, A. Sise

Jude is a consultant specialising in modelling and cost/benefit analyses around the use of DNA tests in sheep, and development of models to estimate greenhouse gas emissions in New Zealand farming systems.

Peter, R. Amer, PhD

Peter is a director of AbacusBio, and specialises in strategy, design and implementation of genetic improvement technologies for farmed terrestrial and aquaculture livestock. Specific expertise is in the formulation of breeding objectives, development of mating plans for commercial breeding programmes, development of genetic evaluation systems and the incorporation of genomic information into genetic evaluation results. Research and advice on these subjects is provided to clients in Australasia, Europe, South America and the Sub-Continent.

Acknowledgements

The authors wish to acknowledge the New Zealand Agricultural Greenhouse Gas Research Centre for funding support for this project as well as the anonymous peer reviewers for their contributions. This work contributes to the 'Low methane producing animals' project coordinated by AgResearch.

REFERENCES

Alcock, D. J. & Hegarty, R. S. 2011. Potential effects of animal management and genetic improvement on enteric methane emissions, emissions intensity and productivity of sheep enterprises at Cowra, Australia. *Animal Feed Science and Technology,* 166–167**,** pp. 749–760.

Amer, P. R., Nieuwhof, G. J., Pollott, G. E., Roughsedge, T., Conington, J. & Simm, G. 2007. Industry benefits from recent genetic progress in sheep and beef populations. *Animal,* 1**,** pp. 1414–1426.

Beard, K. T. 1988. Efficiency of index selection for dairy cattle using economic weights for major milk constituents. *Australian Journal of Agricultural Research,* 39**,** pp. 273–284.

Bell, M. J., Wall, E., Simm, G. & Russell, G. 2011. Effects of genetic line and feeding system on methane emissions from dairy systems. *Animal Feed Science and Technology,* 166–167**,** pp. 699–707.

Beukes, P. C., Gregorini, P. & Romera, A. J. 2011. Estimating greenhouse gas emissions from New Zealand dairy systems using a mechanistic whole farm model and inventory methodology. *Animal Feed Science and Technology,* 166–167**,** pp. 708–720.

Beukes, P. C., Gregorini, P., Romera, A. J., Levy, G. & Waghorn, G. C. 2010. Improving production efficiency as a strategy to mitigate greenhouse gas emissions on pastoral dairy farms in New Zealand. *Agriculture, Ecosystems & Environment,* 136**,** pp. 358–365.

Blaxter, K. L. & Clapperton, J. L. 1965. Prediction of amount of methane produced by ruminants. *British Journal of Nutrition,* 19**,** pp. 511–521.

Burney, J. A., Davis, S. J. & Lobell, D. B. 2010. Greenhouse gas mitigation by agricultural intensification. *Proceedings of the National Academy of Sciences,* 107**,** pp. 12052–12057.

Byrne, T. J., Ludemann, C. I., Amer, P. R. & Young, M. J. 2012. Broadening breeding objectives for maternal and terminal sheep. *Livestock Science,* 144**,** pp. 20–36.

Clark, H. 2008. *Guideline to accompany computerised inventory.* Wellington Ministry of Agriculture and Forestry. http://www.maf.govt.nz/news-resources/publications [Accessed 10 October 2011].

Casey, J. W. & Holden, N. M. 2005. Analysis of greenhouse gas emissions from the average Irish milk production system. *Agricultural Systems,* 86**,** pp. 97–114.

Cruickshank, G. J., Thomson, B. C. & Muir, P. D. 2008. Modelling management change on production efficiency and methane output within a sheep flock. Report for the Ministry for Agriculture and Forestry, New Zealand Government

DairyNZ. 2011. *News archives: a rating system for grasses*. DairyNZ. Available: http://www.dairynz.co.nz/news/pageid/2145874405 [Accessed 12 January 2012].

De Vries, A. G. 1989. A model to estimate economic values of traits in pig breeding. *Livestock Production Science,* 21**,** pp. 49–66.

Dekkers, J. C. M. 2007. Prediction of response to marker-assisted and genomic selection using selection index theory. *Journal of Animal Breeding and Genetics,* 124**,** pp. 331–341.

Eckard, R. J., Grainger, C. & De-Klein, C. A. M. 2010. Options for the abatement of methane and nitrous oxide from ruminant production: A review. *Livestock Science,* 130**,** pp. 47–56.

Emissions Trading Scheme Review Panel 2011. Doing New Zealand's fair share. Emissions trading scheme review 2011 Report for the Ministry for the Environment, New Zealand Government.

Ferris, C. P., Gordon, F. J., Patterson, D. C., Porter, M. G. & Yan, T. 1999. The effect of genetic merit and concentrate proportion in the diet on nutrient utilization by lactating dairy cows. *The Journal of Agricultural Science,* 132**,** pp. 483–490.

Herrero, M., Gerber, P., Vellinga, T., Garnett, T., Leip, A., Opio, C., Westhoek, H. J., Thornton, P. K., Olesen, J., Hutchings, N., Montgomery, H., Soussana, J. F., Steinfeld, H. & McAllister, T. A. 2011. Livestock and greenhouse gas emissions: The importance of getting the numbers right. *Animal Feed Science and Technology,* 166–167**,** pp. 779–782.

Janzen, H. H. 2011. What place for livestock on a re-greening earth? *Animal Feed Science and Technology,* 166–167**,** pp. 783–796.

Kitzes, J., Wackernagel, M., Loh, J., Peller, A., Goldfinger, S., Cheng, D. & Tea, K. 2008. Shrink and share: humanity's present and future Ecological Footprint. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 363**,** pp. 467–475.

Ledgard, S. F., Lieffering, M., McDevitt, J., Boyes, M. & Kemp, R. 2010. A greenhouse gas footprint study for exported New Zealand lamb. Report for the Ministry of Agriculture and Forestry, New Zealand Government.

Leslie, M., Aspin, M. & Clark, H. 2008. Greenhouse gas emissions from New Zealand agriculture: issues, perspectives and industry response. *Australian Journal of Experimental Agriculture,* 48**,** pp. 1–5.

Litherland, A. J., Woodward, S. J. R., Stevens, D. R., McDougal, D. B., Boom, C. J., Knight, T. L. & Lambert, M. G. 2002. Seasonal variations in pasture quality on New Zealand sheep and beef farms. *Proceedings of the New Zealand Society of Animal Production*, 62, pp. 138–142.

Lwelamira, J. & Kifaro, G. C. 2010. Desired-gain selection indices for improving performance of two Tanzania local chicken ecotypes under intensive management. *African Journal of Agricultural Research,* 5**,** pp. 133–141.

McAllister, T. A., Beauchemin, K. A., McGinn, S. M., Hao, X. & Robinson, P. H. 2011. Greenhouse gases in animal agriculture-Finding a balance between food production and emissions. *Animal Feed Science and Technology,* 166–167**,** pp. 1–6.

McClintock, A. E. & Cunningham, E. P. 1974. Selection in dual purpose cattle populations: defining the breeding objective. *Animal Science,* 18**,** pp. 237–247.

McEvoy, M., O'Donovan, M. & Shalloo, L. 2011. Development and application of an economic ranking index for perennial ryegrass cultivars. *Journal of Dairy Science,* 94**,** pp. 1627–1639.

Merks, J. W. M. 2000. One century of genetic change in pigs and the future needs. *In:* Hill, W. G., Bishop, S. C., McGuirk, B., McKay, J. C., Simm, G. & Webb, A. J. (eds.) *BSAS occasional publication* 27. Edinburgh, UK: British Society of Animal Science.

Ministry for the Environment 2010. New Zealand's greenhouse gas inventory 2000–2008. Report for the Ministry for the Environment, New Zealand Government.

Ministry for the Environment. 2011. *New Zealand's greenhouse gas inventory 1990–2009*. Wellington: Ministry for the Environment. Available: http://www.mfe.govt.nz/publications/climate/greenhouse-gas-inventory-2011/index.html [Accessed 14 October 2011].

Ministry of Agriculture and Forestry. 2011. A guide to reporting for agricultural activities under the New Zealand Emissions

Trading Scheme. Available: http://www.maf.govt.nz/news-resources/publications.aspx?title=A%20guide%20to%20Reporting%20for%20Agricultural%20Activities%20under%20the%20New%20Zealand%20Emissions%20Trading%20Scheme [Accessed 12 September 2011].

Moran, D., MacLeod, M., Wall, E., Eory, V., McVittie, A., Barnes, A., Rees, R., Topp, C. F. E. & Moxey, A. 2011. Marginal Abatement Cost Curves for UK Agricultural Greenhouse Gas Emissions. *Journal of Agricultural Economics,* 62**,** pp. 93–118.

New Zealand Treasury. 2010. *Industrial structure and principal economic sectors* [Online]. Wellington: New Zealand Treasury. Available: http://www.treasury.govt.nz/economy/overview/2010/nzefo-10-3.pdf [Accessed 14 October 2011].

O'Mara, F. P. 2011. The significance of livestock as a contributor to global greenhouse gas emissions today and in the near future. *Animal Feed Science and Technology,* 166–167**,** pp. 7–15.

Point Carbon. 2011. *Carbon market Australia-New Zealand 30 September 2011 04 (10)* Thomson Reuters. Available: http://www.pointcarbon.com/polopoly_fs/1.1593038!CMANZ20110930.pdf [Accessed 21 October 2011].

Pryce, J. E., Nielsen, B. L., Veerkamp, R. F. & Simm, G. 1999. Genotype and feeding system effects and interactions for health and fertility traits in dairy cattle. *Livestock Production Science,* 57**,** pp. 193–201.

Rockström, J., Steffen, W., Noone, K., Persson, A., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., De Wit, C. A., Hughes, T., Van Der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R. W., Fabry, V. J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J. A. 2009. A safe operating space for humanity. *Nature,* 461**,** pp. 472–475.

Simm, G. 1998. *Genetic improvement of cattle and sheep,* Ipswich, England, Farming Press.

Sise, J. A. & Amer, P. A. 2009. SNP predictors to accelerate the rate of genetic progress in sheep. *In:* Proceedings of the Association for the Advancement for Animal Breeding and Genetics, 2009 Barossa Valley, South Australia. AAABG, pp. 220–223.

Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M. & De Haan, C. 2006. *Livestock's long shadow*. Rome: Food and Agriculture Organisation of the United Nations, FAO. Available: ftp://ftp.fao.org/docrep/fao/010/a0701e/a0701e00.pdfSimilar [Accessed 10 October 2011].

Thornton, P. K. 2010. Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society B: Biological Sciences,* 365**,** pp. 2853–2867.

UNFCCC 1998. Kyoto protocol to the United Nations Framework Convention on Climate Change. Kyoto, Japan: United Nations Framework Convention on Climate Change.

UNFCCC 2010. Report of the conference of the parties on its fifteenth session, held in Copenhagen from 7 to 19 December 2009. Copenhagen, Denmark: United Nations Framework Convention on Climate Change.

Wall, E., Simm, G. & Moran, D. 2010. Developing breeding schemes to assist mitigation of greenhouse gas emissions. *Animal,* 4**,** pp. 366–376.

Watkiss, P. 2011. Monetary Valuation of Greenhouse Gases. In: Jerome, O. N. (ed.) *Encyclopedia of Environmental Health*. Burlington: Elsevier.

Young, M. J. & Amer, P. R. 2009. Rates of genetic gain in New Zealand sheep. *In:* Proceedings of the Association for the Advancement of Animal Breeding and Genetics 27th September - 2nd October 2009, 2009 Barossa Valley, Australia. AAABG, pp. 422–425.

Appendix A

Equation to estimate the change in EI (in GHG per kilogram of lamb cwt sold) from a one unit change in a trait (EI value)

$$B\_o\cdot\left(\frac{l(g)}{\Sigma y(g)}-\frac{\Sigma e(g)}{\Sigma y(g)\cdot o(g)}\right)-B\_y\cdot\frac{\Sigma e(g)}{\Sigma y(g)\cdot y(g)} + B\_l\cdot\frac{1}{y(g)}+B\_w\cdot\frac{1}{\Sigma y(g)}='Trait\ g'\ GHG_{(Intensity)}\ value\ in\ kg\ CO_2e\ per\ kg\ lamb\ carcass\ sold$$

Whereby:

- ***B_o*** is the amount by which the number of offspring per breeding female changes as trait g changes by 1 unit.
- ***B_y*** is the amount by which the amount of farm output per offspring changes as trait g changes by 1 unit
- ***B_l*** is the amount by which emissions per offspring change as trait g changes by 1 unit
- ***B_w*** is the amount the emissions per breeding female changes as trait g changes by 1 unit.

And:

- $l(g)$ is the amount of lamb emissions per offspring
- $\Sigma y(g)$ is per ewe product output i.e. an increase in emissions per breeding female increases emissions intensity according to the amount of output per breeding female
- $\frac{l(g)}{\Sigma y(g)}$ is the offspring emissions per unit of product from a breeding ewe i.e. more emissions per unit of product
- $\Sigma e(g)$ is the total lamb and ewe emissions expressed per ewe in the flock
- $o(g)$ is the number of offspring per breeding female as a function of trait g
- $\frac{\Sigma e(g)}{\Sigma y(g)}$ is the average emissions intensity for the farm
- $\frac{\Sigma e(g)}{\Sigma y(g)\cdot o(g)}$ is the average emissions intensity for the farm expressed per offspring from a breeding female i.e. extra offspring with output dilutes emissions intensity
- $\frac{\Sigma e(g)}{\Sigma y(g)\cdot y(g)}$ is the average emissions intensity for the farm expressed per unit of output from offspring i.e. extra output per offspring dilutes farm emissions intensity per unit of product
- $y(g)$ is the amount of farm output per offspring as a function of trait g i.e. an increase in emission per offspring increases emissions intensity according to the amount of output per offspring

ISSN 2047-3710

Intra-national importation of pig and poultry manure: acceptability under EU Nitrates Directive constraints

CATHAL BUCKLEY[1] and RÉAMONN FEALY[2]

ABSTRACT

Matching the agronomic limits of manure spread lands from housed animal units is an international concern where receiving lands can become over supplied and lead to water quality problems where eutrophication is a risk. Across the EU, this means establishing policy to export manures to off-farm spread lands under tight regulation. Transitional arrangements across, for example, the Republic of Ireland between 2006–2010 allowed pig and poultry manures to be spread subject only to the nitrogen amendment limits of the EU Nitrates Directive and not the phosphorus limits. From 2013 this arrangement is to be phased out, and pig and poultry producers have consequently expressed concerns about the availability of recipient spread lands for these manures. Using a national farm survey and a multinomial model this paper investigates the willingness of the farming population to import these manures. Results indicate that between 9 and 15 per cent of farmers nationally would be willing to pay to import these manures; a further 17–28 per cent would import if offered on a free of charge basis. Demand is strongest among arable farmers, younger farmer cohorts and those of larger farm size with greater expenditure on chemical fertilisers per hectare and who are not restricted by a Nitrates Directive derogation. The nature of this demand could assist in achieving environmental goals under the EU Nitrates and Water Framework Directives.

KEYWORDS: Pig and poultry manure; willingness to import; multinomial logit model

1. Introduction

The 1991 Nitrates Directive (ND) is one of the earliest pieces of EU legislation aimed at controlling and improving water quality. The ND aims to minimise surplus phosphorus (P) and nitrogen (N) losses from agriculture to the aquatic environment by constraining use to agronomic optima and limiting to periods where mobilisation during runoff events is minimised. The Directive was implemented in the Republic of Ireland through Statutory Instrument (S.I.) 378 of 2006, and updated in Statutory Instrument 101 of 2009 (Government of Ireland, 2006; 2009). Commonly referred to as the Good Agricultural Practice (GAP) regulations, these gave statutory effect to Ireland's national ND National Action Programme. The GAP regulations mandate a minimum slurry storage requirement for the housing of livestock over the winter period and closed periods for spreading organic manures during autumn and winter months. Limits on livestock intensity are also implemented to indirectly constrain organic N use to 170 kg organic N ha^{-1} per annum and up to 250 kg N ha^{-1} per annum where a derogation has been granted[3] (see Fealy et al., 2010 for a more detailed review of ND regulation requirements). The application limit of chemical fertilizers is recommended by crop type at rates defined by crop demand (Coulter and Lalor, 2008). A restriction on spreading according to a P limit is primarily related to a soil P index system which is based on the measured concentration of available P in soil as determined by the Morgan's P test (Morgan, 1941; Schulte et al., 2010).

Export-import of housed animal manures is common throughout the EU and other countries especially for intensive systems such a pig and poultry. In areas of intense pig and poultry production over fertilisation of land locally can result in negative environmental consequences for water quality (Langeveld et al., 2007). Application of these manure to suitable spread lands with correspondent nutrient demand is a challenge across many developed countries (Teira-Esmatges and Flotats, 2003; Adhikari et al., 2005; Paudel and McIntosh, 2005; Biberacher et al., 2009 Paudel et al., 2009;) especially in the EU with the advent of the Nitrates and Water framework Directives (Van der Straeten et al. 2010; Schroder and Verloop 2010; Warneck et al., 2010; Jacobson, 2011).

Across the Republic of Ireland a four year transitional arrangement between 2006–10 applied to pig and poultry manures as well as spent compost from the

[1] Agricultural Catchments Programme, Teagasc, Mellows Campus, Athenry, Co. Galway, Ireland
[2] Spatial Analysis Unit, Teagasc, REDP, Ashtown Research Centre, Dublin 15, Republic of Ireland
[3] A total of 4,190 farmers secured Derogation in 2010. This equates to 3 per cent of the population. Statistics from the Teagasc National Farm Survey 2009 (EU Farm Accountancy Data Network based) indicate a mean organic N and P across all farm systems of 95 kg Ha^{-1} and 14 kg Ha^{-1} respectively (Teagasc, 2010).

mushroom (SMC) industry (Schulte, et al., 2010). This transitional arrangement allowed these manures to be spread subject only to the N part of the regulation and not the P limits of the Directive. The Nitrates Action Programme was reviewed in 2010, and a second Action Programme has come into effect through S.I. 610 of 2010 (Government of Ireland, 2010). In the second programme, the transitional arrangements for pig and poultry manure and spent mushroom compost (SMC) were extended until 31 December 2012. However, from 1 January 2013 onwards, spreading of pig and poultry manure and SMC will be subject to maximum available P application rates. Starting from 2013, P in these organic manures may only be applied at excess rates of 5 kg ha^{-1}; from 1 January 2015 this surplus will be reduced to 3 kg ha^{-1}, and from the 1 January 2017 the transitional arrangements will end, with no further P excess allowed for pig and poultry manure or SMC. The short-term extension of the transitional period effectively recognised the difficulties that implementing the regulations would have on the pig and poultry sectors.

The phasing out of the transitional arrangements will impose significant restrictions on the use of grassland as recipient land for pig and poultry slurry. It is estimated that this could lead to a 50 per cent increase in the land area required for application of this manure (Schulte et al., 2010). From 2013 onwards, where recipient grassland fields are assumed to be in the optimum target Soil P Index 3 (5.1–8.0 mg l^{-1} available P for grass soils) [4], the annual 'maximum fertilisation rate' of P is restricted to between 15 and 29 kg ha^{-1}, depending on Nitrates Derogation and prevailing stocking rate. However, once P inputs from livestock and purchased concentrates[5] are counted and deducted from the maximum annual total P input, the amount of P that may be brought onto these grassland based holdings in the form of either chemical fertiliser or externally produced slurry / manure is likely to be minimal. This is in contrast to arable or root crop area where depending on the crop sown, and assuming P index 3 (6.1–10.0 mg l^{-1} available P for arable soils), maximum fertiliser rates range from 20 to 100 kg ha^{-1} (Government of Ireland, 2010).

Farms generating excessive supplies of N and P can either reduce production, export surpluses as processed or unprocessed manure. Burton and Turner (2003) note that the redistribution of surpluses is a particular issue in a number of EU countries (or regions therein) where local manure surpluses are particularly large due to intensive production (e.g. - Netherlands, Denmark, Belgium). Netherlands pioneered the development of a sophisticated system for distribution, control and accounting of manure from the livestock intense southern region to the more arable north. Van der Straeten et al (2010) notes the issue can be viewed as an allocative problem. Affected farmers have limited spread lands and assuming no decrease in production, are faced with two allocation options; transporting manure to other farmers' land or processing manure. The most common processing options include separation, anaerobic digestion and nitrification/de-nitrification. Teagasc Pig Development Unit (2009) notes denitrification /nitrification is only relevant when there is no economical solution to excess organic N and anaerobic digestion has nothing to offer in dealing with excess N and P. Separation of the slurry into a liquid nitrogen rich fraction and solid based phosphorus rich fraction, which is exported from the farm, has been discussed in the literature (Schroder and Verloop 2010; Jacobson, 2011). The P rich solid fraction is less bulky and can be exported at lower costs to arable farms as a substitute for chemical P fertilizer. Livestock farms could substitute the N rich liquid fraction for chemical N fertilizer. Because of the high density of pigs and cattle in some EU regions, manure processing has become more prevalent. In many cases after separation the P-rich solid fraction is composted before being exported long distances to cropland, however, land application is more difficult requiring specialist equipment (Butron and Turner, 2003; Teagasc Pig Development Unit, 2009). While processing offers an alternative to transporting slurry, it is capital and energy intensive (Lopez-Ridaura et al., 2008) and Jacobson (2011) concludes that traditional handling of animal manure has the lowest costs and separation is difficult to justify unless the farm is situated in a very livestock intensive area where it is difficult to get rid of the slurry.

In the Republic of Ireland a general response to the sector's concerns was that the pig and poultry sectors could shift the focus of land spreading to arable areas. The argument for an arable land based solution to the issue of pig/poultry manure holds that with 10 per cent of the national land area in crop production, there should be land available[6] to take the national output from pig and poultry producers. In response the pig and poultry sectors argued that the concentration of the industry in the border region of Ireland (bordering Northern Ireland) and the lack of arable land in this region could lead to the demise of these industries.

There were 1.62 million pigs in the Republic of Ireland in 2007 (CSO, 2008). The border region[7] accounted for 30 percent of the total pig population while the south west and south east accounted for 22 and 19 per cent respectively. The total poultry population was 11.9 million birds (CSO, 2008) and was dominated by the border region which accounted for 64 per cent of the total population. 375,000 hectares is devoted to cereal or root crops in the Republic of Ireland in 2009 (CSO, 2011a), approximately 10 per cent of this production takes place in the border region. The main cereal or root crop producing regions are the south east (32 per cent), mid-east (23 per cent) and the south west (17 per cent) as outlined in Table 1.

It clear from Table 1 that the border region with 30 and 64 per cent of the pig and poultry populations and 10 per cent of arable and root crop area has the greatest potential disparity between supply of these manures and

[4] Greater quantities are allowed where the field soil P index is sub-optimal level (index 1 and 2), no P is allow where soil P status is enriched at index 4. Refer S.I. No 610 of 2010 for detail of allowances.

[5] Under Nitrates regulations in the Republic of Ireland (S.I. 610 of 2010) the P content of imported feedstuffs is set at 0.5 kg P in respect of each 100 kg except where the actual P content is known and provided by the supplier. There is hence an incentive to import lower P content feedstuffs.

[6] There is no geographical restriction on recipient spread lands.

[7] The regional composition is based on the NUTS (Nomenclature of Territorial Units) classification used by Eurostat. The NUTS3 regions correspond to the eight Regional Authorities established under the Local Government Act, 1991 (Regional Authorities) (Establishment) Order, 1993, which came into operation on 1 January 1994.

Table 1: Regional distribution or pig, poultry and arable production across the Republic of Ireland

Region	Pig Population	Poultry population	Cereals & root crops area
Border	30%	64%	10%
South-West	22%	8%	17%
South-East	19%	9%	32%
Midland	14%	1%	9%
Mid-West	6%	12%	4%
Mid East	5%	4%	23%
West	3%	2%	3%

availably of recipient arable land locally. Historically, grassland farms have been the main receptors of these manures in this region. However, with the ending of the transitional arrangements in 2013, where these manures become subject to P as well as N limits, recipient grassland farms maybe become more difficult to source.

A national survey of manure application and storage practices on Irish farms (Hennessy et al, 2011) reported that 4 per cent of all farmers' imported slurry and/or farmyard manure in 2009. Of those importing, three-quarters reported importing pig slurry. The tillage farm system are the most likely to be importing, almost 20 percent of tillage farmers report that they imported organic fertilisers in 2009. Of these farms, 72 percent had imported pig slurry, 20 percent had imported cattle slurry while the remaining 8 percent had imported poultry manure.

It is estimated that pig manure generates approximately 13,500 tonnes of N and 2,600 tonnes of P annually across the Republic of Ireland (Teagasc Pig Production Development Unit, 2009). This is equivalent to 4.4 and 9.9 per cent of chemical N and P used on farms in the Republic of Ireland (DAFF, 2009). A total of 172,735 tonnes of poultry litter is produced annually (Leahy et al, 2006) it is estimated that this is equivalent to 2,708 tonnes of N and 1,120 tonnes of P based on poultry production profile data (CSO, 2009) and associated average nutrient values (Coulter and Lalor, 2008). This corresponds to 0.8 and 4.2 per cent of chemical N and P used on farms in the Republic of Ireland. The fertilizer replacement value of P for these manures is set at 100 per cent for P and 50 per cent for N under the regulations (Coulter and Lalor, 2008) although N availability maybe increased based on optimal application, timing and method.

Fealy et al., (2012) recently investigated the cost of transporting pig slurry to arable lands. They found that the average distance from a commercial pig unit to arable land was 21 kilometres. However, the counties with an average distance of less than 5 kilometres account for less than 7 per cent of total sow numbers. At the other extreme, the border and western counties had average distances of over 20 kilometres and this area accounts for over one third of all sows. Cavan a county in the border region with nearly 20 per cent of the total sow population has an average distance of 56 kilometres. McCutcheon and Lynch (2008) suggested that, depending on the dry matter content, at distances of 25 to 100 kilometres[8] the marginal cost of the manure may exceed the nutrient benefit derived from importation. This will be influenced by prevailing chemical fertiliser and fuel prices.

The decision to import pig and/or poultry manure is ultimately dependant on the nutrient value of the manure; the cost of transport and application; and farmer preferences. The nutrient value of pig and poultry manure is dependant on the price of chemical fertilisers as there is direct substitution potential. Chemical fertiliser prices have been subject to significant price volatility over the last decade as indicated by an 80 per cent increase between 2005 and 2008 (CSOa, 2011). Sales of 308,960 tonnes of nitrogen and 26,350 tonnes of P chemical fertilisers were recorded in 2008 (DAFF, 2009). Application rates of chemical N on grassland ranged from 106 kg N Ha^{-1} in the south-east to 48 kg N Ha^{-1} in the west and 75–76 N kg N Ha^{-1} in the midlands and border regions. Cereal farms in the mid-east and border regions reported the highest level of chemical N applications at 159 and 151 kg N Ha^{-1} respectively, compared to 84 kg N Ha^{-1} in the south and 128 kg N Ha^{-1} in the south-east. Average P applications on grassland were relatively uniform averaging 5 kg P Ha^{-1} ranging from 6 kg P Ha^{-1} in the south-east to 4 kg P Ha^{-1} in the west and mid-east. Chemical P application averaged 20 kg P Ha^{-1} across cereal farms ranging from 17 kg P Ha^{-1} in the mid-east to 24 kg P Ha^{-1} in the south-west (Lalor et al., 2008).

Farmers' nutrient management preferences will affect their willingness to import pig and poultry manures. Some farmers have express concern about handling pig and poultry slurry and the potential variability of nutrient content across these manures. In a tillage context, pig/poultry manure must be applied within a narrow time period, using specialist equipment, typically immediately before ploughing, hence the manure needs to be available on or close to the tillage farm at the appropriate time or storage facilities need to be available on tillage farms (Schulte et al., 2010). Livestock farmers have also expressed concerns around potential pathogens associated with these manures and many have traditional viewed these organic manures as a waste product to be disposed of more than a nutrient source (Burton and Turner, 2003). On the positive side recent research has shown that pig slurry has the potential to offset crop stressors such as drought (Plunkett, 2011).

Assuming farmer preferences are not biased against pig or poultry manure sources, economic rationality would suggest that they should consider importation of these manures if the cost of importation (nutrient value, transport and applications costs) is less than or equal to the equivalent cost of chemical fertilisers application. In this context this paper seeks to examine if there is a

[8] This range is based on dry matter content of between 3 to 6 per cent.

potential market for these organic manures and to investigate the farm and demographic variables which influence farmers' willingness to import these nutrient sources.

2. Methodology

The main data source employed in this analysis is a National Farm Survey (NFS) conducted in 2007. This NFS is collected annually as part of the Farm Accountancy Data Network requirements of the European Union (Farm Accountancy Data Network (FADN), 2005). The purpose of FADN and the NFS is to collect and analyse information relating to farm activities, financial returns to agriculture and demographic characteristics. A farm accounts book is recorded on a random representative sample of farms throughout the Republic of Ireland. The sample is weighted to be representative of farming nationally across Ireland. In the 2007 NFS survey 1,151 farmers were surveyed representing 111,913 farmers nationally.

In addition to the main survey, additional special supplementary surveys on specific topics are conducted annually. Questions investigating farmers' willingness to import pig and poultry manures onto their land were included and conducted in conjunction with the regular NFS data collection schedule in autumn 2007. Interviews were undertaken on site by a team of trained NFS recorders. Not all the respondents from the main survey participated in the supplementary survey in 2007. Hence it was necessary to re-weight the sample to produce a matched balanced dataset. The final dataset used in this analysis consisted of 986 farmers which represents 97,752 farmers when weighted and is still nationally representative at approximately 1% based on random sampling.

A multinomial logit model was used to investigate the willingness of farmers to import (WTI) pig and/or poultry manures. The landowner decision process had three exclusive outcomes, indexed by $j \in J = \{0, 1, 2\}$: not willing to import pig and/or poultry manures onto farm (j=0), willing to import pig and/or poultry on a free of charge basis where slurry, transport and spreading was free, (j=1) willing to import pig and/or poultry manures on a payment basis, where a farmer would pay towards slurry, transport and spreading (j=2). Assuming that the utility that landowner, n, derives from the chosen alternative, j (denoted U_{nj}) can be written as (Long, 1997):

$$U_{nj} = X_n \beta_j' + \varepsilon_{nj} \quad (1)$$

Where the deterministic part $X_n\beta'_j$ relates to characteristics of the landowner and ε_{nj} is an error term. The framework is based on random utility theory (McFadden, 1973 and Pudney, 1989). The probability that landowner $_n$ will select outcome j from outcome set J is then:

$$\Pr_{nj} = P(j \mid J) = \Pr\left(X_n \beta_j' + \varepsilon_{nj} > X_n \beta_k' + \varepsilon_{nk}\right) \quad \forall k \in J,\ j \neq k \quad (2)$$

By using the logistic distribution the probability, Pr, that landowner n will choose alternative j can be written as (McFadden, 1973):

$$\Pr(y_n = j) = \frac{\exp\left(x_n \beta_j'\right)}{1 + \Sigma_k^K \exp\left(x_n \beta_k'\right)} \quad (3)$$

The probabilities shown in equation (3) are those for the multinomial logit model (Long and Freese, 2006). Interpretation of multinomial logit results requires that one potential outcome is selected as the "default", hence all coefficients for a characteristic group should be interpreted as relative to a default category. In this application farmers not willing to import these manure were set as the primary base category and the model investigates factors which influence willingness to import these manure on a payment and free of charge basis.

3. Results

Descriptive analyses of results show that 58 per cent of the sample were not willing to import pig slurry and 74 per cent were not willing to import poultry manure. A total of 15 and 9 per cent indicated a WTI pig and poultry manure on a payment basis respectively, while 28 percent indicated a willingness to import pig slurry only if offered on a free of charge basis while the relevant statistic for poultry was 17 per cent as outlined in Table 2.

A number of independent variables *a priori* could be expected to affect the probability that a farmer is willingness to import these manures. These include age, expenditure on chemical fertilisers, farm size, per cent of the farm under arable crops and whether the farm is subject to Nitrates Directive derogation. These variables are included in the multinomial logit model and descriptive statistics and a definition for these variables are given in Table 3.

The multinomial logit model requires that one potential outcome be selected as the default or base category and outcomes for all other categories are interpreted relative to this base. The base category for columns 1 and 2 in Tables 4 and 5 are those landowners who were not willing to import these manures. Hence all

Table 2: Willingness of farmers to import pig and poultry manures

	Pig Manure		Poultry Manure	
	No.	%	No.	%
WTI on a payment basis	144	(15%)	92	(9%)
WTI on a free of charge basis	275	(28%)	167	(17%)
Not WTI	567	(58%)	727	(74%)
Total	986	(100%)	986	(100%)

Table 3: Descriptive statistics for variables in multinomial logit model

	Mean	S.D	Min	Max
Age (yrs)	56	12	22	86
Fertiliser expenditure (€ ha^{-1})[1]	76	56	0	381
Farm size (ha)	33	29	3	346
Per cent of farm under cereal/root crops	4	13	0	100
Nitrates derogation (% of farmers)	7	26	0	1

[1]Average fertiliser € ha^{-1} among tillage farmers in the sample was €132 ha^{-1}

coefficients should be interpreted as relative to this base category. Column 3 has a base of WTI for free and compares this with farmers who are WTI on a payment basis.

Willingness to import pig manure

Age was found to be negatively associated with WTI pig manure both on a payment and free of charge basis. Younger farmers tend to be more aware of the nutrient value and potential of these manures and hence more likely to import. Pig slurry is a direct substitute for chemical fertilisers and results indicate that farmers who are applying greater quantities of chemical fertiliser as measured here by fertiliser expenditure per hectare are significantly more likely to be willing to import pig slurry on a payment basis. Farm size is positively related to WTI (free and payment), this suggests larger more commercial farms are more willing to consider this alternative.

Derogation farmers are prohibited from importing organic manure and results reflect this, farmers not restricted under derogation were more likely to be WTI pig manure both on a free of charge and payment basis. Finally, farms with larger proportions of land devoted to arable or root crops were strongly associated with WTI on a payment basis, these farms are growing crops with higher nutrient demand and can potentially utilise these manures most efficiently by incorporation into soils at the cultivation stage.

A Wald test was performed to test whether the parameters of the model are all equal to zero. The Wald χ^2 statistic shows that, taken jointly, the coefficients for this model specification are significant at the 1% level.

Willingness to import poultry manure

Results for WTI poultry manure follow a similar pattern to that for pig manure, however the relationships were not seen to be as strong statistically. Age was again found to be negatively associated with WTI poultry manure as were restrictions under a Nitrates Directive derogation. Farm size was again positively related to WTI, particularly for those WTI on a free of charge basis. Results indicate that farmers with higher levels of expenditure on chemical fertiliser per hectare are more likely to be WTI, but the relationship was not statistically significant. As before farms with a greater

Table 4: Results of multinomial logit model examining landowner WTI pig manure

Variable	WTI – payment (Base=not willing to import) (1)	WTI – Free (Base=non willing to import) (2)	WTI – payment (Base= WTI - Free) (3)
Age	−0.017 (0.01)*	−0.19 (0.09)**	0.001 (0.011)
Fertiliser expenditure € Ha^{-1}	0.003 (0.002)*	0.002 (0.002)	0.0011 (0.0018)
Farm size (hectares)	0.01 (0.005)**	0.01 (0.004)***	−0.001 (0.004)
Nitrates derogation	−0.9 (0.42)**	−0.85 (0.35)**	−0.019 (0.459)
% of farm under arable crops	1.53 (0.63)**	0.41 (0.66)	1.05 (0.65)*
Constant	−1.38 (0.54)**	−0.56 (0.50)	−0.88 (0.594)
Log pseudo-likelihood	−842.61		
Wald chi2	37.89		

(N=975) Standard errors are given in parenthesis beside co-efficients. Individual co-efficients are statistically significant at the *10% level; **5% level; ***1% level.

Table 5: Results of multinomial logit model examining landowner WTI poultry manure

Variable	WTI – payment (Base =not willing to import) (1)	WTI - Free (Base=non willing to import) (2)	WTI – payment (Base = WTI - Free) (3)
Age	−0.003 (0.01)	−0.12 (0.011)	0.008 (0.15)
Fertiliser expenditure € Ha^{-1}	0.002 (0.002)	0.0005 (0.002)	0.001 (0.003)
Farm size (hectares)	0.008 (0.006)	0.012 (0.004)***	−0.004 (0.005)
Nitrates derogation	−0.59 (0.6)	−0.72 (0.38)**	0.13 (0.67)
% of farm under arable crops	1.9 (0.67)***	0.34 (0.64)	1.56 (0.72)**
Constant	−2.47 (0.636)***	−1.43 (0.58)**	−1.00 (0.762)
Log pseudo-likelihood	−660.74		
Wald chi2	30.95		

(N=975) Standard errors are given in parenthesis beside co-efficients. Individual co-efficients are statistically significant at the *10% level; **5% level; ***1% level.

percent of land under arable crops are significantly associated with WTI on a payment basis compared to the other two groups.

The Wald χ^2 statistic again shows that, taken jointly, the coefficients for this model specification are significant at the 1% level.

4. Discussion and Conclusions

Assuming no decrease in production, farms with excessive N and P need to export surpluses, this is either potentially a cost to the system or a benefit if a willing buyer can be located. The long term price outlook for chemical fertiliser is unclear but future energy prices and growing demand from emerging economies would tend to suggest strong future demand with upward price pressure (Heffer and Prud'homme, 2010). This may make the economics of importing pig and poultry manure attractive.

Results from this study indicate that demand for importation of pig and poultry manures is generally highest among younger farmers of larger farm size with greater expenditure on chemical fertilisers per hectare who are not restricted by nitrates derogation and who are arable orientated. The desirability of pig and poultry manure as an imported farm nutrient source will depend on a number of factors including the price of chemical fertilisers, transport and application costs and farmers nutrient preferences. A large number of farmers in this sample indicated that they would not be willing to import these manures even if offered them on a free of charge basis. Issues around nutrient variability of these manures, tight windows for application and specialist equipment necessary for application have been cited as potential constraints (Vermeire et al. 2009; Schulte et al., 2010). More research is needed to examine the rationale behind this preference. Farmers in this study were not asked how much they would be willing to pay to import pig and poultry manures; additional research is also required to establish these price schedules as it may be that farmers value these manures at less or more than chemical nutrient sources.

Pig and poultry farmers across the Republic of Ireland have expressed concerns that the phasing out of the transitional arrangements for land spreading of manures from these sectors will pose significant difficulties with associated production cost implications. However, results from this analysis indicate there is a potential market for these manures across the Republic of Ireland which could be revenue generating as there is a cohort or mainly arable farmers who are willing to import these manures on a payment basis. Historically these manures were supplied to recipient farmers free of charge, but with the increase in chemical fertiliser prices a market has developed for these manures. Depending on local supply and demand conditions these manures can be revenue generating or at least have cost sharing around transportation and spreading (Carroll, 2012).The market for these manures at present is in its infancy and tends to be between local farmers of relative close proximity based on word of mouth and some third party farm advisory facilitation. If chemical fertiliser prices continue in an upward trend and with the ending of the transitional arrangements a more nationally based market may well emerge where these manures are traded much as other agricultural commodities are at present. However, the export and trade of these manures maybe constrained by regional disparities between supply and demand. Beyond 30 kilometres the transport and spreading costs exceed the nutrient value (Fealy et al., 2012). Exporters of these manures in the southern and eastern regions are generally located close to potential arable spread lands and below this threshold. However, in the pig and poultry intensive border region average distance are over double the 30 kilometre which would involve cost subsidisation by exporters. Unless grassland recipient spread lands are available locally, then these exporters are faced with reducing production, subsidising manure redistribution or investing in processing technology as happens in Netherland, Belgium, Denmark, Italy and Spain (Burton and Turner, 2003). Recent analysis in the Republic of Ireland suggests that spreading pig manure on land is still the most economic way of utilising it and that transporting the manure over long distances still compares more favourably than the processing technology alternatives currently available (Teagasc Pig Development Department, 2011).

There is potentially a role for regulators and agricultural agencies in assisting this market to develop. It's clear from this research that demand is strongest among arable farms and this will most likely be reflected in the price they are willing to pay for these nutrient sources. Additionally, depending on the prevailing soil type and hydrology of recipient lands this could prove an environmentally positive outcome as these systems are best able to utilise these manures both from an agronomic and eco-efficiency perspective and could reduce the risk of nutrient loss to the wider water environment and assist in achieving environmental goals under the EU Nitrates and Water Framework Directives.

About the authors

Dr Cathal Buckley is an Economist on the Agricultural Catchments Programme, Teagasc. His research interests include agricultural, environmental and natural resource use economics.

Réamonn Fealy is a senior Research Officer in the Teagasc Spatial Analysis Unit. He specialises in the area of Geographic Information Systems and spatial analysis with special focus on the physical environment.

Acknowledgements

This research was funded by the Department of Agriculture, Marine and Food, Republic of Ireland. The authors wish to thank the two anonymous reviewers for their helpful comments.

REFERENCES

Adhikari, M., Paudel, K.P., Martin, N.R.J., Gauthier, W.M., 2005. Economics of dairy waste use as fertilizer in central Texas. *Waste Management*, 25 (10), 1067–107.

Biberacher, M., Warnecke, S., Brauckmann, H.J., Broll, G., 2009. *A linear optimisation model for animal farm manure* *transports in regions with high intensity animal farming*, 18th World IMACS / MODSIM Congress, Cairns, Australia.

Burton, C. H., Turner, C., 2003. *Manure management: treatment strategies for sustainable agriculture*. Quae Editions.

Carroll, C., 2012. Personal Communication – Head of Teagasc Pig Development Unit.

Central Statistics Office, 2008. *Farm Structured Survey 2007*. Available at: www.cso.ie/releasespublications/documents/agriculture/2007/farmstructure_2007.pdf [Accessed 22.07.11].

Central Statistics Office, 2011a. Area *Farmed in June by Region, Type of Land Use and Year*. Available at: <http://www.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?maintable=AQA01&PLanguage=0> [Accessed 26.10.11].

Central Statistics Office, 2011b. *Fertiliser prices*. Available at: www.cso.ie/px/pxeirestat/Dialog/Saveshow.asp [Accessed 15.07.11].

Coulter, B.S., Lalor, S., 2008. *Major and micro nutrient advice for productive agricultural crops*. Teagasc, Johnstown Castle, Wexford, Ireland.

Department of Agriculture, Fisheries and Food, Dublin, 2009. *Fertiliser Consumption*, 1989–2008.

Farm Accountancy Data Network, 2005. Concept of FADN. Available at: http://europa.eu.int/comm/agriculture/rica. [Accessed 15.04.11].

Fealy, R. M., Buckley, C., Mechan, S., Melland, A., Mellander, P. E., Shortle, G., Wall, D. and Jordan, P., 2010. The Irish Agricultural Catchments Programme: catchments selection using spatial multi-criteria decision analysis. *Soil Use and Management*, 26, 225–236.

Fealy, R., O'Donoghue,C., Hanrahan, K., Martin, M. and Rogier P.O. Schulte, R.P.O., 2012. Modelling the Gross Cost of Transporting Pig Slurry to Tillage Spread Lands in a Post Transition Arrangement within the Nitrates Directive. *Rural Economy and Development Working Paper 12-WP-RE-04*. Teagasc, Athenry, Republic of Ireland.

Government of Ireland, 2006. *European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2006)*. S.I. No. 378 of 2006. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2009. *European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2009).* S.I. No. 101 of 2009. Published by the Stationery Office, Government Publications Office, Dublin

Government of Ireland, 2010. *European Communities (Good Agricultural Practice for Protection of Waters) Regulations (2010).* S.I. No. 610 of 2010. Published by the Stationery Office, Government Publications Office, Dublin

Heffer, P., and Prud'homme, M., 2011. *Fertilizer Outlook 2011 – 2015*. Proceeding International Fertilizer Industry Association, 79th IFA Annual Conference, 23–25 May, Montreal, Canada. Available at: www.fertilizer.org/ifa/HomePage/LIBRARY/Conference-papers/Annual-Conferences/2011-IFA-Annual-Conference [Accessed 15.07.11].

Hennessy, T., Buckley, C., Cushion, M., Kinsella, A., Moran, B., 2011. *National Farm Survey of Manure Application and Storage Practices on Irish Farms*. Teagasc, Athenry, County Galway.

Jacobson, B., 2011. Costs of slurry separation technologies and alternative use of the solid fraction for biogas production or burning – a Danish perspective. *International Journal of Agricultural Management*, 1(2), 11–22.

Langeveld, J.W.A., Verhagen, A., Neeteson, J.J., van Keulen, H., Conijn, J.G., Schils, R.L. M., Oenema, J., 2007. Evaluating farm performance using agri-environmental indicators: Recent experiences for nitrogen management in The Netherlands. *Journal of Environmental Management*, 82(3), 363–376.

Leahy, M. J., Kelleher, B. P., Henihan, A. M. and Leahy, J.J. and O'Connor, J., 2006. *Mitigation of large-scale organic waste damage incorporating a demonstration of a closed loop conversion of poultry waste to energy at the point of source*. Report prepared for the Environmental Protection Agency. Available at: www.epa.ie/downloads/pubs/research/waste/poultry%20epa%20draft%20final%20report%202000-ls-1-m22.pdf [Accessed 15.07.11].

Long, S.J., 1997. *Regression models for categorical and limited dependant variables*. Sage, California, USA.

Long, S.J., Freese, J., 2006. *Regression models for categorical dependent variables using stata*. Stata Press, Texas, USA.

Lopez-Ridaura, S., Deltour, L., Paillat, J.M., van der Werf, H.M.G., 2008. *Comparing options for pig slurry management by Life Cycle Assessment*, 6th International Conference on Life Cycle Assessment in the Agri-Food Sector Zurich, Switzerland.

McCutcheon, G., and Lynch, B., 2008. *Pig manure – an asset to be managed*. Proceedings from the Teagasc National Pig conference 2008. Available at: www.teagasc.ie/pigs/conf_proceedings/pigconferenceproceedings08.pdf [Accessed 22.07.11].

McFadden, D., 1973. Conditional logit analysis of qualitative choice behavior. In: P Zarembka, ed. *Frontiers in Econometrics*. Academic Press, New York, USA.

Morgan, M.F., 1941. Chemical Soil Diagnosis by the Universal Soil Testing System. Connecticut Agricultural Experimental Station Bulletin 450.

Paudel, K.P., Bhattarai, K., Gauthier, W.M., Hall, L.M., 2009. Geographic information systems (GIS) based model of dairy manure transportation and application with environmental quality consideration. *Waste Management*, 29 (5), 1634–1643.

Paudel, K.P., McIntosh, C.S., 2005. Country report: Broiler industry and broiler litter-related problems in the south-eastern United States. *Waste Management*, 25 (10), 1083–1088.

Plunkett, M., 2011. Slurry applied to spring crops is showing a double benefit. *Irish Farmers Journal*, 14 May 2011.

Pudney, S., 1989. *Modelling individual choice*. Basil Blackwell, New York, USA.

Schroder, J.J., Verloop, J., 2010. *Slurry separation could allow a wider use of manure within the EU Nitrates Directive*, 4th Ramiran International Conference, Lisbon, Portugal.

Schulte, R.P.O., Gibson, M.T., Lalor, S.T.J., Hacket, R. *et al*, 2010. *Independent review of the science, implementation and administration of the Draft European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2010*. Carlow: Teagasc, Agriculture and Food Development Authority.

Teagasc Pig Production Development Unit, 2009. A Development strategy for the Irish Pig Industry 2008 to 2015. Available at: www.teagasc.ie/pigs/advisory_services/Strategy_group_report_Final_08.pdf [Accessed 03.11.11].

Teagasc, 2010. National Farm Survey data. Personal communication – National Farm survey Department.

Teagasc, 2011. Pig Development Department Research Dissemination Day Research Results on Alternative Uses for Pig Manure. Fermoy, Ireland.

Teira-Esmatges, M.R., Flotats, X., 2003. A method for livestock waste management planning in NE Spain. *Waste Management*, 23 (10), 917–932.

Van der Straeten, B., Buysse, J., Nolte, S., Lauwers, L., Claeys, D., Van Huylenbroeck, G., 2010. A multi-agent simulation model for spatial optimisation of manure allocation. *Journal of Environmental Planning and Management*, 53(8), 1011–1030.

Vermeire, B., Viaene, J., Gellynck, X., 2009. Effect of Uncertainty on farmers decision making: case of animal manure use. *Applied Studies in Agribusiness and Commerce*, 3(5–6), 7–13.

Warneck, S., Biberacher, M., Brackmann, H.J. and Broll, G., 2010. Nutrient best management practices need regional material flow management for soil protection. *World Congress of Soil Science*. Brisbane, Australia, August 1–6.

Adopting a Farming Systems Research Approach to carry out an economic and environmental analysis of food supply chains

ELENA TAVELLA[1], SØREN MARCUS PEDERSEN[1] and MORTEN GYLLING[1]

ABSTRACT

Agricultural systems are complex, because managers need to cope with interlinked and dynamic ecological, social, political and economic aspects. Understanding and analysing such systems requires researchers to adopt a holistic approach to grasp the links between those aspects. Holistic approaches within agricultural research – known as Farming Systems Research (FSR) support researchers in sharing knowledge and different perspectives concerning the research process and problems. Sharing knowledge and perspectives enables to holistically understand and conceptualise complex systems, as well as to structure and manage research projects.

The aim of this paper is to suggest and present a guideline for agricultural researchers to carry out an economic and environmental analysis of food supply chains with a FSR approach. We describe how participants of the EU-project SOLIBAM (Strategies for Organic and Low-input Integrated Breeding and Management) used the guideline to structure, manage and carry out an economic and environmental analysis of the food supply chains of concern. The FSR approach enabled the participants to jointly define and model the structure of the supply chains, identify the requirements for data collection and collect data.

KEYWORDS: Organic food; local food; agro-food system; systems thinking

1. Introduction

Agricultural managers face complexity and uncertainty in decision making and problem solving. Complexity is caused by the inter-connectedness of ecological, social, political and economic aspects within agricultural systems (Wilson and Morren, 1990). Fragmented and uncertain information about the system, stakeholders' divergent views concerning management activities and different interests and goals, as well as a lack in understanding of the whole system cause uncertainty (Bosch et al., 2003; Fountas et al., 2006; Bosch et al., 2007).

Agricultural researchers face similar complexity especially because their activities and results are rarely integrated with the agricultural system of concern. This often leads researchers to seek generic understandings of the system in order to come up with solutions and recommendations. Those solutions and recommendations however may differ from managers' needs and objectives (Bosch et al., 2003).

Agricultural researchers furthermore face complexity caused by the variety of organisations that participate in research projects (e.g. universities, research centres, non-agricultural ministries and non-governmental organisations), participants' multiple objectives and interests, as well as differing backgrounds, the globalisation of knowledge sharing and the need to develop and maintain partnerships (Byerlee, 1998; Gibon et al., 1999).

Some studies emphasised the need for a 'new way of thinking' and a holistic approach to agricultural research. As a response researchers suggested the application of Systems Thinking (ST) in order to understand the natural and human aspects involved in agricultural systems. ST enables researchers to view complexity from different perspectives, share knowledge and achieve a common understanding of complex agricultural systems (Wilson, 1988; Wilson and Morren, 1990; Bosch et al., 2003; 2007).

The application of ST in agricultural research, known as Farming Systems Research (FSR) has been found useful to understand and optimise agricultural systems, and to develop, test and introduce new technologies (Byerlee et al., 1982; Norman and Gilbert, 1982; Simmonds, 1985; Fox et al., 1990; Bawden, 1991; Keating and McCown, 2001; Le Gal et al., 2011). FSR – especially including hard and soft ST – has also been carried out with the purpose of structuring and managing agricultural research projects (Dillon, 1976; Collinson, 1981; Byerlee et al., 1982; Bosch et al., 2007). This paper intends to make a further contribution to this area.

[1] University of Copenhagen, Institute of Food and Resource Economics, Rolighedsvej 25, DK-1958 Frederiksberg C.

The aim of this paper is to suggest and present a guideline for agricultural researchers to carry out an economic and environmental analysis of food supply chains with a FSR approach. For this purpose, we report and illustrate how participants of the EU-project SOLIBAM (Strategies for Organic and Low-input Integrated Breeding and Management) (SOLIBAM, 2010) have used the guideline to structure, manage and carry out an economic and environmental analysis of SOLIBAM food supply chains.

2. Systems Thinking

Systems are sets of interrelated elements that form a whole and together they behave differently as when isolated (Schiere et al., 1999). The whole is framed by boundaries that define systems as subsystems of some wider system – their environment, which influences and may change the system (Ackoff, 1971). Ackoff (1971) classified systems as 'abstract systems' (e.g. languages and philosophy), 'concrete systems' (e.g. objects), 'closed systems' (systems without environment), 'static systems' (e.g. a table) and 'dynamic systems' (e.g. an automobile). In this classification he defined organisations as "purposeful systems that contain at least two purposeful elements which have a common purpose" (p. 669). Street (1990) and van der Vorst (2000) described agro-food supply chains as systems composed of interlinked organisations that produce, process and distribute food. Supply chains include suppliers, producers, customers and end-consumers, also transporters, warehouses and retailers, depending on the specific configuration (van der Vorst et al., 2007).

Organisations have been defined as 'open systems' (von Bertalanffy, 1969), as social and living systems that maintain themselves in a steady state by taking from and giving to the environment. Open systems show behaviour – they act, react and respond to changes in the environment and are controlled by human beings. The human beings involved attempt to change the rules of interaction in order to achieve a higher level of order and organisation and co-evolve with their environment (Ackoff, 1960; von Bertalanffy, 1969). The behaviour of open systems produces outputs and leads to consequences according to the pursued goals. While pursuing common goals the human beings within the system are able to adapt to the changing environment, learn, store information and use the new knowledge for changing and improving the system (Ackoff, 1971).

Systems Thinking (ST) supports researchers and practitioners in looking at everything in the world and the world as a system and "as if it were composed of systems" (Wilson and Morren, 1990, p.70). It is an approach for looking at systems from a whole perspective and understanding how the parts of the system are related to each other (Ackoff, 1971; Georgiou, 2003).

ST has been found useful to understand open systems as it enables to identify the relationships between the different elements; the influence of the external environment on the system; the cycles of input; the transformation processes within the system that create the outputs and the emergent properties (Ackoff, 1971; OConnor and McDermott, 1997; Georgiou, 2003). The emergent properties result from the interaction between the elements of a system and define its unique identity (Georgiou, 2003).

ST has been used in all fields of science. Its roots reach back to thinkers such as Nicholas of Cusa, Paracelsus and Marx, further evolved within biology, the study of living organisms and through the perception of "individual organisms as a sum of cells" (von Bertalanffy, 1969). Ludwig von Bertalanffy extended this perception to other disciplines, e.g. the inquiry within and understanding of organisations, behavioural and social science, and general complexity.

The first applications of ST in practice were carried out by the allied during the Second World War in order to tackle real world problems, optimise military operations and after the war to manage governmental and industrial engineering projects (Jackson, 2003). Such applications belong to the stance of hard ST (Checkland, 1981) which relies on quantitative, optimisation techniques. It is based on the idea that the world is a system composed of subsystems (Checkland and Scholes, 1990, p. 25) and that complexity can be shaped to fit models in order to reduce it (Wilson and Morren, 1990, p. 109; Munro and Mingers, 2002). Peter Checkland criticised hard ST for being inappropriate for dealing with the complexity in human affairs and management situations, therefore he developed Soft Systems Methodology (SSM) during the 80s as the first soft ST approach (Chekland and Scholes, 1990). Soft ST aims at managing relationships and making sense of problem situations in order to understand, improve and change them (Checkland and Holwell, 1998, p. 48). The goals of inquiry are considered to change constantly and stakeholders priorities to be conflicting (Wilson and Morren, 1990, p. 111). Complexity is approached from different points of view and a wide ranging perspective (Checkland and Holwell, 1998, p. 48). Soft ST relies on qualitative and participatory approaches, as well as systemic modelling that aims at including different human perceptions and values (White and Lee, 2009; Mingers, 2011). Soft ST has been criticised for having limited potential to ensure a proper participation of all stakeholders in decision making, also to consider disadvantaged stakeholders that are affected by the decisions, but not involved in the agreement. Besides, it has been argued that soft ST is inadequate for dealing with conflict between interest groups, a lack of common interest between stakeholders, difficulties to achieve consensus and an unequal distribution of power. Critical ST has been introduced as a response to this critique. Critical ST enables researchers and practitioners to critically choose and combine different ST methods, methodologies and techniques depending on the problem situation of concern (Jackson, 2001, 2003).

3. Systems Thinking in agriculture

Systems thinking, especially hard ST has had a long tradition within agricultural research and practice (Wilson and Morren, 1990 and Bawden, 1991 review the use of ST in agriculture). The use of ST in agricultural research, known as 'Farming Systems Research' (FSR) (Dalton, 1975; Shaner et al., 1982; Jones and Street, 1990; Schiere et al., 1999; Keating and

McCown, 2001) has been carried out in order to holistically analyse, describe and understand complex links within agricultural systems. This understanding, usually in a model format (Wilson and Morren, 1990; Keating and McCown, 2001) has been found useful for further inquiry, e.g. to predict the outcomes of different strategies; develop, test and introduce new technologies; as well as to optimise the performance and increase the productivity of systems (Byerlee et al., 1982; Norman and Gilbert, 1982; Simmonds, 1985; Fox et al., 1990; Bawden, 1991).

FSR has usually been restricted to microeconomic analysis (Fox et al., 1990) and supported by, e.g. (i) economic decision analysis for representing whole systems, identifying static input-output transformations, formulating recommendations and optimising production, (ii) dynamic production modelling that simulates the dynamics of production processes, (iii) bio-economic modelling which is useful for economic decision analysis and (iv) simulation modelling for decision support (Keating and McCown, 2001).

Similar to the evolvement of ST, farming systems researchers began to criticise hard approaches. They recognised the need for soft approaches in order to deal with value-laden complexity, ensure stakeholders' involvement and active participation in decision making, problem solving and innovation (Wilson and Morren, 1990; Ison et al., 1997; Cardoso et al., 2001; Goma et al., 2001; Stoorvogel et al., 2004).

Researchers have applied hard and soft approaches in structuring, managing and carrying out agricultural research projects (Biggs, 1994; Bosch et al., 2003; 2007). Bosch et al. (2007) described how they had used qualitative and systemic group techniques, e.g. brainstorming sessions, farm visits, discussions and workshops to conceptualise and design a research project. These group techniques supported the researchers in identifying the requirements for pursuing the research objectives and collecting data, as well as in carrying out the analysis.

Byerlee et al. (1982, p. 900) defined the collection of data as a "sequential process in which information becomes more and more detailed and focused at each subsequent step in the process". They recommended starting the survey rounds with an exploratory and qualitative approach in order to get a broad picture of the agricultural system and indentify the research priorities. Field interviews and observations may help researchers better understand the system of concern and identify the requirements for a more detailed data collection. The next survey rounds serve to collect quantitative data and focus on key variables that refer to the research questions and objectives. Quantitative data are useful to gain insight into the productivity and efficiency of the system. This insight enables researchers to identify possible weaknesses to improve and strengths to evolve, furthermore to support the development of new systems (Hart, 1982).

The combination of hard and soft approaches in FSR has also been found useful for interpreting and integrating research results and formulating policy recommendations (Bosch et al., 2007). This because soft approaches enable researchers to consider stakeholders perspectives, needs and wishes (Checkland and Scholes, 1990) concerning the system of focus.

A similar FSR approach including hard and soft ST was adopted by participants of the EU-project SOLIBAM (Strategies for Organic and Low-input Integrated Breeding and Management) in order to structure, manage and carry out an economic and environmental analysis of food supply chains.

SOLIBAM aims to "...develop specific and novel breeding approaches integrated with management practices to improve the performance, quality, sustainability and stability of crops adapted to organic and low-input systems..." A major objective is to assess economic and environmental impacts of SOLIBAM strategies (novel breeding approaches integrated with management practices) "in order to identify farm businesses, consumer preference, food supply and legislation related issues that are likely to influence their adoption" (SOLIBAM, 2010). The results are supposed to be integrated in practice and recommendations for the introduction of SOLIBAM strategies to be formulated.

To analyse SOLIBAM food supply chains from an economic and an environmental perspective the participants were first concerned with the definition of those supply chains. Second, the participants were required to identify, understand and model the structure of the supply chains of concern. Modelling would enable the participants to identify the requirements for structuring the collection of data and carrying out the analysis. A systemic approach was adopted in order to share knowledge and different perceptions among the participants, moreover to holistically understand the structure of the food supply chains and manage the research project. The FSR adopted is shown in Table 1 and some steps are illustrated next.

The FSR approach (Table 1) was conceptualised within the EU-project SOLIBAM. The participants conceptualised the research process and the food supply chains of concern by discussing in the group, carrying out brainstorming sessions and drawing on agro-food (e.g. Lyson and Green, 1999; Morgan and Murdoch, 2000; Sonnino and Marsden, 2006; Milestad et al., 2010) and FSR literature (Byerlee et al., 1982; Norman and Gilbert, 1982; Simmonds, 1985; Biggs, 1994; Gibon et al., 1999; Bosch et al., 2007). The data requirements were identified, the framework for data collection developed and the data collected during group discussions, enterprise visits and surveys.

The FSR approach (Table 1) beginning with holistically describing and understanding the complexity of agro-food systems to collecting data for socio-economic and environmental analysis is illustrated next.

4. Holistically describing and understanding the complexity of agro-food systems

First, SOLIBAM participants were concerned with the definition of the food supply chains of concern. This concern led to a discussion about the overall structure of the agro-food system. The aim was to holistically understand the agro-food system. A holistic understanding would enable to narrow down the perspective (OConnor and McDermott, 1997) on SOLIBAM food supply chains in order to define their nature, to identify their characteristics and formulate a definition. A literature review provided input for gaining an understanding

Table 1: The use of Farming Systems Research for economic and environmental analysis of food supply chains – the example of the EU-project SOLIBAM

Farming Systems Research (Byerlee et al., 1982; Norman and Gilbert, 1982; Simmonds, 1985; Biggs, 1994; Gibon et al., 1999; Bosch et al., 2007)	**EU-project SOLIBAM**
• Holistically describe and understand the complexity of agricultural systems	• Locate SOLIBAM food supply chains within the agro-food system to identify their characteristics
• Formulate the problem	• Identify, describe and understand the structure of SOLIBAM food supply chains with focus on: - the supply chain partners (number and type) - the connections between the supply chain partners - the activities carried out by each partner - the inputs that are transformed into outputs - the external elements that influence the supply chain, e.g. the labour market, consumer attitude, control authorities and the climate
• Model the system of concern to: - predict the outcomes of different farming strategies - optimise the performance of the system - increase the productivity of the system - involve stakeholders - make decisions - improve and innovate structures and processes	• Model the structure of SOLIBAM food supply chains to visualise the internal and external elements and their connections (Fig. 3)
• Collect qualitative data to identify the data requirements	• Identify the data requirements among the project participants • Develop the framework for data collection in collaboration with project participants
• Collect quantitative data	• Collect quantitative data during surveys and interviews with stakeholders – examples of necessary data: - building and machinery inventory (price, technological features, interest rate, insurance and life time) - fuel (quantity and price) - feed (quantity and price) - fertilisation (quantity and price) - plant protection (quantity and price) - crop rotation (% of crop to the total area) - work processes (number of passes and machinery used) - labour (number of man-hours and wage) - sold product quantities (volume/number and price) - distances between suppliers and consumers
• Calculate a solution	• Assess the financial impact (e.g. gross margins, net income, net present values and internal rate of return) • Assess the environmental performance indicators (e.g. N-leaching, phosphorus applications, C02-emissions, odour, chemical treatment index and animal welfare) • Asses the degree of product diversity and biodiversity • Assess the supply chain internal distribution of net benefits
• Test the model and the solution	• Compare SOLIBAM strategies to other agricultural practices, e.g. other organic, low-input and conventional practices
• Implement the solution	• Formulate recommendations for implementing the SOLIBAM strategies and developing regulations among partners. Consider the involvement of stakeholders and their perspectives.

of the agro-food system and discussing possible alternatives for its conceptualisation.

The literature distinguishes between ‘conventional/alternative’ (Morgan and Murdoch, 2000; Sonnino and Marsden, 2006) and ‘global/local’ (Lyson and Green, 1999; Milestad et al., 2010) food systems. A major difference between ‘conventional/alternative’ concerns the nature of the relationships between food suppliers and consumers. Conventional food systems rely on long-distance relationships that limit direct communication not only between suppliers and consumers, but also between the suppliers themselves. Alternative food systems, on the other hand are built on trust, familiarity and direct relationships that enable sharing of value-laden information between suppliers and consumers, as well as learning and collaboration among suppliers (Hinrichs, 2000; Morgan and Murdoch, 2000; Sonnino and Marsden, 2006).

Similarly, the distinction 'global/local' refers to the relationships between the people involved (Hinrichs, 2000; Milestad et al., 2010). The definition of 'global' includes aspects such as mass production and uniform diets; fewer, larger and low diversified farms; economic self-interest and maximisation of profit; and the dominance of marketing and supply firms over farmers and local communities. The term 'local', in comparison refers to aspects such as diversity in production, distribution and marketing; the support of local diets; economic returns to the farming sector and the development of social capital; the distribution of power among individuals and families; community building; and short distances between suppliers and consumers (Lyson and Green, 1999; Ilbery et al., 2006; Ilbery and Maye, 2006).

The aspects of 'local' and 'alternative' food systems are connected with each other. 'Alternative' has been related to local food systems, as well as local production, distribution and consumption of often organic food and short food supply chains (SFSCs) (Hinrichs, 2000; Marsden et al., 2000; Sonnino and Marsden, 2006). SFSCs are classified as (i) "face-to-face" supply chains, in which consumers directly purchase products from the suppliers, e.g. at farmers markets and street stands, and in farm shops; (ii) "spatial proximity" supply chains, where production and distribution of food occur locally, e.g. through local shops, box schemes, restaurants, hotels, schools and the internet; and (iii) "spatially extended" supply chains, in which food is produced in a specific region, but also distributed outside the region, e.g. through the internet and (inter)national channels (Marsden et al., 2000). Especially, the distribution of food within "face-to-face" supply chains enables direct communication among suppliers and between suppliers and consumers. Suppliers and consumers experience the value of social ties as they get to know each other, share feelings, opinions and perceptions (Marsden et al., 2000; Sage, 2003).

Following the literature review, SOLIBAM workshops and group discussions the agro-food system was conceptualised as consisting of a 'global' and an 'alternative' food system (Figure 1). The distinction 'conventional/alternative' (Morgan and Murdoch, 2000; Sonnino and Marsden, 2006) and 'global/local' (Lyson and Green, 1999; Milestad et al., 2010) food systems implies an explicit connection between 'alternative' and 'local', but not necessarily between 'conventional' and 'global'. The main reason for drawing this distinction is that organic food is not only produced, processed and distributed within the local, alternative food system by small-scale enterprises (Milestad et al., 2010), but also within the global food system by large, more conventionally oriented enterprises. The alternative food system, besides, does not only include local organic, but also local non-organic food enterprises (Ilbery and Maye, 2005). Local non-organic food enterprises are not certified organic (EC 834/2007), but are small-scale and produce, process and distribute food based on sustainability principles.

This conceptualisation enabled the participants to focus on the subsystems of the agro-food system and think about SOLIBAM food supply chains as embedded within the system.

5. Formulating the problem: identifying and describing food supply chains

During project meetings and brainstorming sessions the participants formulated a definition of SOLIBAM food supply chains and defined them as: short, local, diverse and sustainable; based on ethical aspects, as well as collaboration, direct contact, mutual trust and confidence among the supply chain partners. Besides, the supply chains were characterised as consisting of small-scale enterprises that produce organic vegetables, cereals, flour, bread and/or dairy products that are directly sold to consumers (e.g. at farmers' market) or to cooperatives, local shops and restaurants.

The discussion concerning the definition of SOLIBAM food supply chains led the participants to consider where to locate the supply chains within the overall agro-food system (Figure 2). The participants felt that locating the supply chains within the broader agro-food system would support them in comparing

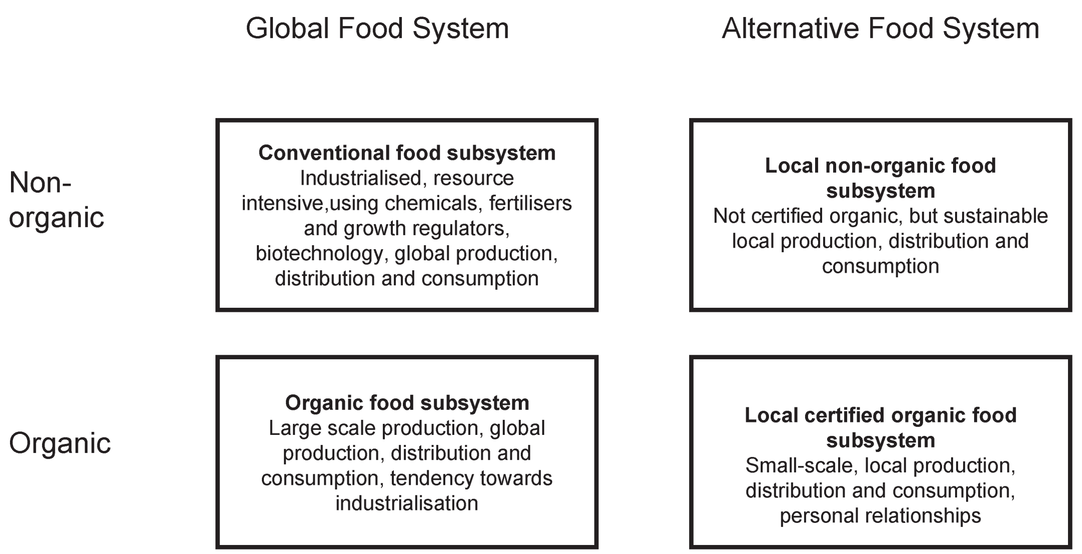

Figure 1: The agro-food system – conceptualised within the EU-project SOLIBAM

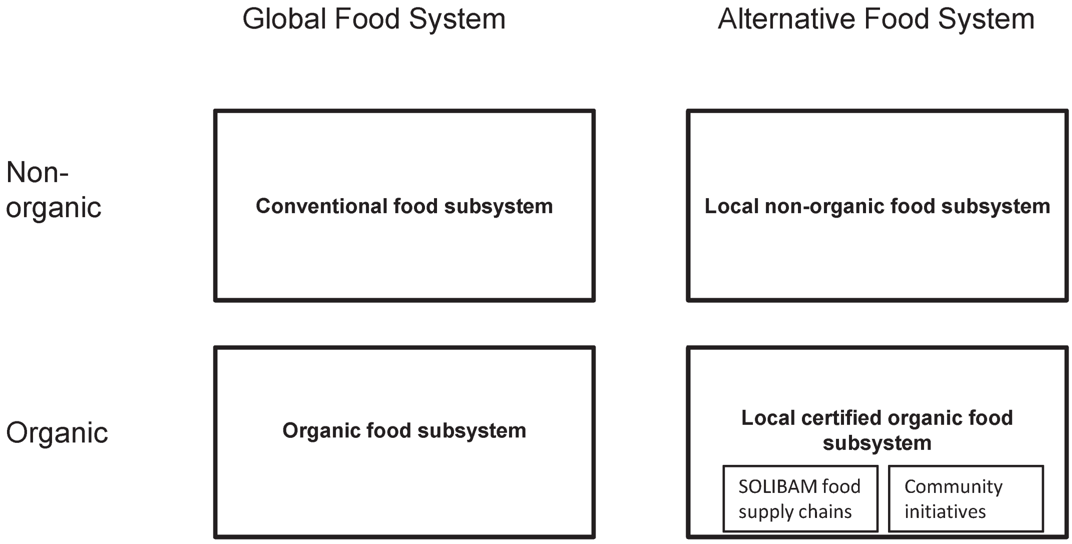

Figure 2: The location of SOLIBAM food supply chains within the overall agro-food system

SOLIBAM strategies with current organic and non-organic agricultural practices. This comparison would help illustrate and emphasise the results of the economic and environmental analysis and support the recommendations for the adoption of the innovative strategies.

In figure 2 SOLIBAM food supply chains are represented as a subsystem of the 'local certified organic food subsystem'. This subsystem may also include other local certified organic subsystems that are not structured as supply chains, but that are formed by 'community initiatives' (e.g. Community Supported Agriculture and Community Gardens). Within community initiatives consumers are involved and participate in growing food, which they directly purchase at the farming site. Besides, consumers and producers engage in community building, e.g. joint learning and decision making, recreation and mental well being (King, 2008). Supply chains, on the other hand consist of interlinked organisations that produce, process and distribute food. Moreover, consumers do not participate in food production, but purchase food from suppliers and retailers (van der Vorst et al., 2007).

6. Modelling food supply chains

During enterprise visits and group discussions SOLIBAM participants modelled the structure of SOLIBAM food supply chains by adopting a systemic view. This is illustrated with an example of a food supply chain in France (Figure 3).

The example shows a farm which cultivates cereals (wheat, rye, einkorn wheat and barley), peas and grassland. Barley, peas and grass are used for feeding livestock. The farm purchases production factors such as fuel, the tractor and equipment for haymaking from the agri-supply industry and shares other equipment within a CUMA-network (a farmers' cooperative). Own manure is used for fertilisation and seed is provided by a 'Participatory Plant Breeding' (PPB) network. In PPB networks farmers, researchers, seed producers and traders collaborate with the aim to develop new varieties adapted to local field circumstances and users' needs (Ceccarelli and Grando, 2009).

The farmer produces and sells flour, meat and dairy products (e.g. yogurt, cheese, butter and cream) to a cooperative for organic food (biocoop France), meat to an organic shop and a restaurant, moreover flour and dairy products directly to consumers at the farm and farmers' markets. The supply chain is here represented as a system composed of interrelated elements and framed by boundaries. The links between the elements enable material, information and financial flows – the emergent properties that characterise the identity of the system. These flows need to be coordinated and controlled by the humans involved in the system in order to meet demand and achieve competitiveness (Stadtler, 2005). The environment surrounding the supply chain provides resources such as solar energy, water, CO_2, minerals and soil that go into the production processes, the transformations from inputs into outputs (the products sold). Other factors, e.g. national and international control authorities, the labour market, demography, norms, believe, consumer attitude, finance and investment also influence the supply chain and contribute to the transformations.

Modelling the food supply chains enabled the participants to identify the partners involved, the activities they carry out and the products they supply. The identification of these elements was necessary in order to clarify the data requirements for economic and environmental analysis, build a framework for data collection and collect data.

7. Collecting data, calculating and implementing solutions

Based on the supply chain models SOLIBAM participants identified the data requirements for economic and environmental analysis during workshops and group discussions. To identify the data requirements qualitative surveys (as suggested in Table 1) were not necessary. Some project participants have been collaborating with the enterprises involved for many years,

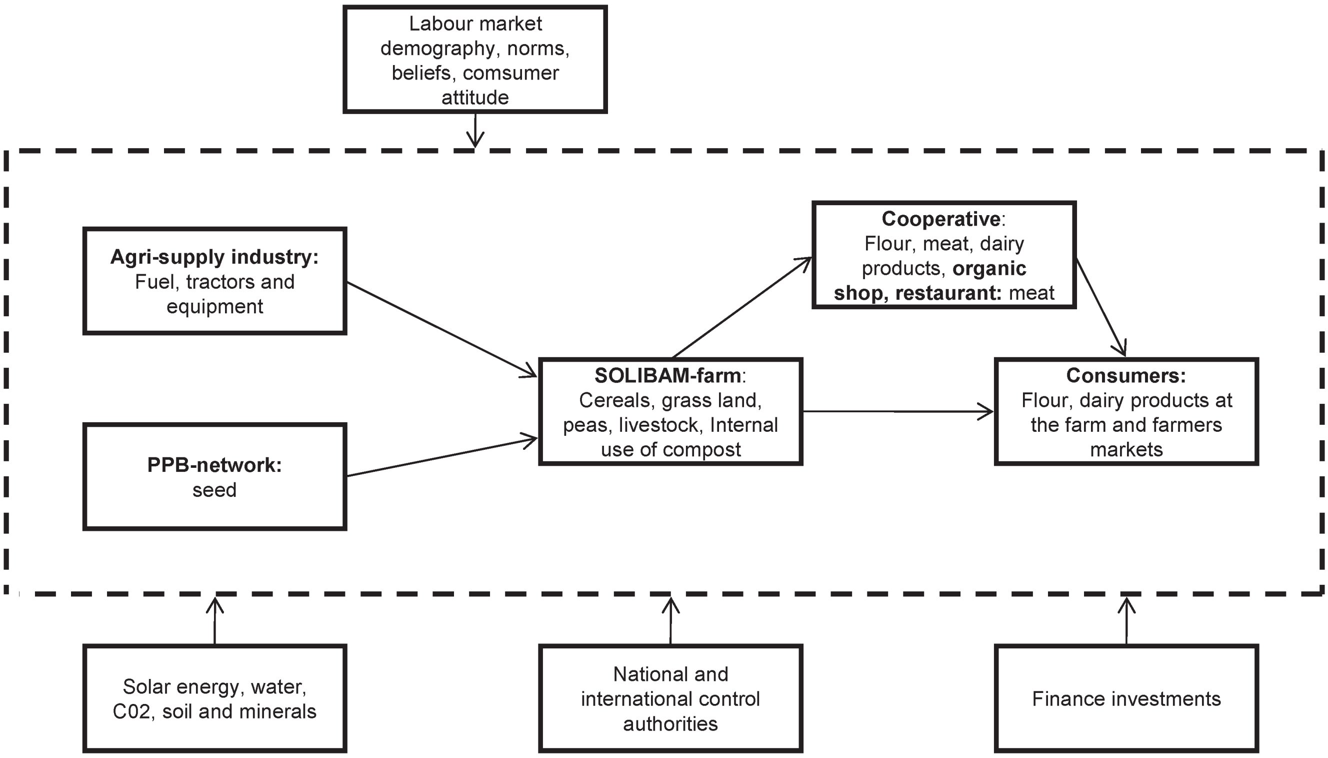

Figure 3: A systemic view on food supply chains – an example of a SOLIBAM food supply chain in France

thus were aware of the specific features within the individual enterprises.

Data were collected during enterprise surveys, and the analysis and formulation of recommendations for implementing SOLIBAM strategies will follow (EU-SOLIBAM runs until 2015). Following the steps to calculate and implement a solution (see Table 1), researchers can analyse the products supply chains and formulate recommendations from a whole system, as well as from an individual partner's perspective. The analysis approaches, e.g. gross margin and net income calculations, and emission assessment allow shifting the analytical lens from a whole system to an individual partner's perspective by adapting the mathematical formulas respectively.

8. Discussion and conclusion

This paper has reported and illustrated how SOLIBAM participants used a FSR approach including hard and soft ST to structure, manage and carry out an economic and environmental analysis of food supply chains. The FSR approach (Table 1) enabled the participants to holistically understand and conceptualise the agro-food system (Figure 1) and narrow down the perspective on the supply chains of concern. Subsequently, the participants defined SOLIBAM food supply chains, located them within the broader agro-food system (Figure 2) and modelled their structure (Figure 3). Modelling the supply chains supported the participants in identifying the data requirements for economic and environmental analysis, build a framework for data collection and collect data.

The FSR approach was carried out during project workshops, group discussions, brainstorming sessions, enterprise visits and surveys. These enabled the participants to share knowledge and experiences (Bosch et al., 2003; 2007), to look at the research objectives and approach from different perspectives and holistically understand (Wilson and Morren, 1990; Keating and McCown, 2001; Bosch et al., 2007) the food supply chains of concern.

As described in previous studies FSR is useful for developing and conceptualising research problems and projects (Byerlee et al., 1982; Norman and Gilbert, 1982; Simmonds, 1985; Biggs, 1994; Gibon et al., 1999; Bosch et al., 2007), because it allows for consideration of interlinked aspects within the agricultural system, as well as interlinked activities within the research project (Bosch et al., 2007). This paper has contributed to those FSR studies by providing a further example of how FSR has been used to conceptualise a research project (the economic and environmental analysis of SOLIBAM food supply chains) and the problems encountered (the need to holistically understand the agro- food system; locate, define and model the SOLIBAM food supply chains).

The aim of this paper was to suggest and present a stepwise FSR approach to economic and environmental analysis of food supply chains (Table 1), which may be used as a guideline for similar research. This guideline suggests how to achieve understanding of food supply chains, model their structure, collect data for economic and environmental analysis and carry it out.

Drawing on the above illustration of the FSR approach and the SOLIBAM experience it can be suggested that considering the guideline for economic and environmental analysis of food supply chains is useful. This because FSR – especially when comprising soft and hard approaches supports researchers in systematically tackling the complexity within agricultural systems (Bosch et al., 2003; Fountas et al., 2006; Bosch et al., 2007) and research projects (Byerlee, 1998; Gibon et al., 1999; Bosch et al., 2003). The adoption of soft approaches such as group discussions and brainstorming sessions enabled SOLIBAM participants to share different knowledge about the food supply chains of concern, thus to achieve a better common understanding of the research problem. Group discussions also helped the participants consider different perspectives on how to structure, manage and carry out the research project. The use of hard approaches such as the calculation of gross margins and emissions will enable the participants to identify the economic and environmental performance of SOLIBAM innovations and assess their impact on the supply chains, as well as the partners involved.

The guideline shows how economic and environmental analysis of food supply chains may be carried out and identifies steps to follow. Following those steps may not only help researchers structure and manage their analysis, but also consider alternative courses of action (Biggs, 1994). As Biggs (1994) emphasised it is important that researchers develop approaches, strategies and guidelines that account for the requirements of their specific research project and problems. A focus on the requirements of specific research projects and problems is important in order to achieve a detailed understanding of the system to be analysed and to integrate the results in recommendations for practice and policy making (Bosch et al., 2003; 2007).

It is hoped that the guideline presented within this paper provides inspiration for similar economic and environmental analysis of food supply chains, as well as for further development of research approaches, strategies and guidelines.

About the authors

Elena Tavella (eta@foi.ku.dk) is a PhD-fellow and her main research areas are the design and management of alternative food networks and Systems Thinking. She holds a degree in Agriculture with specialisation in Agricultural Economics and Marketing.

Søren Marcus Pedersen is Senior Researcher and his main research areas are technology assessment, production economics and agricultural systems. He has 15 years experience with international research projects in technology assessment and production economics in the agro-food sector.

Morten Gylling is a Senior Advisor and his main research areas are socio-economic analysis of agricultural systems, alternative food systems and production economics. He has several years experience with international applied research projects and consultancy in the agro-food sector.

Acknowledgements

The authors wish to acknowledge the helpful comments made by the two anonymous reviewers that helped improve the article considerably. We also wish to thank the partners involved in the project EU-SOLIBAM who contributed to carry out this research.

REFERENCES:

Ackoff, R.L. 1960. Systems, organizations, and interdisciplinary research. *General Systems Yearbook,* 5, pp.1–8.

Ackoff, R.L. 1971. Towards a system of systems concepts. *Management Science,* 17(11), pp.661–671.

Bawden, R.J. 1991. Systems Thinking and Practice in Agriculture. *Journal of Dairy Science,* 74, pp.2362–2373.

Biggs, S.D. 1994. Farming Systems Research and Rural Poverty: Relationships between Context and Content. *Agricultural Systems,* 47, pp.161–174.

Bosch, O.J.H., Ross, A.H. and Beeton, R.J.S. 2003. Integrating Science and Management Through Collaborative Learning and Better Information Management. *Systems Research and Behavioral Science,* 20, pp.107–118.

Bosch, O.J.H., King, C.A., Herbohn, J.L., Russell, I.W. and Smith, C.S. 2007. Getting the Big Picture in Natural Resource Management – Systems Thinking as 'Method' for Scientists, Policy Makers and Other Stakeholders. *Systems Research and Behavioral Science,* 24, pp.217–232.

Byerlee, D., Harrington, L. and Winkelmann, D.L. 1982. Farming Systems Research: Issues in Research Strategy and Technology Design. *American Journal of Agricultural Economics,* 64(5), pp.897–904.

Byerlee, D. 1998. The Search for a New Paradigm for the Development of National Agricultural Research Systems. *World Development*, 26(6), pp.1049–1055.

Cardoso, I.M., Guijt, I., Franco, F.S., Carvalho, A.F. and Neto, P.S.F. 2001. Continual learning for agroforestry system design: university, NGO and farmer partnership in Minas Gerais, Brazil. *Agricultural Systems,* 69, pp.235–257.

Ceccarelli, S. and Grando, S. 2009. Participatory Plant Breeding in Cereals. In: M.J. Carena, ed. 2009. *Cereals. Handbook of Plant Breeding.* Springer Science + Business, LLC, pp.395–414.

Checkland, P. 1981. *Systems Thinking, Systems Practice*. Chichester: John Wiley & Sons Ltd.

Checkland, P. and Holwell, S. 1998. *Information, Systems and Information Systems – making sense of the field*. Chichester: John Wiley & Sons Ltd.

Checkland, P. and Scholes, J. 1990. *Soft Systems Methodology in Action*. Chichester: John Wiley & Sons Ltd.

Collinson, M. 1981. A Low Cost Approach to Understanding Small Farmers. *Agricultural Administration,* 8(6), pp.433–450.

Dalton, G.E. ed. 1975. *Study of Agricultural Systems*. Essex: Applied Science Publishers Ltd.

Dillon, J.L. 1976. The economics of systems research. *Agricultural Systems,* 1, pp.5–22.

EC 834/2007. Council Regulation of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91, pp.1–22.

Fountas, S., Wulfsohn, D., Blackmore, B.S., Jacobsen, H.L. and Pedersen, S.M. 2006. A model of decision-making and information flows for information-intensive agriculture. *Agricultural Systems,* 87, pp.192–210.

Fox, R., Finan, T., Pearson, S. and Monke, E. 1990. Expanding the Policy Dimension of Farming Systems Research. *Agricultural Systems*, 33, pp.271–287.

Georgiou, I. 2003. The idea of emergent property. *The Journal of the Operational Research Society,* 54(3), pp.239–247.

Gibon, A., Sibbald, A.R., Flamant, J.C., Lhoste, P., Revilla, R., Rubino, R. and Sørensen, J.T. 1999. Livestock farming systems research in Europe and its potential contribution for managing towards sustainability in livestock farming. *Livestock Production Science,* 61, pp.121–137.

Goma, H.C., Rahim, K., Nangendo, G., Riley, J. and Stein, A. 2001. Participatory studies for agro-ecosystem evaluation. *Agriculture, Ecosystems & Environment,* 87(2), pp.179–190.

Hart, R.D. 1982. An Ecological Systems Conceptual Framework for Agricultural Research and Development. In: W.W. Shaner, P.F. Philipp and W.R. Schmehl eds. 1982. *Readings in Farming Systems Research and Development*. Colorado: Westview Press, Inc. pp.44–58.

Hinrichs, C.C. 2000. Embeddedness and local food systems: notes on two types of direct agricultural market. *Journal of Rural Studies,* 16, pp.295–303.

Ilbery, B. and Maye, D. 2005. Food supply chains and sustainability: evidence from specialist food producers in the Scottish/English borders. *Land Use Policy,* 22, pp.331–344.

Ilbery, B. and Maye, D. 2006. Retailing local food in the Scottish-English borders: A supply chain perspective. *Geoforum,* 37(3), pp.352–367.

Ilbery, B., Watts, D., Simpson, S., Gilg, A. and Little, J. 2006. Mapping local foods: evidence from two English regions. *British Food Journal,* 108(3), pp.213–225.

Ison, R.L., Maiteny, P.T. and Carr, S. 1997. Systems Methodologies for Sustainable Natural Resources Research and Development. *Agricultural Systems,* 55(2), pp.257–272.

Jackson, M.C. 2001. Critical systems thinking and practice. *European Journal of Operational Research,* 128(2), pp.233–244.

Jackson, M.C. 2003. *Systems Thinking: Creative Holism for Managers*. Chichester: John Wiley & Sons Ltd.

Jones, J.G.W. and Street, P.R. eds. 1990. *Systems Theory Applied to Agriculture and the Food Chain*. Essex: Elsevier Science Publishers Ltd.

Keating, B.A. and McCown, R.L. 2001. Advances in farming systems analysis and intervention. *Agricultural Systems,* 70(2–3), pp.555–579.

King, C.A. 2008. Community Resilience and Contemporary Agri-Ecological Systems: Reconnecting People and Food, and People with People. *Systems Research and Behavioural Science,* 25, pp.111–124.

Le Gal, P.Y., Dugué, P., Faure, G. and Novak, S. 2011. How does research address the design of innovative agricultural production systems at farm level? A review. *Agricultural Systems*, 104, pp.714–728.

Lyson, T.A. and Green, J. 1999. The Agricultural Marketscape: A Framework for Sustaining Agriculture and Communities in the Northeast. *Journal of Sustainable Agriculture,* 15(2), pp.133–150.

Marsden, T., Banks, J. and Bristow, G. 2000. Food Supply Chain Approaches: Exploring their Role in Rural Development. *Sociologia Ruralis,* 40(4), pp.424–438.

Maxwell, S. 1986. Farming Systems Research: Hitting a Moving Target. *World Development,* 14(1), pp.65–77.

Milestad, R., Bartel-Kratochvil, R., Leitner, H. and Axmann, P. 2010. Being close: The quality of social relationships in a local organic cereal and bread network in Lower Austria. *Journal of Rural Studies,* 26(3), pp.28–240.

Mingers, J. 2011. Ethics and OR: Operationalising discourse ethics. *European Journal of Operational Research,* 210(1), pp.114–124.

Morgan, K. and Murdoch, J. 2000. Organic vs. conventional agriculture: knowledge, power and innovation in the food chain. *Geoforum,* 31(2), pp.159–173.

Munro, I. and Mingers, J. 2002. The use of multimethodology in practice – results of a survey of practitioners. *The Journal of the Operational Research Society,* 53(4), pp.369–378.

Norman, D.W. and Gilbert, E. 1982. A General Overview of Farming Systems Research. In: W.W. Shaner, P.F. Philipp and W.R. Schmehl eds. *Readings in Farming Systems Research and Development*. Colorado: Westview Press, Inc., pp.17–30.

OConnor, J. and McDermott, I. 1997. *The art of Systems thinking. Essential skills for creativity and problem solving*. London: Thorson.

Sage, C. 2003. Social embeddedness and relations of regard: alternative 'good food' networks in south-west Ireland. *Journal of Rural Studies,* 19(1), pp.47–60.

Schiere, J.B., Lyklema, J., Schakel, J. and Rickert, K.G. 1999. Evolution of Farming Systems and System Philosophy. *Systems Research,* 16, pp.375–390.

Shaner, W.W., Philipp, P.F. and Schmehl, W.R. eds. 1982. *Readings in Farming Systems Research and Development*. Colorado: Westview Press Inc.

Simmonds, N.W. 1985. *Farming Systems Research. A Review*. Washington: The World Bank.

SOLIBAM, 2010. http://www.solibam.eu, accessed 2011-09-07.

Sonnino, R. and Marsden, T. 2006. Beyond the divide: rethinking relationships between alternative and conventional food networks in Europe. *Journal of Economic Geography,* 6, pp.181–199.

Stadtler, H. 2005. Supply chain management and advanced planning-basics, overview and challenges. Invited review. *European Journal of Operational Research,* 163, pp.575–588.

Stoorvogel, J.J., Bouma, J. and Orlich, R.A. 2004. Participatory research for systems analysis: prototyping for a Costa Rican banana plantation. *Agronomy Journal,* 96(2), pp.323–336.

Street, P.R. 1990. A Systems View of Commercial Supply and Marketing Links. In: J.G.W Jones and P.R. Street eds. 1990. *Systems Theory to Agriculture and the Food Chain*. Essex: Elsevier Science Publishers Ltd. pp. 159–203.

van der Vorst, J.G.A.J. 2000. *Effective food supply chains: Generating, modeling and evaluating supply chain scenarios*. PhD thesis. Wageningen University, Wageningen, Holland.

van der Vorst, J.G.A.J., da Silva, C.A. and Trienekens, J.H. 2007. *Agro-industrial supply chain management: concepts and applications*. Rome: Food and Agriculture Organization of the United Nations.

von Bertalanffy, L. 1969. *General System Theory. Foundations, Development, Applications. Revisited Edition*. New York: George Braziller, Inc.

White, L. and Lee, G.J. 2009. Operational research and sustainable development: Tackling the social dimension. *European Journal of Operational Research,* 193(3), pp.683–692.

Wilson, J. 1988. *Changing Agriculture, An Introduction to Systems Thinking*. Kenthurst: Kangaroo Press.

Wilson, K. and Morren, G.E.B., J.r., 1990. *Systems Approaches for Improvement in Agricultural and Resource Management*. New York: Macmillan Publishing Company.

BOOK REVIEW

Economics of Farm Management in a Global Setting

Kent D. Olson

University of Minnesota, Published November 5, 2010, copyright © 2011 (www.wiley.com/college/olson) by John Wiley & Sons, Inc., (Hoboken, NJ). 560 pp. Hardcover: ISBN 978-0-470-59243-4. Price $123.95 USD/£42.99. E-book, March 2012: ISBN 978-0-470-91377-2. Price $74.50 USD/£26.87.

The study of the economics of farm management covers an enormous area especially when viewed in a global and competitive setting.

This new and up to date textbook offers a refreshingly original and agreeable style and has the capacity to be used at different levels, from the basic understanding of farm management through to those seeking a more advanced level where it can be of value for reference or applied to the development of farm business plans.

In the context of global change following recession this book is a welcome addition, one of the main objectives of the book being to introduce readers to the key concepts of farm management and its application for decision making in the industry.

The book, through its wide subject base and the applied practical nature of its content, meets its objectives to suit and be appropriate for its varied level of target audience. The focus takes the reader not only through operational procedures but the development of farm strategy and production of a viable and sustainable business plan. The author guides the user on how to derive the maximum benefit from the text and suggests varying sequences for use in academic sessions depending on the level and output sought.

The chapters in the book are logically laid out, building up a picture of the economics of farm management and the practical implications in a global setting. Each chapter progresses through the activities logically through to the events that relate to the specific subject area; including activities, economic environment, the functions, associated skills and the decision processes. Tables are well constructed, user friendly and well-illustrated. Financial costings and legal aspects are dealt with from a US viewpoint but this does not tend to distract from the sound methodology which can be applied across boundaries. Each chapter ends with summary bullet points and has review questions which probe the reader's understanding, together with guidance for further reading. Additional study notes and further examples which incorporate updating are available via the author's website together with PowerPoint slides for lecturers - an innovative development.

In the first section the author incorporates chapters 1–3 which consider the concept of a global economy and give a good insight into the functions of management activities incorporating planning, controlling and the decision process with good examples given regarding the application of a business plan.

The second section summarises lessons from economics and considers policy issues on a world stage. Chapters 4, 5 and 6 specifically look at microeconomics for the understanding of business and the decisions of others followed on by the concepts of macroeconomics, all-important after the global recession where economic growth, inflation, employment, trade and banking issues are considered. Although the emphasis tends to be on the US, lessons can be applied across borders. Policy issues and the resultant impact on world trade are discussed; this is good reading from a student perspective and gives a broad overview, but may be passed over by practitioners.

The third section, Chapters 7–11, introduces and focuses on strategic planning, its values and objectives. External and internal analysis including traditional techniques such as SWOT and Porter's Five Forces are considered with examples illustrating application in a commercial situation. The author goes into considerable detail regarding the crafting of a strategy, and this may prove a little heavy for some readers; however tests for evaluating strategies including risk are incorporated in the text and have applied practical uses. The section concludes with marketing; despite the chapter implying it deals with only the basics it gives excellent coverage, illustrating to great effect how the need to know how markets function and how businesses can benefit from a good marketing strategy.

The fourth section, Chapters 12–14, covers financial statements, incorporating the key issues of analysis and financial positioning of businesses. The concepts are well illustrated and the point is well made that businesses that lack knowledge of how to build, understand and interpret statements will struggle in the global economy post-recession. Traditional measures such as solvency, profitability, liquidity, repayment capacity and financial efficiency are covered. Appropriate consideration is given to sources and uses of funds, discount rates, credit and control. All these areas are approached with sufficient detail to make them a useful applied management tool. The text is well illustrated with clear tables and suggested layouts for statements: again the reference is to US standards but this does not detract from the sound information absorbed from the text which can be readily applied to most farm business situations.

The concept of farm planning is brought together in the fifth section, Chapters 15–19. From the building blocks of enterprise budgeting through partial budgeting to whole farm planning and cash flow budgets and the concept of linear programming, coverage is good in terms of text and illustrative tables. Novel and useful additions such as balanced score cards for measuring against targets are given consideration; areas like this strengthen the book's standing. Operations management and quality management and control are given detailed coverage allowing the material to be applied in a very practical way.

Section six covers Chapters 20 and 21. Here investment analysis, also known as capital budgeting, is considered, where the reader is taken through identification, evaluation and feasibility of investments covering all aspects likely to be considered in a farm situation.

Pay back periods, net present value (NPV), and internal rate of return (IRR), subject areas often deemed complex are treated in an accessible way allowing the concept to be understood whilst examples illustrate how they can be used to great effect for various purchasing opportunities. The section concludes by looking at land use and control, including purchasing, leasing, and renting and the subsequent financial implications: whilst the transferability of examples may be limited by geography the advantages and disadvantages of tenure options are highlighted well.

The important concepts of risk management are covered in the seventh section. Chapter 22 focuses on sources, including production risk, marketing risk, financial risk, legal risk, and human resource risk. Here managing risk and the implications of risky decisions are considered through various scenarios for risk management planning. This chapter gives a good overview of business' exposure to and tolerance of risk and covers many management options that can readily be identified on farms, as well as how to distinguish between risk and uncertainty. Chapter 23 looks at production contracts and considers a process for evaluating them with appropriate examples and check-list.

The eighth section, Chapters 24–27, covers the all-important aspect of human resources including business organisation and succession planning. In Chapter 24 the general principles of employee needs and the basic steps of human resource management planning are covered, together with a section on recruitment through to evaluating performance and how to improve labour efficiency. This is a useful chapter giving a good synopsis of this subject area. The next two chapters cover business organisation and structures and succession planning and transfer. Both these areas give the reader a good insight into how planning can directly influence future outcomes and how vital it is for this to be considered within the business life cycle. The final chapter considers the opportunities and challenges of farming in the future. Whilst post-recession crystal-ball-gazing may be deemed hazardous, opportunities and challenges need to be considered by global farm managers of the future and this chapter looks at niche markets, the value chain, redesigning production systems, the adoption of new technologies and the need for increasing management skills.

This is an extremely useful and topical book that is well organised and covers a wide range of material that is presented well. The material is current and relevant to the economics of farm management in a fast-changing global market

The book will appeal to a wide audience and is an asset to those involved in farm management.

Dr Barrie Florey[1]

[1] Head of Land, Farm & Agri-business Management at Harper Adams University College, Shropshire, United Kingdom.

