EDITORIAL

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When I first took over the editorship of IJAM from Martyn Warren I had lots of ideas for the journal to build on the work already done by Martyn. It was pre-Brexit, pre-covid and really does feel like a different world.

Since the launch of IJAM there has been a significant proliferation of online journals. Feedback from readers and authors suggests that there isn't a journal that is in direct competition, in the sense of having the same objectives and scope as IJAM, but it does mean that authors now have a much wider range of possible outlets for their work. Significantly it also means that demands on the time of Reviewers is much greater. One consequence of this is that has become harder and harder to secure agreement to review papers because reviewers receive so many requests.

IJAM did not set out to be the top academic journal but rather to appeal to a much wider audience, with a mix of academic and applied papers as well as other types of article. This is one of the factors that attracted me to the role of Editor but it is also a challenge. Many academics, particularly in the UK (because of the way we are assessed), will seek to publish in what are perceived to be higher quality journals.

One of the other significant developments since the launch of IJAM is 'open access'. Without going into all the details, it is possible for authors to pay a fee to a journal to enable an article to be open access (ie freely available). This is not the same as paying for publication as there is still a rigorous review process in place, but it is a payment to increase the accessibility of papers that are accepted for publication. I know some authors have been put off publishing in IJAM as papers are only made freely available 12 months after publication.

So, as a result of a constellation of reasons we have taken the difficult decision to close the Journal.

However, The Institute of Agricultural Management will look at ways to continue to publish research findings and reports via the Members' Only section of its website.

As this is the last issue of IJAM it's great to see the diversity of subject matter that characterises the Journal reflected in this final issue. I'd like to thank the authors who have written papers specifically for the final issue (you know who you are). Special thanks go to Martyn Warren for coming out of editorial retirement and choosing his 'top picks' for republishing in this issue. Every issue of IJAM is a collective effort and I am really grateful for the support of my team of Associate Editors past and present including Eric Micheels, Ajuruchukwu Obi and Emma Jane Dillon. Thanks also to colleagues at the Charlesworth Group, Ingenta, the Council and administration team of the Institute. Finally, I would like to express my gratitude to all the authors and reviewers across the world who have chosen to support IJAM by publishing with us and volunteering as reviewers. I don't suppose I'll ever get to meet many of you personally but it has been great working with you.

Matt Lobley
December 2020

COMMENTARY

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International Journal of Agricultural Management

Articles for final issue

What I didn't expect, when Matt Lobley asked that I select some articles for the final and celebratory issue of 'The Journal', was the strong emotional tug I felt when browsing those early issues. It reminded me of the long struggle to keep the old Journal of Farm Management alive; of the hard graft involved in establishing a model for its replacement; of seeking the collaboration between the UK's Institute of Agricultural Management and the International Farm Management Association (with huge credit to Richard Cooksley and Tony King respectively); of securing publishers and online providers, and so on. But most of all it reminded me of the sheer pleasure of working with a large number of authors and reviewers across the world, most of whom I never met, linked by a common interest in the theory and practice of agricultural management.

I have chosen three authors who represent my ideal of engaged, down-to-earth academics: Thia Musgrave, Nicola Shadbolt and Ivy Drafor. All three are women, reflecting a welcome rise in the influence of female professionals in the industry: there is plenty more to be done in this regard, but a glance at the Journal of Farm Management of twenty years ago will show how far we have come. All are from countries which place a high value on the study of agricultural management, and where there is an expectation that researchers and teachers will work hand in hand with advisers and practitioners. Their writing is readable and relevant – not everyone will want to engage in the details of data analysis, but an intelligent, properly professional reader will have no problem absorbing the message of each article and applying it in context, where appropriate.

The three articles I have selected will not meet everyone's criteria for 'the best' – even the authors may wonder why I have chosen those and not 'better' examples of their own work – but they are significant to me, not least because they were all published in the first volume of IJAM and are still tinged with the excitement of a new venture. The article by Thia Musgrave, an impressive force in agricultural education, is in the best tradition of a team effort, with young talent nurtured by senior principals, and a government agency working closely with a university. Ireland has become a truly influential player in the world of farm management, contributing more articles to the journal than any other nation.

Another country in the forefront of agricultural management policy and practice is New Zealand:

> Nicola Shadbolt (English in origin) has thrived in this environment, and her article reflects her excellence as a senior academic while also being informed by her experience as farmer, consultant, and director of a huge dairy cooperative. Both Thea and Nicola are from two of the richer countries of the world, with similar temperate-climate agriculture: in contrast Ivy Drafor is from Ghana, a nation with very different challenges with regard to climate, culture, incomes, education and policy. Ivy has written other more extensive refereed articles (we published one in Volume 2, for example), but this short conference paper is particularly effective at reminding us that sometimes it is the simplest skills, or their lack, which have the most profound impact on the lives of others, and how, as professionals, we need constantly to be using our imagination, thinking out of the box, and not shying away from approaches that, while apparently unsophisticated, can have enormous power. I have long held that those of us in the richer countries can learn a great deal from extension approaches developed in poorer ones, so for me this paper has symbolic as well as practical value.

Thia Hennessy, Doris Läpple, Laurence Shaloo and Michael Wallace. 2012. *An economic analysis of the Irish Milk quota exchange scheme*. Vol 1, issue 3, pp10-18

Nicola M. Shadbolt. 2012. *Competitive strategy analysis of NZ pastoral dairy farming systems.* Vol 1, issue 3, pp19-27

Ivy Drafor. 2011. *Rural household capacity building: innovative approaches to ensure adoption of record keeping by farm households.* Vol 1, issue 1, pp24-28

Martyn Warren
17 July 2020

VIEWPOINT

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Agriculture, Coronavirus and the following Recession in the UK

GRAHAM REDMAN[1]

Anything that makes a toilet roll more valuable than a barrel of crude oil is going to make us think. When the Bank of England sells gilts with a negative yield to willing buyers (which has never happened before in its 320-year history), you know you should hold onto your hats. We have all lived through several decades, this year alone!

A third of the UK economy was closed down in March 2020 and another third of it sent to work from home. It has since been reopened gradually at Government's choosing. Farming carried on. An economy is a complex network of relationships, trade, and consumption which is constantly changing. Freezing, then thawing an economy will have the effect of freezing salad, not meat; it will incur lasting damage. Reconnecting business links will not be instant and demand for some goods may have declined or switched to other solutions. Thankfully for farming, the demand for food, will have changed less than most other goods.

One reassuring thing about the food sector is that regardless how the supply chain is structured and who gets the food ultimately to the consumers, we all need our 2 or 3,000 calories a day, pandemic or no pandemic, job or no job. Whether we are worth billions or nothing, our food requirement is similar in volume and calories. And to the commodity producer, the purest part of agriculture, the ultimate financial value of the food at the point of consumption, makes relatively little difference as most value is added to it after the farm. We could argue the nuances of minced beef versus fillet steak, but you get my point. Whilst some supply chains were briefly affected whilst they were re-routed through retailers instead of food service, agriculture and the entire food supply chain can be complemented on how remarkably resilient it has been. *Nobody went hungry since the start of lockdown as a result of food supply chain failures.* That is something for the industry to be proud of. It is a responsibility that was taken seriously.

Consumers did eat slightly different food whilst at home than when they are at the fast food outlets, pizza houses, fine dining restaurants for some or indeed in their cars. But, whilst consumers appeared to be eating less, they were in fact simply wasting less! That is wonderful news despite the considerable cost it placed on agriculture of course. Food waste in the home fell by over a quarter in lockdown and hotel waste simply stopped. Food waste probably fell by more than the total decrease of consumption, suggesting any decline in demand experienced was because greater care was taken with food. Waste reduction is a good thing (regardless of the cost to farming).

Other differences in consumer preferences might emerge as we experience the force of the recession and feel poor again; recession will probably change consumption habits more than lockdown did. Usually, we head for value goods, choice becomes less important and the urge to feed our conscience becomes less affordable. High value foods with certain standards such as organic or other marks of production, tend to become less important when the basic needs of feeding the family are more costly.

Agriculture may not directly feel the recession (or dare I say depression) we face; we will supply 3,000 calories per person a day. Such a flat demand for goods is tough for farming in times of rapid economic growth, but when the proverbial Black Swan flies, farming keeps going. The Black Swan is the factor that is unforeseen, or not predicted. It is the event at the end of a long tail in a statistical curve, some refer to as bell shaped curve. The thing that is unforeseen and seldom happens, but when it does, it makes a big impact, changes the way we act and think, and usually costs us dear. To most of us, COVID-19 was a Black Swan.

The Government debt that will have built up since January will be enormous, certainly the highest since the last world war, perhaps much longer. The capitalist will largely pay for it, and that includes many farmers and rural entrepreneurs. It is clear the country has no appetite for austerity, and arguably, when the economy needs to grow rapidly, austerity would be the wrong policy anyway. There are 4 ways of reducing Government debt; Default, Economic Growth, Taxation, and Inflation.

No country would opt willingly to default on its debt, Mr Sunak, the Chancellor of the Exchequer is relying on investors buying his treasury bonds (gilts) to finance his lockdown spending. He will not be able to do this if Government defaults.

Rapid growth will help get people back into work. It will require softer business regulations and free market encouragement. Laissez-faire free market economics will fill gaps in the economy, left by society when it bolted for safety. Adam Smith in his Wealth of Nations explained the concept of Spontaneous Order, whereby entrepreneurs find spaces in the economic network just as a river

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finds and fills low voids. Government and planned economies are less adept at this; no protectionist economy in the world was subsidising the manufacture of face masks. Protectionism has a role, but politicians do not know what to subsidise, nobody does for sure. In this situation, manufacturing is a more robust way to regenerate an economy. Making physical things, that can be exported, and that will then generate secondary service industry business magnifies the benefit. Primary manufacturing generates more employment. It is often low paid, but it gets people back to work.

Tax increases on the 'have's' are inevitable. Farmers are generally in this cohort, by assets at least. Those with income may bear the brunt of higher taxes but also those with property, or other assets could face large tax bills. Wealth taxes might appear. This is a tax on all assets that you have accrued, including investments, businesses assets and property. Capital Gains might be taxed more. Both could affect farming. Whilst taxing the 'haves' is more fruitful than the 'have nots', it is unfortunate that such taxes penalise those who have been prudent and mindful of their future whilst others with similar incomes and an addiction to frivolous consumption would not.

The only person who benefits from inflation is the borrower. Inflation erodes debt as fast as it erodes assets. Land value is not proportional to its earning capacity so would not *necessarily* rise in value at the rate of inflation, that is, unless it is seen as a safe asset and many people try to secure their capital into farm land, knowing it will still be there in a few years' time, something you cannot say for certainty about any business.

The farmer, as manufacturer of commodities makes one of the more inflation-proof assets. Commodity values fluctuate faster than most other assets or consumables, when exchange rates between currencies shift and as costs change, they tend to lead the way with inflation. Other costs tend to change periodically or annually, think about your salary for example.

Read Adam Smith again. He points out that capital in business flows in 2 directions, to the labour force or the business owners. Government has looked after the worker and the entrepreneur but will not support the capitalists; it is they who will lose value in their shares when the dividends are cancelled again. Those with capital will suffer from inflation when it goes up and will pay more in tax. If you don't consider yourself in any way part of the capitalist society, it is time to check your pension arrangements and what it is invested in. If the day of the capitalist is ending, the day of the entrepreneur is possibly dawning. Free trade is the best way to re-establish supply chains that are not so fragile, those prepared to invest in new ideas will flourish in these times.

Innovative people used lockdown time being thoughtful and creative. Many more patents have been registered than usual this year. This might be because there is more time on people's hands, but also as the world has changed and new ideas are required. Change creates threats, and opportunity. What you find depends which you look for.

The world must recover from COVID-19 whilst undergoing decarbonisation, removing greenhouse gasses from our lives. This will be one of the big issues of the 2020's. The virus has helped; whilst in lockdown, fossil fuels have accounted for less than 15% of electricity generation in the UK. This is a scoop for the renewables sector of course. As we emerge from the pandemic we must simultaneously emerge from our addiction to fossil fuels, our love of the car, the plane and other green-house gas emitters. There are lots of things the food supply chain needs to take on board. If it is *really* going to become carbon neutral then massive changes are required, rather than adjustments and improvements to current systems. Defending our current ways with new numbers will not wash.

According to the Economist, despite half of the world population in lockdown of some kind at one point, the demand for coal only fell by 8% and 5% for oil. The International Energy Agency estimates global emissions will fall by 8% this year taking us back to 2010 levels. Is that enough? Not really. Since March 2020, the UK economy shrank 22 percent shedding 17 years' of economic growth in 4 months taking it back to its size in 2003. The maths is not great for the environment.

Several ideas are emerging that might reduce farming's carbon emissions, some substantially. For example, clever biochemists have learnt how to manufacture meats and milks, without the need for animals and will be trying to roll this technology out to the market in the coming few years. This could solve many of farming's problems such as animal diseases, animal welfare, greenhouse gas emissions, and insufficient land. But it might cause only one big problem for farming, it will be less needed!

It would be an environmental boon, if society could learn at least a few small lessons of constraining unnecessary consumption. But the world is eagerly consuming again: The streets of Chinese cities are more congested than this time last year.

Lockdown reminded us of the fabulous uses for plastic. It returned as the standard packaging for food delivery, and with its properties of keeping food fresh for a longer time, might have a useful resurgence for a while. Let's dispose if it wisely.

This viewpoint has not been about the virus, as the world will remember it for its economic impact rather than the illness. Each physical death is clearly a tragedy, which medics with their medicines tried to minimise. But the insolvencies will continue long after the doctors leave the headlines. I admire the work of medics, but they are primarily for helping the sick, not keeping people healthy. For our health, I thank the food supply chain, the farmers, processors, hauliers, retailers and yes, the person who delivers the food unfailingly to my door. All that, and so often on the living wage. That is who I applaud for keeping me safe and well.

About the author

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VIEWPOINT

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A Personal Viewpoint: UK Farming After Brexit

CARL ATKIN[1]

The first volume of the *Journal of Farm Management* (JFM) was published in 1967, the year the second application by the United Kingdom (UK) to join the European Economic Community (EEC) was vetoed by French President Charles de Gaulle. Having first vetoed the UK's application to join in 1963, de Gaulle was concerned that the UK would not support his vision of a Common Agricultural Policy (CAP); at the time agriculture accounted for 25% of the French economy whereas it only accounted for 4% of the economy in the UK. As de Gaulle noted in his memoirs ''How (else) could we maintain on our territory more than two million farms, three-quarters of which were too small and too poor to be profitable, but on which, nonetheless, nearly one-fifth of the French population live?'' (The UK would eventually join six years later, in 1973).

The last volume of the JFM's successor, the *International Journal of Agricultural Management (IJAM)*, is being published some fifty three years later, as the United Kingdom finally appears set to fully leave the apparatus and structures of the EEC's successor – the European Union (EU) - on 31 December 2020, having 'technically' left on 31 January this year. Thus, for pretty much the entire life of the Journal, the CAP has been the dominant force shaping farm policy, farm enterprise decision making and, ultimately, farm management practices in the UK. Outside of CAP, British agriculture is about to undergo its most significant change in almost a century with a move to a new support system based almost entirely on delivery of public goods and maintaining and enhancing natural capital.

Well, that is the theory at least. The background arguments are well rehearsed: 20th century farm policy – firstly through a UK deficiency payments scheme until the 1970s – and then through CAP's intervention buying scheme until the 1990s – pursued a largely one-dimensional policy of increasing food production at almost any cost. Farmers were paid to rip out hedgerows, drain wetlands and intensify production, and swathes of taxpayer funds were directed to constructing buildings and other farm infrastructure. The environmental or societal consequences of all of this were largely ignored.

Since the 1990s and the gradual 'awakening' in the policy arena (by a raft of stakeholders, society, governments, NGOs and the like) that this 'one dimensional' approach is not sustainable there has been a gradual shift in emphasis of farm policy. Initially this was by 'partial decoupling' of support under Commissioner Ray MacSharry (1992) shifting the emphasis from price support to direct crop and livestock payments; and then 'full decoupling' of support under Commissioner Franz Fischler (2003). This latter reform left the CAP a curious beast – increasingly 'uncommon' and over 80% of farm support being paid to farmers in the form of 'single' or 'basic' payments: to essentially occupy land, adhere to a few minimal legal environmental requirements (so called 'cross compliance'), and draw the area based payment with neither food production or significant environmental obligations attached. To a rational economist the nonsense of this was clear to see – such non-targeted payments typically just capitalised themselves in the land or its occupancy costs – or leaked through the value chain – and the proportion kept by the 'farming business' remained woefully thin. The exact 'purpose' of these decoupled payments was always somewhat a mystery to me (despite a little bit of ''green washing'' of the payments from 2013 onwards) but as so often in the agricultural industry, the forces of inertia beat the forces of change.

Whilst Brexit brings many challenges to the industry – most notably around trade and food standards - it also brings one huge opportunity. There is the opportunity to break free from the nonsense of the archaic CAP and start with a blank sheet of paper: what do we want farmers to do that the market doesn't easily provide – and how should we best pay for that? The term natural capital, which had not entered the vocabulary of most agricultural economists and farm business managers even a decade ago has been thrust into the limelight – how do we pay farmers to maintain and enhance natural capital, or in simple parlance, the value of the soil, air, water and biodiversity of their holdings and landscapes?

A great new dawn was promised. The Government's Vision for a ''Green Brexit'' launched in 2019 talked about innovative delivery mechanisms and payment methodologies for new policies; we could have reverse auctions, payment by results and landscape scale impact schemes. Finally it seemed if we were making a break from the mentalities of the past.

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Yet almost two years later, the great Vision championed by the then Secretary of State Michael Gove seems to be ebbing away. In its necessity to create a scheme which will be 'accessible' to the majority of the 80,000 farming businesses in the UK some simplification was always going to be necessary, but when the middle "tier 2" of the new Environmental Land Management Scheme (ELMS) is described as "continuity stewardship" – already a fairly prescriptive and box ticking scheme which has been around in various iterations since the early 1990s – one has to wonder whether the "entry" tier 1 is going to be little more than a further greenwashed direct payment by another name.

Predictably the topic of payment transition and replacement of farm support fills the column inches of the farming magazines and provides endless fodder for seminars and farmer meetings. Too many in the industry look forlornly at the declining graph of direct farm support after 2021 and have become fixated on the pot of money ("will it still be three billion?") that the industry receives. This of course, completely misses the point – the question should be – how much money should the government need to pay to deliver the natural capital services *that the market won*'t provide. If only the industry had spent as much time talking about the development of markets for environmental services, of climate change mitigation, carbon trading and offsetting and of biodiversity net gain – as it had about how much money the government was going to transfer to them – the debate might have moved a bit further forward. But old habits die hard.

Whilst a sub-set of the industry continues to tail spin about fiscal transfers, or lack thereof, the truly innovative and successful will get on and do what they've always done: innovate and develop their businesses. The market for environmental income streams will likely be many tens of times larger in the medium term than any fiscal transfer by government through ELMS or similar schemes. The opportunities for high welfare, highly sustainable livestock products, for plant-based alternatives, for added value crops, for new and innovative sources of protein (algae, insects, cultured) and for new farming systems (aquaculture, landless agriculture) opens up exciting opportunities for entrepreneurs and risk takers, not to mention the monetisation of environmental services and the development of added value supply chains and ancillary service sector businesses.

The question is – does our industry have the skills and leadership competences to grab hold of these challenges? Sadly, large parts of our industry probably still do not. Perhaps it is time to replace the modules on agricultural policy with ones on entrepreneurship, strategy and innovation in our university and college agriculture curricula – as our industry moves to a new world breaking from the norms of the past. So as the Institute of Agricultural Management looks forward to life beyond IJAM– the need for professional management in agriculture is greater than ever. Communicating management innovations and developments remains central to what we do, albeit it in a new format for the 21st century.

About the author

Carl Atkin has over twenty years management and consulting experience across agricultural supply chains and farming and food businesses with a focus on the CEE-CIS region. He has worked with clients across the whole agribusiness value chain including life science companies and food processors, private and institutional investors and numerous private and corporate farming businesses. He has experience in all aspects of strategic and operational agribusiness management (finance, HR, operations, strategic projects) and leads on strategy and research assignments for Terravost Ltd, an agribusiness management, consultancy and investment business he co-founded in 2010. Carl has a BSc (Hons) in Agriculture and Farm Business Management from Newcastle University (2000), a Postgraduate degree in Business Administration (MBA) (2007) and he has also attended the Agribusiness Executive Education Programme at Harvard Business School. He is a Fellow of the Institute of Agricultural Management (FIAgrM) and former member of the Editorial Committee of the JFM and former Deputy Editor of IJAM.

VIEWPOINT

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Mobilising Land Mobility in the European Union: An Under-Researched Phenomenon

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ABSTRACT

Interest in land mobility and its impact on the structural development and economic growth of the agricultural sector has grown considerably amid concerns about the ageing European farming population. There have been calls throughout Europe for structural and institutional deterrents obstructing the passage of farmland from the older to younger generation of farmers to overcome this phenomenon and help facilitate generational renewal in agriculture. Nonetheless, gaining access to land is widely reported to be the single largest barrier facing young people attempting to enter farming. Whilst land mobility is given homogenous importance throughout Europe, this view point paper highlights that policies and regulations relating to land differ considerably across EU Member States. There is also a surprising scarcity of literature and academic discussion on access to land in a European context, despite its crucial role in the survival, continuity and future prosperity of the farming industry and the broader sustainability of rural communities. By focussing on the key policy and structural issues hampering access to agricultural land throughout Europe, and using the Republic of Ireland's Land Mobility Service as a good practice example of how to help facilitate the process, this paper provides a rationale for why a major European study is required to investigate the factors which influence land mobility in each of the 27 EU Member States in order to inform future Common Agricultural Policy (CAP) Strategic Plans, particularly in relation to generational renewal objectives.

KEYWORDS: land mobility; access to land; generational renewal; family farming; rural sustainability

1. Introduction

Agriculture is the main land use in the EU, accounting for more than 47% of the region's total land area (Giannakis and Bruggeman, 2015). Agricultural land is essential for food, energy production and the delivery of public goods. Land is also a finite resource, and therefore of infinite value. Recognising its fundamental importance to viable food production, the ongoing CAP reform discussions have brought the debate on land mobility (i.e. transfer of land from one farmer to another, or from one generation to the next) in agriculture to the forefront yet again. An infusion of 'new blood' into farming by means of efficient and effective land mobility is considered to be critical to achieving a more innovative and sustainable agricultural sector. Indeed, a recent study by Zondag *et al.* (2016) found that the acquisition of agricultural land (through purchase or rent) is the most important requirement for young farmers / new entrants who want to pursue a career in farming, while gaining such access to land is also the largest barrier to entering the European agricultural sector (EIP-AGRI, 2016; CEJA and DeLaval, 2017; Zagata *et al.*, 2017). Not only this, but a convergence of other factors, ranging from the older generation's reluctance to step aside, land concentration and the low supply of land for sale or rent in many regions combined with the prevailing high price of available land, have exacerbated the current land access issues for prospective farmers.

Overcoming these structural and institutional deterrents obstructing the transfer of farmland from one generation to the next is a pressing matter in contemporary Europe, due to the fact that generational renewal in agriculture is viewed as crucial for survival, continuity and future prosperity of the European farming industry and the broader sustainability of rural communities. However, whilst land mobility is given consistent importance throughout Europe (CEJA and DeLaval, 2017), policies and regulations relating to land differ considerably across EU Member States (Zagata *et al.*, 2017). These differences can be explained partly by the differing land use patterns which have emerged historically, the prevailing physical conditions (such as size, climatic, geographic and demographic circumstances) and the economic incentives available for particular types of activity (OECD, 1996). The European

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Commission therefore regards land policy as a competency of each Member State of the European Union on a national level, i.e. each country is solely responsible for their own land sales and rental markets (ENRD, 2019). There is also a surprising scarcity of literature and academic discussion on access to land in a European context, despite its centrality in the production efficiency and economic growth of the agri-food sector (Franklin and Morgan, 2014). As such, this view point paper now explores the policy and structural issues that are hampering access to agricultural land throughout Europe. This is followed by a presentation of the Republic of Ireland's Land Mobility Service as a good practice 'match-making' service example linking landowners and farmers interested in collaborating and developing sustainable viable farm enterprises in a sensitive manner.

2. 'Greying' of the European Farming Population

Interest in land mobility and its impact on the farming economy has grown considerably amid concerns about the ageing European farming population. Demographic trends reveal an inversion of the age pyramid with those aged 65 years and over constituting the fastest growing sector of the farming community (Zagata and Sutherland, 2015). Only 5.6% of all European farms are run by farmers younger than 35, while more than 31% of all farmers are older than 65 (European Commission, 2017). To put this into context, for each farmer younger than 35 years of age, there are 5.6 farmers older than 65 years (ibid). This 'greying' of the farming workforce is reported to have major implications for government policy, raising concerns about the economic, social and environmental sustainability and viability of an ageing farming population. Older farmers are reported to be less competitive in the current market place because they are slower to adopt new innovative agricultural technologies, alongside arguments that many are unwilling to recognize or accept their physical limitations, with subsequent risks to their health and safety (Conway *et al*., 2018). On the contrary, the younger generation are perceived to be eager to embrace smart agriculture, innovative farming practices and science-based research to help guarantee a more sustainable, profitable and productive future for farming (CEJA and DeLaval, 2017). As young farmers' preparedness to innovate and invest is also crucial for the future survival of rural communities throughout Europe, generational renewal is one of the European Commission's key priorities in the upcoming Common Agricultural Policy (CAP) post 2020.

3. Transitional Barriers in Farming

Family farms dominate the structure of European agriculture in terms of their numbers and their contribution to agricultural employment. There were 10.8 million farms in the EU in 2013, with the vast majority of these (96.2%) classified as family farms (Eurostat, 2018). In spite of the inherent desire to keep the family farm in the family, research indicates however, that older farmers often experience difficulty transferring managerial control and ownership of the family farm, even to their own children (Conway *et al*., 2017). This lack of correlation between the younger generation's readiness to begin their career in farming, and their elders lack of preparedness to step aside, has resulted in a severe lack of land mobility throughout European Member States. Research indicates that the low levels of land mobility currently being experienced is impacting on the younger generation's ability to embark on a true and meaningful career path of full-time farming, and under such incidences it could take 20 to 30 years to assume managerial control of the farm (ibid). An absence of young people with decision-making responsibilities on farms throughout Europe is a major concern, particularly for an industry facing constant change and challenge in the digital era (EIP-AGRI, 2017).

Conway *et al*. (2017) warn that younger farmers are becoming increasingly impatient as they yearn for greater financial independence, recognition and opportunities for leadership on the family farm. Indeed, results from a recent EU-wide survey, carried out by CEJA – the European Council of Young Farmers in partnership with DeLaval, with young farmers across all European Member States on the factors they consider to be most important for the development of an economically sustainable farm, found that gaining access to land is one of most significant barriers for young people wishing to enter or remain in the agricultural sector (CEJA and DeLaval, 2017). Consequently, in order to deal with the problem of land access, Zagata *et al*. (2017) recommend creating new incentives such as retirement schemes, for older farmers to pass on their farms. However, it must also be recognised that farm succession and particularly retirement are considered major transitional challenges for the older farming generation, with many believing farming to be a 'way of life' and not just an occupation or profession (Conway *et al*., 2017). Nevertheless, the younger generation must be given the opportunity to gain access to land and evolve into a more formidable role in family farm business or otherwise they may lose interest working in their elder's shadow and decide to leave the family business in pursuit of more fulfilling career opportunities elsewhere (Cush and Macken-Walsh, 2016; Zondag, *et al*., 2016). Furthermore, as White *et al*. (2012) have argued, any initiative to stimulate generational renewal in agriculture will be weakened if prospective farmers lose interest and motivation as a result of being unable to secure access to land. Such a detrimental manifestation requires immediate policy attention.

4. Land Concentration

As two thirds of the 10.5 million family farms in the EU are less than 5ha (Eurostat, 2018), securing long-term access to additional land is imperative for those wishing to assemble an efficient size farm holding to increase productivity and viability. A major difficulty in gaining access to such land however is the increasingly intensive process of land concentration taking place in European farming. Between 2005 and 2015 the number of farms in the EU decreased by approximately 3.8 million and the average size of the farms increased by about 36% (Eurostat, 2017). The result is a heightened contest between farming and non-farming investors, and also between both generations of the farming community,

all competing in the same land market (Zagata *et al.*, 2017). Under such conditions it is becoming increasingly difficult for young people to gain access to land in order to establish a commercially viable farm, be they the sons and daughters of farming families or young people from a non-agricultural background (van der Ploeg *et al.*, 2015; Zagata *et al.*, 2017). This is particularly problematic in Eastern Europe, which has seen substantial foreign investment by both Western European farmers and businesses (ibid). This trend towards fewer but larger farms is having a detrimental effect on the economic viability of Europe's small and medium sized farms who do not have substantial financial resources behind them to purchase or secure rental of land (Zagata *et al.*, 2017).

5. Mobilising Land Mobility Case Study – Focus on the Republic of Ireland

In the Republic of Ireland, it is argued that significant changes and modifications to boost the competitiveness and production efficiency of agriculture through land mobility and structural change are required in order to realise ambitious growth targets such as those identified in the Food Wise 2025 strategic document (DAFM, 2015a). Gaining access to land remains particularly inflexible in the Republic of Ireland however, despite a number of policy initiatives designed to address land mobility, most notably tax exemptions on income derived from the long-term leasing of land (Geoghegan *et al.*, 2015). Entry to farming is predominately by inheritance or purchasing highly inflated farmland, resulting in the level of land transfer by sale being minimal, with less than 1% of the total land area in Ireland being sold on the open market annually (DAFM, 2018). Furthermore, the predominant system of land rental is short-term and frequently through informal arrangements which provides little security for farmers. These cultural norms have resulted in extraordinary socio-economic challenges for young people aspiring to embark on a career in farming (Cush and Macken-Walsh, 2016), with profound implications not only on the development trajectory of individual family farms but also the production efficiency and economic growth of the Irish agri-food industry and rural society more broadly (Conway *et al.*, 2017). A report on 'Land Mobility and Succession in Ireland' claims the lack of land mobility currently experienced in the Republic of Ireland is stifling agricultural growth by preventing young 'enthusiastic' farmers gaining access to productive assets (Bogue, 2013). Findings from a recent national study by Macra na Feirme (2017), an Irish voluntary rural youth organisation, with over 1000 young Irish farmers entitled 'CAP 2020 Young Farmer Roadmap for Generational Renewal' support such arguments, as it discovered that over 40% of young farmers believe that gaining access to land is the biggest obstacle to establish or expand their farms.

The prevalence of low levels of land mobility and the steadfast adherence to traditional patterns of inheritance in the Republic of Ireland led to the establishment of an Irish Land Mobility Service in 2013, by Macra na Feirme, with the financial backing of FBD Trust and industry wide support. The Land Mobility Service is a dedicated, proactive support service for farmers and farm families who are contemplating expansion, changing enterprise, or stepping back from farming. It provides a confidential and independent 'match-making' service to introduce older farmers and/or landowners to young people who want to develop their career in farming in order to establish a sustainable and mutually beneficial business arrangement (Land Mobility Service, 2019). The main aim of the service is to facilitate access to land through land leasing and various forms of collaborative farming arrangements developed by Teagasc, the Agriculture and Food Development Authority in Ireland, or Joint Farming Ventures (JFVs) as they are also referred to (Cush and Macken-Walsh, 2016). Collaborative farming arrangements, such as farm partnerships, share farming and contract rearing, supported by the Land Mobility Service are actively promoted within Irish policy discourses as ideal stepping stones to help overcome obstacles to land access. Indeed, since its inception (initially as a pilot and now rolling out nationwide) the Land Mobility Service has been involved in excess of 500 collaborative farming arrangements, covering more than 47,000 acres (Land Mobility Service, 2019), illustrating the success of the service to date. Today, the Service actively engages with over 200 people who are either looking for opportunities or their options. These people fall into three categories: landowners who wish to step back, new entrants to Farming, and existing farmers looking to expand (ibid).

Collaborative farming arrangements have the potential to 'tick all the boxes' in relation to the ideal land mobility facilitation strategy as they enable young ambitious farmers become formal partners in the farm business, whilst also allowing for the older generation to remain actively engaged in farming and embedded in the farming community, as their continued guidance and lifelong knowledge is considered to be invaluable to the future development of the farm (Ingram and Kirwan, 2011; Hennessy, 2014). Although a national Land Mobility Service similar to the one in the Republic of Ireland has not been explicitly established elsewhere in the European Union to date, there are a number of analogous 'match-making' initiatives in existence throughout Europe that link farmers to available land as well as connecting new farmers with older ones, leading to a better return for all parties involved. For example, Perspektive Landwirtschaft (Perspective Agriculture) in Austria; Répertoire Départ Installation (Directory Departure Installation) and Terre de Liens in France; Hof sucht Bauer in Germany; Banca delle Terre Agricole (National Bank of Agricultural Lands) in Italy, and Landgilde and Boer zoekt Boer (Farmer Seeks Farmer) in the Netherlands.

6. Conclusion

Given the importance of land mobility in achieving generational renewal in agriculture, and the extent to which low levels of mobility can hinder structural development and growth within the farming sector, increasing access to land for young farmers and new entrants is one of the European Commission's key priorities in the upcoming CAP reform. Traditional patterns of inheritance, in addition to a highly competitive land market and inflated land prices however have resulted in extraordinary socio-economic challenges for new entrants

aspiring to pursue farming as a career, as well as for young farmers seeking additional land to develop a more viable farming enterprise.

As every farm and farmer is unique throughout Europe, there are no uniform or easily prescribed solutions to resolving this conundrum, however the Republic of Ireland's Land Mobility Service example discussed in this view point paper demonstrates the value of 'match-making' models and structures in helping to increase the availability of land for farmers and new entrants. By providing a function for intergenerational cooperation, whilst also allowing for greater recognition, financial independence and leadership opportunities for the younger generation; collaborative farming models facilitated by such a service can also assist in alleviating concerns of an ageing farming population and maximize production efficiency and competitiveness.

With regard to access to land across the EU as a whole however, whilst CEJA – the European Council of Young Farmers, have actively been promoting innovative 'match-making' models of collaboration between generations to help young people commence and develop their farming careers, the major problem in rolling out such initiatives is the fact that policies and regulations relating to land differ considerably across Member States. This, combined with the scarcity of literature and academic discussion on access to land in a European context, means that provision should be made for a major study to investigate the factors which influence land mobility in each of the 27 EU Member States. By focusing on the key policy and structural issues affecting the process, such a study could inform an integrated EU-wide land mobility policy aimed at facilitating generational renewal in agriculture.

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VIEWPOINT

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Policy Push & Commercial Pull - What's Changing UK Farming and Food?

JOHN GILES[1]

Introduction

How will we look back on 2020? COVID - 19 is going to stick in the mind for a long time and the impacts of this will be felt for many years to come as we come to terms with the ''new normal''. The Brexit discussions seem far from settled. Talks on a US – UK trade deal are underway and we have a new Agricultural Bill passing through Parliament.

There is clearly a huge amount of change taking place in the UK farming and food sector. This will produce a very different looking sector over the next 5 – 10 years.

I have tried to summarise these changes in this piece – they are to my mind, a combination of ''policy push'' and ''commercial pull''.

The Agricultural Bill

Leaving the EU by the start of 2021, means the UK is also leaving the EU's Common Agricultural Policy (CAP). Farmers in the UK currently receive around £3.5 billion support annually under the CAP. More than 80% of these CAP payments that UK farmers receive are 'direct payments' based on how much land they farm. The remainder pays mainly for rural and environmental farm management schemes.

The EU Common Agricultural Policy (CAP) has for a long time been heavily criticised by many in the UK farming sector. This is now seen as an opportunity to develop a policy framework that is much more in line with the more specific needs of the UK farming industry.

The Agriculture Bill now being proposed provides the legislative framework for the replacement of existing agricultural support schemes. Farmers will be paid largely in the future to produce 'public goods' such as environmental or animal welfare improvements and see payments for production of agricultural products phased out over a 7 year period. The Bill also includes wider measures, including improving fairness in the agricultural supply chain and on the operation of agricultural markets.

The other objectives of the Agricultural Bill include as follows:

- balancing the need for food production with the requirement for better standards of environmental practice and sustainability
- de linking payments to farmers to create the environment for faster structural change in UK farming and encourage new entrants in to the sector
- a fairer and more transparent supply chain
- increasing awareness of the importance of food security
- the ability to provide emergency assistance to farmers if required – but this would not include extreme weather or disease outbreak, unless they result in markets being disrupted and damage to producers incurred.
- to encourage the production of organic food
- maintaining high standards of animal welfare, food safety etc. for UK producers and protection for UK farmers from imports from countries that have lower standards of production. This is one of the most contentious issues and will be put to the test during the UK - US Fair Trade Agreement discussions vis a vis the importation of US poultry products, GM soybeans and hormone treated beef and pesticide regulations/tolerences on fresh produce etc.

The complete and rapid abandonment of direct payments has been treated with more caution by the devolved administrations in Wales, Scotland and Northern Ireland, at least up to 2024. This is not surprising given that agriculture is a devolved issue, and Scotland, which refused to consent to the initial Bill, published its own Agriculture Bill in November 2019. This allows the Scottish government to continue current CAP schemes, including direct payments, beyond 2020.

Differences between the countries of the UK regarding farm support could create tensions, with farmers complaining about the lack of a 'level playing field'. But the amount of money to be allocated to UK farming still lies with Westminster, and therefore the devolved governments may find themselves constrained on how they can use their own budget.

So, what does this all mean for UK farming? The proof will be in the pudding, of course, but some things seem clear:

- UK farmers will be required to demonstrate they produce food in a more environmentally friendly manner than in the past
- the amounts of financial support received by farmers for production will be reduced over time and they have c. 7 years to plan on how they will run their business with vastly reduced subsidies than they have enjoyed in the past and this is a major challenge

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- the UK supply chain should operate in a more transparent and fairer manner – but to our mind will still be fiercely competitive
- UK farm standards should be upheld to the benefit of producers and consumers, but much will depend on the outcome of the UK – US Free Trade Agreement and the precedent that this might set
- it should be easier for new entrants to begin farming and produce a greater degree of structural change of UK farming than seen in the past

As such, the Agricultural Bill, which is passing through the legislative process now (summer 2020), will represent a fundamental change in how UK farming and food production is supported over the next 10 years and beyond. There will be a huge shift to an emphasis on environmental enhancement and a more sustainable supply chain per se. It has been estimated that the actual amount of money paid out to farmers might not reduce that much, but what will happen is that it will be paid out in a very different way.

This therefore presents something of a brave new dawn for UK agriculture and food and its development will be watched with interest in other countries around the world, and not least, around the various regions of the UK.

While, this does indeed represent an opportunity for things to be done differently in the future, it is not without its challenges. For many farmers in the UK, especially in the beef, sheep and dairy sectors, there has been an over reliance on the CAP subsidy schemes. This has historically been less so the case in the less protected sectors, such as horticulture, pigs and poultry. Many of the more capable farmers in the UK, including beef/sheep and dairy have for some time though believed they can compete in international markets without the use of CAP subsidies. We are about to find out if this is the case.

Brexit - Still to be Played Out?

The whole issue of Brexit, before the COVID – 19 pandemic, has been the dominant issue across UK society for the last 4 years. The debate about what happens next in the agricultural and food sector has been a key feature of the ongoing discussions both within the UK and then with the EU Commission.

While the decision to leave was confirmed in January 2020 after the Conservative governments overwhelming election victory in December 2019, the final details of on what terms this will be on are still to be decided. The key issues are still many, but the most important are what happens in terms of market access to the rest of the EU for the UK (and of course, vice versa), the issue of the border between Northern Ireland and the Republic of Ireland, fishing rights and then the question over the freedom of movement of labour. This issue is of particular concern to the UK agricultural and food sector as in many cases, there is a high dependency on the use of migrant labour from the likes of Eastern Europe as well as Africa and parts of North Africa and the Middle East.

As of this summer, the UK government has consistently stated that if a satisfactory agreement cannot be reached, they are prepared to walk away from negotiations and accept a No Deal situation. This would in effect see the UK revert to trading with the rest of the EU, and indeed, the rest of the world on WTO terms. As such, the possibility of a No Deal situation cannot be ruled out. It is expected, though that the discussions will go on through the autumn/early winter until the proposed end date of January 2021.

Boris Johnson's apparent bravado around No Deal might eventually be somewhat tempered by the fact that most predictions are that this could be potentially disastrous for the UK economy. This is already facing a huge down turn post COVID - 19. There is only so much that the economy can take. - as well as the electorate.

There have been several studies carried out, not least by the likes of the National Farmers Union (NFU) and the Agricultural & Horticulture Development Board (AHDB) to assess the impact of the decision to leave the EU. These have all been based on a number of scenarios, such as still having good access to the EU markets and then this not being the case and then variations on this such as a Norwegian and/or Swiss style relationship with the EU. In most cases, the conclusions have been that unless a ''good'' deal is secured, Brexit is not a positive outcome for the UK, at least in the immediate future. To be able to survive and thrive in any post Brexit environment, farmers will need to strive to be:

- in the top quartile of industry performers
- and probably (but not always) be operating at an increased scale

There are also ongoing discussions with the likes of the US, New Zealand and Australia as to the development of Free Trade Agreements (FTA) which will provide some new opportunities for UK farmers and food businesses, but also threats too. It is also hoped that there will be similar FTA's concluded with the likes of India and China, but these still seem some way off.

The other key conclusion reached, is that almost regardless of what sort of Brexit is reached, the key trends and influences on the UK supply chain will merely be accentuated, and in some cases, be accelerated.

A US Trade Deal?

So where does this leave the UK/US Free Trade Agreement? Talks have started and this is a good sign. But, with packed agendas for Johnson (dealing with impact of COVID - 19 and then Brexit) and then President Trump - who also must deal with economic impact of COVID - 19 and then has the small matter of a US election too) - how much time can be given to this? No doubt, the civil servants on both sides will be working away on this, but can the knock out blows required really be achieved in the short term?

A US deal does represent a significant opportunity for the whole UK economy. It has the potential to create a substantial increase in trade with the US of approximately £15.3 billion in the long run, delivering a £1.8 billion boost to UK workers' wages, as well as lowering prices on key consumer goods imported from the US. The US should remove the punitive tariffs imposed following the WTO's ruling on Government subsidies to Airbus. For example, some 62% of all US goods imported into the UK and 42% of all UK goods

exported into the US are used in supply chains, where extra gains could also be found from lowering barriers.

What you can be sure of though is that agriculture and food will almost certainly be a sticking point in all of this. There is concern in the UK about a free trade deal opening opportunities for the US to sell GM soybeans, chlorinated chicken and hormone treated beef to the UK. Some farmers are worried that agriculture will be thrown under the bus, in order to get concessions in other areas of the negotiations. And it would be a brave supermarket in the UK to boldly claim to its customers ''our chicken comes from the US''.

Our experience also shows that just having market access to a particular country does not mean that exporters immediately rush to that market. Has the US supplied the UK in the past – yes. Have the leading US farmers, processors and shippers got the technical and commercial ability to deal with the UK – yes. Does it mean that they will look to the UK market at a time when post COVID - 19, UK importers and retailers might be looking to shorten supply chains? Not automatically, in my view. At the same time, UK agriculture and horticulture are still looking to boost domestic productivity, not least through the use of various forms of so called ''agri tech''. The best of the best in the US might re look at the UK market, but this is by no means certain.

Sealing a UK/US Free Trade Deal will almost certainly take longer than the much heralded ''quick and outstanding deal'' that President Trump promised. He might not even be around by the end of the year to see this through. Trade deals normally take several years to negotiate, and even then, there is a longer implementation period – and ''outstanding'' – for who, you wonder? What does seem sure is that there is some way to go on this and there is plenty of water to flow under the bridge before a UK/US deal is finalised.

The Impact of COVID - 19

COVID -19 has had a major impact in the UK. Since the first outbreaks in early March 2020, there have been some 45,700 deaths from the disease and there has been huge pressure on the economy, as well as the National Health Service as a result. The government has introduced a range of emergency support measures to the tune of some £300 billion.

25% of the workforce has been ''furloughed'' – a scheme by which the government has paid 80% of the wages of workers who would have otherwise been made unemployed. The scheme will come to an end later on in the year and there are predictions that the unemployment rate will soar to around 3 million - maybe even higher over the winter months.

The country of course was in lock down for much of the period between the end of March and early July. The service and hospitality sectors have been it very hard in this period. The government, is very keen, for understandable reasons to try and kick start the economy, but there are also huge concerns around the prevention of a second spike in the number of infections too.

At farm level, there have been a number of major challenges to face up to, especially in the early days of the outbreak. Agriculture and food were both deemed by the government to be ''essential industries'' and could carry on working. Some dairy farmers, however, were forced to throw away milk as collection schedules were severely disrupted.

There were also concerns over the availability of farm labour. This has been an ongoing issue over the last few years but was accentuated by the need for seasonal labour, especially in the horticultural sector, which has a high degree of dependency on workers from Eastern Europe.

Farmers who supplied food to the catering sector saw sales disappear overnight and had to quickly find alternative customers. Some relief was provided by switching to online selling mechanisms. In some cases, deliveries of agricultural inputs were not possible, as distributors struggled to come to terms with reduced work forces, enforcing social distancing measures and general business disruption.

At the outset of the pandemic, it was clear that many farmers were under stress and anxiety as to how they would be able to manage their operations. At the same time, many farmers seemed to adopt a policy of ''just getting on with the job''. There appears to have been no knee jerk reaction to the outbreak of COVID – 19, although many have used the opportunity to review how they run their farms going forward.

There has been no apparent rush to invest in robotics and automation, as an example, as a result of concerns over labour. Farmers though have used the time to get closer to their banks and even closer to their customers. Most farms have introduced social distancing measures effectively. This has not stopped problems arising, especially on horticultural units, where several hundred people can be employed at any one time. Several farms have been forced to shut if large outbreaks have occurred.

In terms of the impact of COVID – 19, these have been seen more clearly in the rest of the supply chain and can be summarised as follows:

- foodservice sales have all but collapsed and even the re-opening of pubs, restaurants and hotels in early July does not guarantee a full return to normal of this route to market
- despite using a range of social distancing measures, food processing factories have been closed due to COVID - 19 outbreaks. This is associated with the working conditions and environment in these factories as well as the nature of the labour often used in them (i.e. often migrant labour who also live and travel to the place of work in close proximity to each other).
- online selling has boomed in this period - this was something that had already begun to be a more prominent feature of the UK supply chain.

At the start of the outbreak, it was common to see supermarket shelves empty of key essentials such as fresh produce, canned and dry goods. To some extent, this was due to a level if panic buying, but also demonstrated how fragile at times UK supply chains can be with a strong reliance on just in time delivery operations. Within a few weeks though, most products could be found on supermarket shelves without too much of a problem. This, in turn, is testament of how robust UK supermarket supply chains are as well. In the mid to long term though, there are probably a number factors that

will drive change in the UK supply chain and the businesses (including farmers) who supply it as follows:

- because of COVID – 19, all suppliers and supermarkets which still dominate the UK point of sale, will stress test the robustness of their supply chains and we might well see the shortening of these in the future
- there will be a trend towards more home preparation of food and demand for convenience foods
- shopping habits will change with consumers opting to buy food on a more localised basis
- issues that were important before March 2020 to the supply chain will not go away - these include areas such as plastics reduction, water usage, meeting the challenge and in some cases, the opportunities of climate change etc
- the experience to date – and we suspect going forward - is that no one has been immune from the impact of COVID - 19 be they big, small, well established or relatively new businesses etc
- the ongoing pressure in the retail market as this discount chains continue to gain ground on the Big 4 retailers (i.e. Tesco, JS, Asda and Morrisons) and at the expense the higher value retailers such as M & S and Waitrose. It is reported that some supermarkets have requested significant price discounts over the rest of the year from their suppliers. This is a direct result of the predicted severe down turn in the economy that we have begun to already see

The economic situation in the UK for the next 24 months looks very challenging indeed. COVID - 19 has been another major shock to the UK supply chain, but to a totally new level. As a result, companies need to be more agile and resilient than ever before and not all are going to make it through this incredibly challenging period. In my experience, the full impact of a supply chain shock such as COVID – 19 again, will be to speed up change/trends already taking place in the market.

COVID - 19 impacts and uncertainty over Brexit are something of a double challenge and are all accentuated by the threat of supply chain price pressures that seem likely to follow over the next 3 – 6 months and beyond.

Commercial Pull

A reality of the UK food chain is the power of the food processing sector, and then in particular, the role of the major supermarket chains (i.e. the 4 largest supermarkets account for c. 70% of food sales). They operate in a fiercely competitive market environment and are constantly seeking, if not at times, demanding improvements from their supply base in terms of efficient and increasingly, sustainable food production.

Beyond the Agricultural Bill, Brexit and any international trade deals we the UK do or do not secure, this is therefore the other huge driver for change in the UK - the sheer "commercial pull" of the major retailers and food processors in the UK. The key players operating at the point of sale have also been impacted by a whole range of factors over the last 10 years. This includes the development of the discount chains in the UK, the move to online retailing, the need for New Product Development (NPD) and innovation in food products and the need to meet a clear consumer demand for environmentally friendly and sustainably produced food. And all of this at often no additional cost.

The big difference is that the Agricultural Bill, although the direction of change is clear, will take 7 years to unwind in full. A new trade deal with the US might take several years to negotiate and then be followed by an implementation period. Even an extension of Brexit cannot be totally ruled out, although we suspect there is little appetite for this in the UK or the rest of the EU.

A change in procurement policy, however, by a leading supermarket or a food processor can see change happen almost overnight. While there are several policy push drivers in the UK and these will influence the future direction of farming, the commercial pull factors are probably even stronger as an agent of change.

Final Words

This all points to a very different looking sort of farming sector in the future. Will some thrive in this new environment and take advantage of new opportunities - yes. Will some struggle - potentially - quite a few. The sector will need to be open to new ways of farming and doing things – yes. The new political, economic and social climate in the UK over the next few years will also see us, the managers, of farm and food businesses needing to be at the very top of their game.

I finish this viewpoint by making an unashamed plug for what we do at the Institute of Agricultural Management. Everything we get involved with is to help farmers and others in the supply chain be "better and more professional managers". And we are going to need to be. The work and activities of the IAgrM, to my mind, has never been more important.

About the author

John is a Divisional Director with Promar International, the agri food consulting arm of Genus plc and a former Chair of the Institute of Agricultural Management – he still serves on the Council. He has also been a Council Member for the Oxford Farming Conference and is the current chair of the annual City Food Lecture. He has worked in over 60 countries around the world on an equally wide range of projects, but a good deal of his work has been in the horticultural and dairy sectors. He can be contacted at john.giles@genusplc.com

VIEWPOINT

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Food Quality – The Solution?

SIMON WARD[1]

ABSTRACT

Tariffs and trade barriers not only fail to ensure the highest food quality but also reduce opportunities for producer innovation. While the government has an important role in ensuring food safety, other aspects associated with food quality are better managed through labelling, allowing consumers to judge food quality on their own terms.

In order to respond to opportunities created by a reduction in tariffs and focus on new food quality drivers the creation of farmer controlled innovation hubs is proposed.

KEYWORDS: Food Quality; Tariffs; Innovation

Food Quality

UK and EU food standards are high. So too are US standards and in fact few products at the farmgate are likely to result in harm to the consumer. The key risks of bacteriological contamination or inclusion of dangerous contaminants are addressed by nearly all food producers. Reasonable quality is essential for any producer In order to maintain personal health or retain customers. If there is a problem it is usually in the kitchen; not everyone has a refrigerator or the wealth allowing food to be discarded where the health risk is judged to be small.

Managing food quality is a more significant problem where the producer and consumer are separated by a long supply chain and there is not a direct link between the two parties. However, most suppliers in any supply chain rely on repeat sales and are unlikely to risk creating a health hazard. All actors in the supply chain must have clear responsibilities and this is the function of traceability measures. Risk is particularly high where supply cannot be easily traced to an individual such as where amalgamation occurs in shared grain storage or milk tanker. As an additional safeguard any failure must be investigated independently and penalties applied. Inevitably this will require some government intervention.

Imports, Tariffs and the WTO

While safe food is a reasonable expectation, even where this fundamental is achieved it is not necessarily, or even usually, possible to profitably import the product. UK WTO (World Trade Organisation) tariffs, inherited from the EU for agriculture, are high and for many products import is prohibitively expensive irrespective of quality.

The objective of the tariffs is to allow UK/EU producers to receive a higher price and forces UK/EU consumers to pay a higher price than would be the case without the tariff. Tariffs also provide a source of tax revenue which may not be apparent to those actually paying a premium for the food. Control of goods entering a port is much easier than applying income tax on a population.

Tariffs are not new to UK agriculture. The Corn Laws from 1815 to 1846 imposed restrictions on grain imports and later taxed imports from US and Canada, increasing the return for UK landowners while leading to starvation and riots for the increasingly urban British population that had to pay more for food. Food quality was not an issue and if anything toxins were likely to have been lower on the imported grain from drier parts of the world.

The WTO recognises the reluctance for vested interests to adopt free trade. It is a complex subject, but in essence for a country to ban an import, the WTO requires the country to prove that the food poses a health risk. Other quality attributes may be enforced where there is agreement. This usually requires enforcement of an internationally accepted agreement such as that on slavery. There urgently needs to be consensus in some of the more difficult issues such as reducing pollution and climate change.

Where tariffs are reduced, for example as part of a Free Trade agreement or as in dispute resolution, the agreement can enforce any number of rules. The EU has been unable to demonstrate any health risk associated with hormone-treatment of beef and has consequently been threatened with penalties following appeal to the WTO. The resolution was the creation of a Tariff Rate Quota (TRQ) that allowed the import of a volume of untreated beef subject to a lower tariff. Those damaged by the ban on the export to the EU of hormone-treated beef decided that it was more profitable to export beef into a high priced EU market, with a lower tariff, than export hormone-treated beef subject to the full tariff.

WTO standards are only enforced where a disadvantaged country appeals.

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Chlorination

Another consumer myth concerns chlorination of chicken.

The data suggest that chlorination of chicken is safer than non-chlorination. The 2017 UK government report on zoonosis states that there were just under 64,000 cases of campylobacter in the UK or 96.8 per 100,000 head of population. In the USA (reported by the Centers for Disease Control and Prevention) there were 20 cases per 100,000. For the vast majority of cases in the UK the source was not identified but where they were, three-quarters were associated with poultry and one-quarter raw milk. Testing of poultry in UK retail outlets (August 2016 to March 2017) showed 57% of UK poultry was contaminated while in the US the reported rate for 2015 was 24%. While not conclusive, it is at least an indicator, that US poultry poses a lower risk than UK production. While chlorination may permit poorer hygiene standards, and thus lower production costs, it is not a necessary condition of chlorination. In terms of safety, chlorination results in fewer cases of campylobacter than (arguably) better hygiene standards in the production process.

Chlorinated chicken does not enter the EU because it is unsafe but because it is subject to a tariff (varies between about £21 and £27 per 100kg). There are lots of other similar barriers in real life associated with protection of producers and not protection of consumers.

Product Labelling

The objective of the WTO is to promote trade and not allow politically motivated objections to be imposed to protect less efficient production or to raise taxes. In the main this is reasonable.

However, there is a role for government taking the lead in environmental protection (pollution, greenhouse gas emissions, destruction of habitat, etc.) and helping to develop global standards. But there is a balance to be maintained. The poorest in society are more worried about food today than future global warming or habitat loss so political compromise is necessary.

However, where there are differences in opinion without an unambiguous scientific basis (genetic modification, chlorination, hormone treatment, organic production and many animal welfare issues) enforcement of labelling provides the solution. This allows each consumer to express an opinion without imposing their views on others.

Systems such as ''organic'' or ''conventional'' farming create particular problems where elements are combined that have both desirable and undesirable consequences under a single label. It is up to those using the label to define key features in an unambiguous way and not the government.

Labelling allows product differentiation which is one of the key means of maximising consumer spending. The cost of producing different coffees in a coffee shop differs by 1p or 2p at most while the price charged varies by over 10p.

The prophylactic use of antibiotics in animal feed poses a meaningful risk to human health and labelling use allows product differentiation that is likely to chime with many consumers. The EU and UK classifies coccidiostats as a feed additive while in Norway and USA classify them as antibiotics (they control protozoa). Norway has phased out prophylactic use while the US has premium antibiotic free supply chains. While an international agreement on classification might be appropriate, in the short term labelling would allow the consumer to determine desirability and a premium for the non-prophylactic producer.

Product differentiation through labelling has already been effective in egg production where over half the eggs consumed in the UK are free range.

The subtleties provided by labelling and the exposure to world markets is an important driver for the future of the UK farming industry.

Innovation

The UK has many disadvantages compared with other countries in commodity food production and with the exception of sheep meat and barley is a net importer of most foodstuffs. However, UK producers have a number of marketing advantages: cost of import is relatively high, transport distances within the UK are small, the local population is large, GDP per head is high and many consumers treat food consumption as a leisure activity. While the low price of food may be seen as a problem for the industry it can also work in the industry's favour.

The UK has a strong technological base that can be used to develop unique products, reduce cost and permit new supply mechanisms.

Opportunities Where Prices are Low

Many consumers are happy to pay a premium for something they believe in, and in many cases the cost of the food material is tiny compared to the rent and labour cost for the retailer. The farm product may be the draw to create the premium brand and is relatively price insensitive allowing the supplier a substantial gain.

The cost of the milk in your takeaway coffee is miniscule compared with rent and labour costs. If the milk provides value through a more efficient dedicated supply system or through supply of quality attributes that, say, improves the ability of the milk to froth in a cappuccino, and the story attracts more customers, the producer price of the milk can be doubled.

The Producers' Marketing Arm

Supermarkets survive on the margin between purchase and sale price. The supermarket's customer is the consumer; the producer's customer is the supermarket. If one producer is prepared to produce at a lower price the supermarket would not expect to pay more for a product that was indistinguishable from the cheaper alternative.

In order for a producer to increase the price paid by a supermarket the product firstly has to be distinct, and secondly, there needs to be something that prevents other producers from supplying the product. If this can be achieved the supermarket becomes a highly effective marketing business allowing a large volume to be sold, sometimes with relatively little effort by the producer. In recent years the drinks industry has capitalised on this with both artisan brewers and gin manufacturers accessing large markets.

Take Back Control

The processor can on occasion lead to disconnection between the producer and retailer. The retailer may gain a premium from product differentiation (e.g. heritage grain in its bread, coccidiostat-free poultry production or low campylobacter poultry meat (e.g. chlorinated)) and the producer may be happy to supply at a price. In contrast, the processor may just see complication and risk. Toll processing (where the processor is paid for the work done and doesn't have to buy the material) can allow the producer to distinguish the product and both the producer and retailer gain a higher price. Carefully managed the contract between producer and processor helps to maintain control over the product. It is worth recalling that Bailey's Irish Cream was the result of an innovation project to dispose of surpluses: the innovators did not manufacture anything.

Profitable production usually requires innovation, a barrier to other parties producing the product and ownership of the idea. A new variety of wheat may allow replacement of imported wheat but the benefit will not go to the grower since the seed cost will largely reflect any increase in price achieved by the producer or if the price is constrained by allowing the seed producer to flood the market to the point that the premium is reduced.

While the best way to own an innovation is to produce the idea, this is not the only way to take a share in the gain. Most start-up innovators require investment and this may be a means for a producer to take a share in the gain by taking on shares in the innovation company. Many problems are soluble by those with specialist knowledge but have no awareness of the farming industry.

Innovation hubs, where groups of farmers identify problems, look for expertise to help solve the problem, hold the patent and invest in the project are under-exploited. The hub allows the farmer to retain the value of the innovation either through retaining the gain from the idea or via selling the device to others.

There are plenty of ideas:

- Many nutrient recommendations derived from soil analysis and mapping fail to determine the optimum nutrient application while measurement of the nutrient in the grain gives a much better indicator of the optimum fertiliser application. Is there scope for inline grain sampling analysis at harvest?
- Data mapping is fashionable but use of that data is poor. Even crops are sought after via seed rate adjustment while the optimum point (where marginal cost equals marginal gain) may result in increased yield variation across the field. Analysis is required to determine where the gain is actually made.

The list of ideas for better marketing and production is long and means must be found for producers to undertake their own research.

There is also a long list of University projects and projects from existing innovation hubs (such as Barclays Innovation Labs) that require a farmer mentor, someone to trial the product and investment. The proposed innovation hub may provide the means of developing mutual gain.

About the author

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VIEWPOINT

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Regenerative Agriculture - Another Passing Fad or A System Fit for the Future?

WILLIAM WATERFIELD[1]

Open just about any agricultural journal and one is bombarded by stories about regenerative agriculture but why all this interest? The confusion surrounding the subject is compounded by terms such as holistic management circular systems, closed production cycles, conservation agriculture, agroecological systems, enterprise stacking, agroforestry, mob grazing, herbal leys or new business models and that is before one starts to consider terms such as mycorrhizal fungi, liquid carbon pathways, rooting zones and the plethora of techy geek speak that surrounds just about any subject these days.

So, what is Regenerative Agriculture? two definitions sum up the situation. The first from Robert Rodale the son of the founder of the Rodale Institute in the United States defines it as ''A holistic approach to farming that encourages continuous innovation and improvement in environmental, social and economic measures.'' The second from Gabe Brown a US farmer from North Dakota who defines it ''regenerative agriculture is a renewal of the food and farming systems which aims to regenerate the topsoil, increase biodiversity, improve the mineral carbon and water cycles whilst improving profitability throughout the supply chain.''

These two definitions clearly show that regenerative agriculture can be more than just about the farming practises that are being carried out. It is a systems approach to agriculture and the food supply, encompasses the whole food system highlighting the broken and linear nature of the current supply system. One which is dominated by a few multinational players and loses any connection back to the farm and the impact that the current system is having on the whole eco system that we depend on.

At the heart of regenerative agriculture is the understanding that we are all dependent on the top few inches or centimetres of soil on this planet. That we have failed to grasp how important it is to look after this finite resource, ensuring that the whole production cycle uses less finite resources and becomes more efficient whilst ensuring that the benefits from this are better shared by all the stakeholders including consumers.

As Robert Rodale put it it's a continuous learning process, one that is based on the fact that the only free source of energy is sunlight and that plants alone can harvest it. When we focus on this it becomes obvious that we need to understand the role that plants above and below ground play in this process and how we as farmers can help to maximise this biological process.

Approximately half a plant's dry matter is below ground and until recently out of mind, however without the roots and their connections the system clearly falls down. Understanding what goes on below ground and how this drives the whole above ground system is key to agriculture. The below ground eco system is hugely complex and only recently becoming understood, in that there is greater species diversity in a teaspoon of soil than there is in a rain forest. To put it simply, plants exchange some of their photosynthetic gains (sugars and carbohydrates) with the eco system below ground in return for the essential nutrients that the plant needs to grow and survive and in so doing build organic matter.

Why is Soil Organic Matter Important?

Increasing soil organic matter has four major benefits some of which may sound contradictory:

- Improved water holding capacity
- Improved cation exchange capacity (nutrient holding)
- Better soil structure (drainage)
- Carbon sequestration

The farmer's role therefore starts with the aim of ensuring that the below ground eco system is happy, healthy and productive. This is the core of Regenerative Agriculture and upon this the whole system can be built. The critical components required by productive below ground communities are that they are not disturbed (reduce cultivation), they have a continuous source of food (continuous above ground plants cover), that they perform best when they are very diverse and are not upset by large dollops of inorganic material. Sounds simple doesn't it, but does regenerative agriculture work? Let's start by looking at some of the claims for organic matter.

One of the major claims for organic matter is that the more you have the more drought tolerant your soils. Table 1 below from way back yonder shows that simply increasing soil organic matter by 1% increases its water holding capacity by 30-40%

One of the fundamental tenants of regenerative farming is that it's the farming practices that influence the level of organic matter in the soil. Table 2 show the

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Table 1: Organic Matter and Available Water

	Sand		Silt Loam		Silty Clay Loan	
Percent SOM	**In of Water / foot**	**% Increase**	**In of Water / foot**	**% Increase**	**In of Water / foot**	**% Increase**
1	1		1.9		1.4	
2	1.4	40%	2.4	26%	1.8	29%
3	1.7	70%	2.9	53%	2.2	57%
4	2.1	110%	3.5	84%	2.6	86%
5	2.5	150%	4	111%	3	114%

Berman Hudson Journal of Soil & Water conservation 49 (2) 189-194 March-April 1994

Table 2: Organic Matter and Farm System

Farm	Cultivation	Crop Diversity	Synthetic Inputs	Livestock	OM
1	Tillage	Medium	Zero		1.7
2	No Till	Low	High		1.7
3	No Till	Medium	High		1.5
4	No Till	High	Zero	Livestock	6.9

Source Cabe Browne tested by Dr Rick Hanay, Temple TX

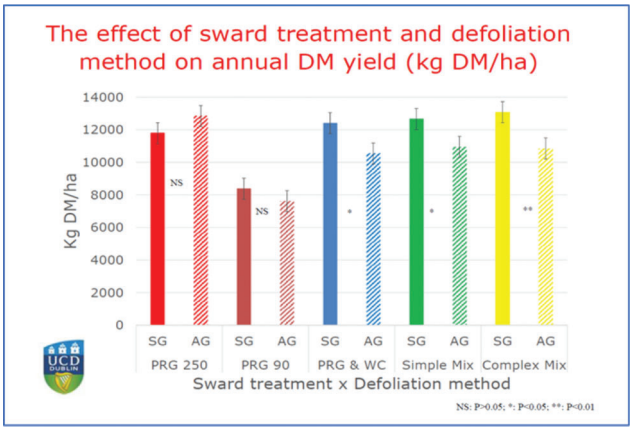
Table 3: The Effect of Soil Organic Matter on Available Nutrients

Farm	N	P	K	WEOC
1	2	156	95	233
2	27	244	136	239
3	37	217	199	262
4	281	1006	1749	1095

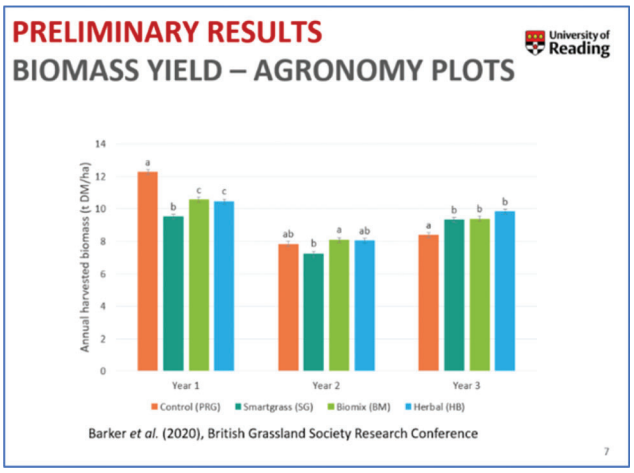
Source Cabe Browne tested by Dr Rick Hanay, Temple TX

Table 4: Farming System and Soil Sequestration of Carbon

Farm Description	Carbon (Kg/M2)	Carbon (t/ac)	Carbon (t CO2 Equiv)
Adaptive (5yrs regenerative)	12.69	51.41	188.13
Rotational grazing (50+ yrs.)	7.09	28.71	105.07
Continuous Grazing (30+ yrs.)	5.47	22.16	81.09



Graph 1 Defoliation and yield of 5 sward types



Graph 2 Biomass Yields from 4 sward types over three years. Source Humphries University of Reading

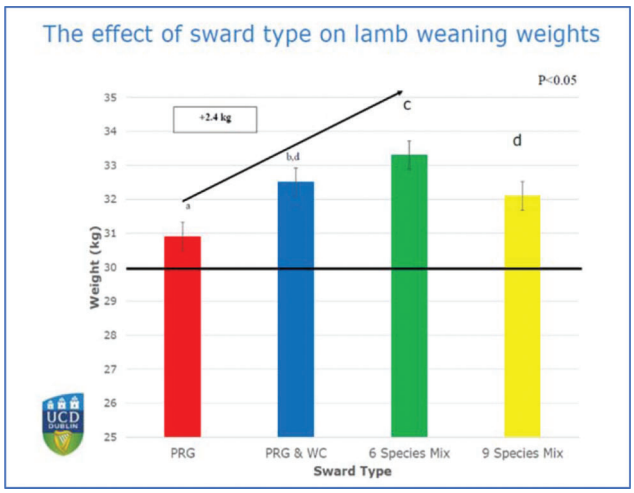
results from four neighbouring farms in North Dakota US which we can assume have broadly similar soil types but different farming system. We can see that Farm 4 is the only one who has significantly higher level of soil organic matter but combines all the elements as well as livestock.

That's great but it doesn't confirm that the organic matter has any effect on the availability of nutrients. Table 3 is from the same four farms and shows the level of the three major nutrients plus the level of water extractable organic carbon which is an important component in the soil food web.

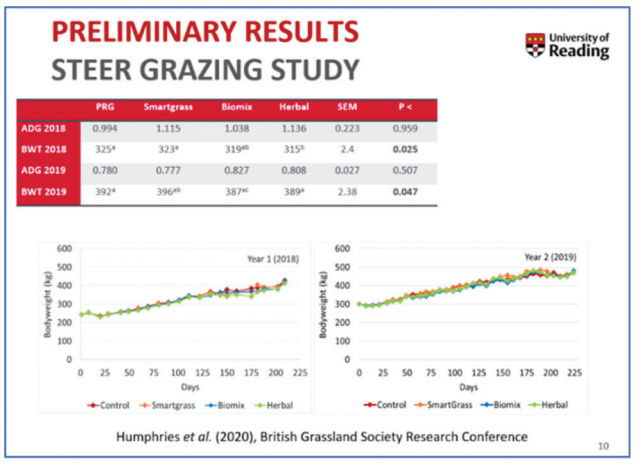
Here again the high organic matter soil has higher levels of available nutrients.

Carbon Sequestration

It's widely claimed that the soil can help to lock up carbon and that agriculture and forestry can be part of the solution to global warming. Looking at the level of carbon in the soil after a number of years we see that the farming system has a major influence and after just 5 years the level of carbon is significantly higher than on the traditionally managed farms.



Graph 3 The effect of sward type on Lamb growth. Source UCD Smart Grass



Graph 4 Animal performance across a range of sward types. Source Humphries University of Reading

At this point the question that is usually asked is does it work - economically and productively? To fairly assess the full impact of regenerative practices we need to consider the effect that the alternative (conventional system) is having, be it on the environment or water quality and whilst this data is available it's beyond the scope of this article.

The Economics of Regenerative Agriculture

A systems approach such as regenerative agriculture demands that we should start looking at the whole system or at least all the component parts of the system. Approaches that only counts the £ of income or the gross margins are no longer any good. Many would argue that we let ourselves down if we do not consider the true costs. We as farmers impose costs on those down stream from us be that water companies or the natural environment.

In accounting for our activities, we have to start somewhere and accepting that you can't be green when your accounts are in the red and therefore counting the pennies is probably a good place to start.

Many arable farmers who have moved into regenerative agriculture via direct drilling route will have seen a release of capital from machinery no longer required to be replaced by a very expensive direct drill. At the same time substantial savings in overhead costs with lower labour, machinery repairs and reduced fuel bills. For livestock farmers, a move towards a more grazing based system results in a reduction in feed costs and when accompanied with outwintering substantial reduction in capital as well as lower running costs.

With improving soil organic matter and the associated increase in available nutrients, a reduction in fertiliser costs in nitrogen where annual reduction of at least 10% are achieved on many arable units.

Looking at the specific performance data from some of the trials it is clear that the expected benefits in terms of additional dry matter are achieved as illustrated by both the work at University of Dublin and the University of Reading.

In terms of production one can consider the yield of dry matter. Work at the University of Dublin has shown that diverse leys with seed mixtures consisting of 40% Grass 30% Legumes and 30% Herbs with no artificial nitrogen out yielded ryegrass only swards receiving 250 Kg of Nitrogen by 500kg per hectare.

Closer to home, work at the University of Reading over a three year period has shown that the greater the diversity in the mixture resulted in increased yield. As years progress in a challenging dry season the effect of drought on PRG only sward was dramatic.

A second experiment at UC Dublin compared five swards with actual or simulated grazing. Again, this showed that the two diverse swards out yielded mono cultures.

In terms of animal performance lambs of diverse swards were shown to be 2.4 kg heavier over the trial period compared to perennial ryegrass only swards. At the same time the lambs on diverse swards needed less anthelmintic treatments.

Proving the economic benefits under trial circumstances is more of a problem. The preliminary results from Reading with a group of Frisian steers showed that the sward diversity was converted into increased liveweight gain.

So, to answer the question in the title of this Viewpoint: No regenerative agriculture is not a passing fad but a system of agriculture that is truly sustainable with the potential benefits for consumers and the wider environment. At the same time, it can allow farmers to diverse their systems adding value or new enterprises.

About the author

William is a Director and Consultant at Waterfield & White Ltd, based in the Andover Office of the Farm Consultancy Group. William specialises in the provision of advice to farmers and landowners who farm or are considering farming to organic or adopting regenerative practices. He undertakes strategic planning, business appraisals, budget preparation & monitoring. He has a background in dairy herd management and a keen interest in improving farm profitability whilst enhancing the environment.

REFEREED ARTICLE

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Development of Organic Farming on the Path of Growth for Farmers' Good Quality of Life according to the Sustainable Environmental Management

WISAKHA PHOOCHINDA[1]

ABSTRACT

Most agricultural practices have focused on high volume of produces by using chemicals. Currently consumers highly focus on the safety of food and agricultural produces that increases trend of green and organic consumption resulting in increasing organic farming. This study aimed to analyze factors affecting development of organic farming; to investigate guidelines of sustainable organic farming management; and promote networking of organic farming on the path of growth under Thailand 4.0 in the EEC. Data collection was conducted via questionnaire to farmers practicing organic farming in three provinces in the EEC, with 150 farmers in each province, 450 in total, as well as interviews with officials of District Agricultural Extension offices, organic farmers, and network leaders. Data analysis was conducted using descriptive statistics and content analysis.

Factors affecting the development of organic farming consisted of sufficient production and management according to the organic farming standards, and farmers' accessibility; efficient and appropriate production system management; potential in farming of organic vegetables; good attitude towards organic farming; marketing of organic farming; and attention to health and consumers' organic vegetables. All these factors are in accordance with the organic productivity, income and health. In addition, organic farming is environmentally friendly. Guidelines for development of the organic farming include marketing, logistics, and standards for organic products such as promotion of production and creation of self-reliant networks; support changes in production to secure sustainable farming; drive pilot projects to integrate the development of organic farming; and integration of the development of production and marketing.

KEYWORDS: Organic Farming; the Eastern Economic Corridor (EEC); the Sustainable Development; Environmental Management; Good Quality of Life; Factors

1. Introduction

Based on the Strategy of Thailand 4.0 focusing on stability, prosperity, and sustainability with the aim of, achieving a new form of economic growth, the industrial sector is one target to upgrade the country's competitiveness. The east of Thailand is an area which is strategically located in ASEAN with basic infrastructure responsive to both residential and industrial estates or industrial zones which collectively account for a major part of the country's industrial production base, especially in the petrochemicals, automotive and parts, and electronic appliance sectors. Moreover, it is a global hub of investment, tourist destinations, and an industrial base for energy. The three target provinces are Rayong, Chonburi, and Chachoengsao, located in the Eastern Economic Corridor (EEC). However, investment in EEC projects is indicative of the readiness of Thailand in many aspects such as best location in ASEAN thanks to the strong industrial foundation, large production base, connectivity of transport in many forms, as well as world-class tourist locations, preparing it to support and provide integrated business services, as well as potential towards prosperity and growth from investment in parallel with urbanization and future needs of ASEAN markets. Industrial production in the EEC needs efficient distribution channels of import-export including land, sea, and air. If the EEC succeeds in attracting growing numbers of investors, the increase in volume of the goods will be in line with the heightened level of economic growth.

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The continual expansion of the population increases demand for and volume of agricultural products both for domestic consumption and export. Farmers and entrepreneurs must compete and accelerate the development of their produces to gain wide access to the market system. As a result, the agricultural system focuses on raising economic benefits. Farmers turn to agricultural chemicals to improve the quality of produces, increase output, prevent disease, and reduce the number of pests that cause damage to the farmers' produces. According to a report, Thailand ranks 48th in the world agricultural output. However, it imports the highest quantity of agricultural chemicals in Southeast Asia and ranks fourth in the world in the use of pesticides (Thairath, 2018). This indiates that there is a tendency for farmers to continually increase the use of chemicals as they want their produces to be sufficient for the market demand and to be competitive with other farmers while dealing with the problems of climate change and the volatility of the economic system for survival, which both continue to impact the society and environment.

Most agricultural practices that focus on high volume of produces, with processes starting from plantation to production for consumption or further processing industries, all affect the environment. This includes energy consumption from the use of agricultural machinery, and danger from chemical fertilizers and chemical pesticides that cause sudden and chronic health problems among farmers who come into close contact with the chemicals, as well as contamination to consumers and in the environment such as soil pollution and water pollution, resulting in widespread negative impacts on the ecosystem. The quality of export produces both in the forms of fresh or processed fruits is affected by chemical residues. Due to these problems, consumers are concerned about their health and the health of the environment. Consumers highly focus on the safety of food and agricultural produces. This can be seen from the increasing trend of green consumption, consumption of organic fruits and vegetables, and organic products. Agricultural products are important to the health of farmers, producers, consumers, as well as to the country's economy and environment. As a result, farmers, producers, and entrepreneurs must focus on the shift of the agricultural sector toward safety, health, and sustainability. A study found that the three key performance indicators evince the transition away from conventional or chemical farming towards a sustainable form of farming; climatic impact, economic stability, and social stability (Cristache *et al*., 2018).

For the past many years, policies formulated by the government and agencies supervising agricultural products have focused on the promotion of farmers to reduce the use of agricultural chemicals and shift to more organic farming. Organic farming, mixed farming, sustainable farming, and natural farming all contribute to the agriculture that avoids using chemicals, synthetic substances, promotes the balance of agricultural eco-system, as well as contributes to sustainably increased value and volume of produces more than agriculture using chemicals (Chaimongkol, 2013). At the same time, the development of agricultural logistics consists of basic infrastructure and more facilities for agricultural logistics, trainings, promotion and development of farmers, as well as agricultural institutions that have the ability for management, marketing, network creation, and environmentally friendly operation. However, the operation of agricultural logistics and the creation of value-added in the supply chain still face limitations. Most farmers still lack knowledge, understanding, and skills required for efficient organic farming management in according with the study of Jesarati *et al*. (2018) which stated that organic agriculture is rapidly growing while the lack of knowledge and skills to manage organic farms and the lack of market opportunities for the organic products are the most important reasons. This has become an issue that corresponds to the development of Thailand's agricultural sector.

Therefore, this researcher is interested in studying factors affecting the development of organic farming on the path of growth under Thailand 4.0 for sustainable quality of life and environmental management in the three aforementioned provinces. The factors investigated are therefore used to propose guidelines to encourage and develop the organic farming as well as establish a network of organic farming in the EEC. There are areas with basic infrastructure that can facilitate the upgrading of the traditional agricultural sector into a higher quality agricultural system, one that is safe for the health of consumers and is environmentally friendly.

2. Methods

The methodology included a review of the literature on policies, measures, and guidelines relevant to organic farming by applying the principles of environmental management appropriate to the community in each area, compiling information on the development of the EEC, scope of target areas in the development of the EEC, as well as the development plan of the EEC of the three provinces to investigate the context and scope of the development of each area. After that, field trips to survey and collect both qualitative and quantitative data by random sampling of specific communities, covering agricultural communities in the areas in the agricultural pilot project were conducted. Other areas in the EEC by Ministry of the Interior and Ministry of Agriculture and Cooperatives namely Chachoengsao, Chonburi, and Rayong.

Data and information were collected by interviewing four groups of informants namely; (1) District Agricultural Extension Offices in Chachoengsao, Chonburi, and Rayong; (2) organic farmers in provinces outside the EEC; (3) networks of organic farmers in Chachoengsao, Chonburi, and Rayong; and (4) networks of organic farmers in provinces outside the EEC.

In addition, a questionnaire was used to gather data from farmers practicing organic farming in the three provinces in the EEC. There have been 102,711 farmers and so the sample size of the farmers was 400. The researcher used disproportional quota and accidental sampling to 150 farmers in each province, totaling 450 samples.

Tools used in this study i.e. interviewing form and questionnaire were validated by experts in the field.

IOC (Items Objective Congruence Index) was employed and it was above 0.5. In addition, questionnaire was tested with farmers who are outside the EEC areas and a reliability of questionnaire was about 0.803.

Data analysis of the results of the questionnaire and interviews was conducted by content analysis to group factors affecting organic farming and positive and negative effects of the organic farming. The descriptive statistics was also used to analyze the frequency of each factor and effect.

The conceptual framework used in the study is shown in Figure 1.

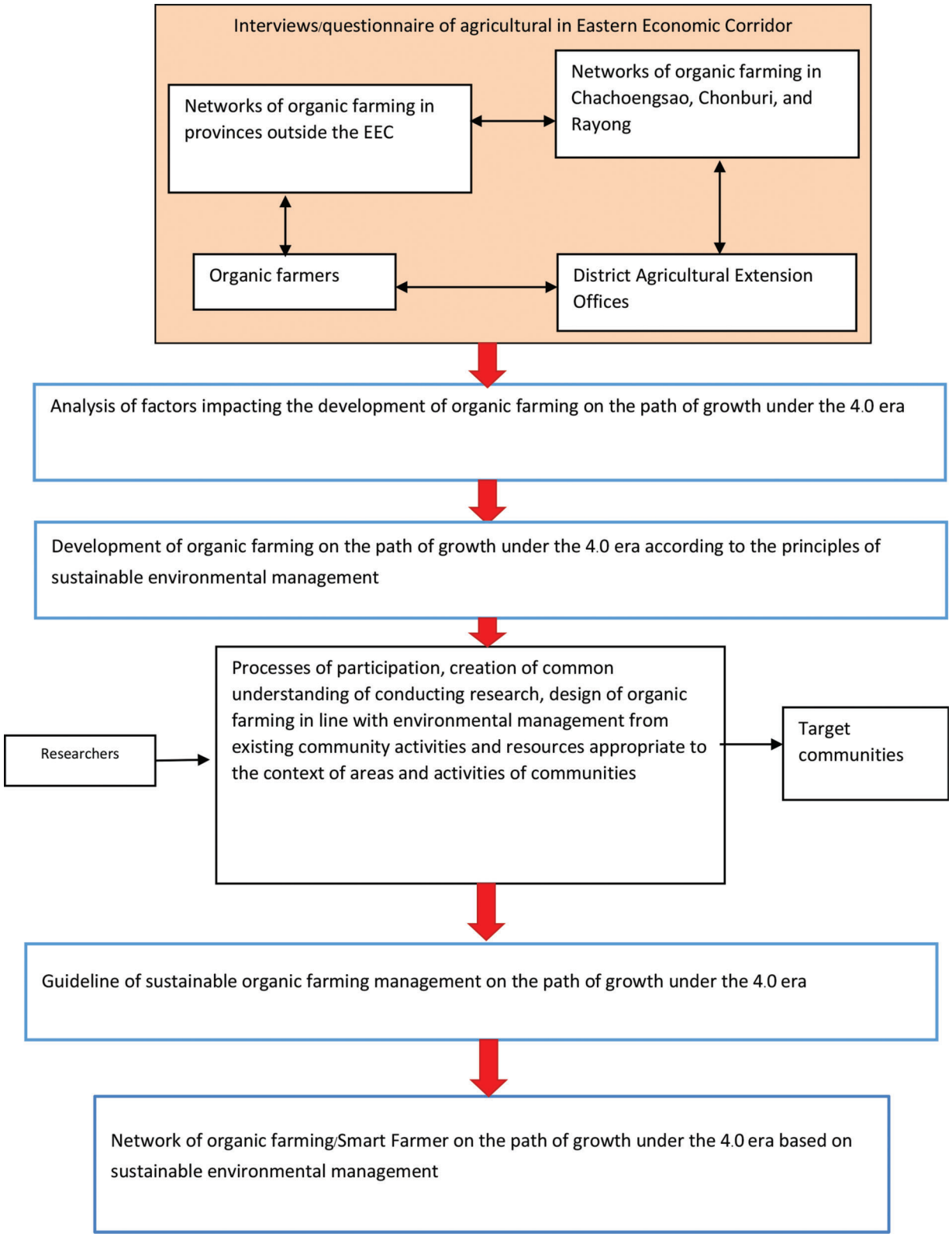

Figure 1: Conceptual Framework used in the study

3. Results and Discussion

3.1 State of the Art of Organic Farming in the EEC

Based on field trips to compile data on the operation of development of organic farming networks in Chachoengsao, Chonburi, and Rayong, the researcher concludes a guideline to integrate organic farming networks in the EEC from the recommendations of the sample to Thailand 4.0 Development Plan, as referenced by the Permanent Secretary for Agriculture and Cooperatives (2009). This includes the promotion of farmers to gain easy access to information, increased potential of sufficient production of agricultural products for domestic consumption, innovation and development including advanced technology, solutions to farmers' debt problems, modernization of existing rules and regulations, value-added for agricultural goods, improvement of production in line with climate change, focus on more research and development, and integration of work of all relevant ministries covering all dimensions.

The integration of the networks of organic farmers should operate with the private sector in cooperation with relevant agencies, including those at the center and at provincial levels, farmer groups, and academic institutions in the form of memorandums of cooperation to develop and strengthen organic farmers in local communities, and new farmer groups with potential to enter the organic farming system. This needs the government's support of production factors and basic infrastructure, academic knowledge, market linkage, funding sources, processing, budget, and personnel, as well as setting up local working groups to consider planning, production, marketing, standards, and budget as follows:

1. Provide the mechanism and networks to drive the development of organic farming for systematic, integrated supervision, production, and marketing of organic farming at local, provincial, and network levels in the form of sub-committees/working groups such as organic farming group at Sanam Chai Khet District. These should place importance on farmer communities as a main driving force with government agencies such as District Agricultural Extension Offices acting as supporting and facilitating agencies in various aspects, recruitment and nomination processes of farmer representatives and experts through considerations of the appropriateness of areas such as ''Doctor Ku,'' local wise people, and farmer representatives at Environmental Conservation Organization at Wang Chan District, Rayong.
2. Assess regular performance of the development of organic farming in order to use the results to improve the action plan for flexibility, and appropriateness amidst the fast-changing situations in the EEC.
3. Promote regional academic institutions as networks to drive the development of organic farming in collaboration with communities such as Kasetsart University. Kasetsart supports agricultural technology such as in the case of the installation of pumping stations and solar cells for farmers in Singhanart Sub-district, Lat Bua Luang District, Ayutthaya.
4. Arrange for the study of guidelines to establish the National Institute of Organic Farming Development similar to the royally initiated Center for Training and Development of Agricultural Occupation at Wat Yannasang Wararam as a major organization to drive the development of organic farming into the future.

3.2 Factors Affecting the Development of Organic Farming on the Path of Growth under Thailand 4.0

The results of the quantitative analysis by using questionnaire with 450 farmers in the three province of the EEC revealed the factors affecting the development of organic farming as follows: management of sufficient production factors in line with organic farming standards, and farmers' accessibility; efficient and appropriate management of production system, as well as farmers' knowledge and understanding of business operation of organic vegetables; and potential in producing organic vegetables and good attitude towards organic farming of relevant farmers, producers, and entrepreneurs in organic farming networks. These affecting factors are in accordance with the organic farming productivity and profitability and thus farmer income (Ullah *et al*., 2015). In addition, the factors included marketing of organic farming that facilitated the consumers and farmers to understand the health benefit of organic vegetables and expanded consumers' demand in line with the most important factors, which are the health factors for farmers to adopt organic farming (Cukur *et al*., 2019). Furthermore, there are crucial factors involving logistic management to support organic farming; consumers' concern for health and confidence in organic vegetables; robust groups and networks of organic vegetables in the EEC; pro-active communication and public relations that impacted the mechanism to drive organic farming development of all stakeholders in organic farming networks; clear and appropriate standards and certification system of organic vegetables; database on organic vegetables that was reliable and accessible, covering all dimensions; research that supported the development of organic farming; concrete and continuous support from public and private agencies; potential and good attitude toward organic farming of government officials involved in the development of organic farming; and policies and laws that supported and promoted the development of organic farming. Many other studies also mentioned environmental protection (Cukur *et al*., 2019) which is one of the important factors for adoption of the organic farming as organic farming is an environmentally friendly form of agricultural management. It was confirmed by one study that the five major factors that influence the adoption of organic farming are economic, social, marketing, cultivation, and government policy with marketing and government policy factors being most crucial (Azam & Shaheen, 2019).

3.3 Impact of the EEC on Organic Farming in Chachoengsao, Chonburi, and Rayong

The results from the questionnaires and the interviews revealed the positive and negative effects of the organic farming as shown in Table 1. According to the government's targets, the EEC areas would be

Table 1: Positive and Negative effects of the organic farming

Positive affect	Negative affect
- Growth of industries focusing on the application of new agriculture-based technology such as use of sensors to measure soil quality and volume of water, advanced techniques to analyze data, and automatic system.	- The government's insufficient and discontinuous budget support to develop potential and competitiveness in agricultural and industrial sectors.
- Research and development on biotechnology such as improvement of plant and animal species, quality screening, packaging, preservation of vegetables, fruits, and flowers using advanced technology such as use of sensor system to test meat in fruits, etc.	- Limited support and assistance from the government sector, support might not cover the development of organic farming which was unable to gain access to capital sources, resulting in a lack of liquidity for the organic farming business and finally going out of business.
- One of the areas with investment in transport, basic infrastructure to create economic activities across dimensions, resulting in expansion, attracting both domestic and foreign investors.	- Pollution problems and global warming derived from the industrial sector, impacting long-term development of organic farming.
- Marketing and logistics that speedily distributed organic products both by land and air, convenient and speedy transport system to distribute products.	- Area expansion of industrial estates necessitated the move of agricultural communities to the outside, reducing farmers' land to earn living, etc.
- Increased visits from tourists in the areas, providing good opportunity for marketing of organic products.	- Reduced labor force in organic farming due to the focus on agricultural development using machine technology and experts in specific fields.
- Policy put in place to assist small entrepreneurs with SME development fund according to the concept of civil state of Chachoengsao to assist organic farmers, support SMEs to develop towards high-valued agro industry according to the National Strategy and Thailand Reform Strategy in line with Thailand 4.0 Policy and as a fund to fulfill the needs of SMEs engaging in organic farming who otherwise would not gain access to regular sources of funding.	- Increased use of water resources due to immigration of people from outside the EEC.
	- Laws gave rights to many non-local entrepreneurs to own land in the Eastern Special Development Zone, resulting in a lack of security to control ownership or possessory rights of locals, impacting the stability of resource ownership of local communities.
	- No true participation process for farmers if the government did not have the clear policy on the participation of farmers in the development of organic farming.
	- Increased use of water resources due to immigration of people from outside the EEC.
	- The EEC Plan did not focus on small organic farming but rather on large farming with no common benefit seen for small farmers.
	- Lack of transfer of organic farming wisdom due to the fact that the next generation turned to industrial jobs.
	- Personnel of District and Sub-district Agricultural Extension Offices lacked knowledge on organic farming so they could not fully promote and support the development.

upgraded as the country's leading economic zone by combining industrial technology with IT, affecting the development of organic farming both positively and negatively.

3.4 Guidelines to Develop Organic Farming according to the Principles of Sustainable Environmental Management in the EEC

Based on the study of the factors affecting the development of organic farming on the path of growth under Thailand 4.0 from the lessons learned from nationwide organic farming and in the EEC, two guidelines were developed that can be summarized as follows:

1. Promotion of production, marketing, logistics, and standards of organic products.

- Promote production and create networks of self-reliance both by promoting and supporting production factors necessary for organic production, and creation and linkage of organic farming which would assist the grouping of farmers to practice organic farming and link with networks, as well as reduce reliance on external production factors. Moreover, marketing channels and price guarantees were developed to accommodate the excess of community and local produce in order to help farmers.
- Promote the shift of production to secure and sustainable agriculture such as projects to promote organic farming and production of safe products, projects to promote the use of organic substances in place of agricultural chemicals, projects of learning centers for organic livestock, creation of networks to connect and exchange learning towards self-reliance with government agencies such as Department of Agriculture, Department of Agricultural Extension, Land Development Department, and

Department of Livestock Development as supporting agencies.

- Drive pilot projects to integrate the systematic development of organic farming at area level such as the project to forge skills and promote agricultural occupation in Wang Chan District, Rayong. The project generated income for small farmers. It was one of the projects operated by Ministry of Agriculture and Cooperatives to allow farmers to learn and adapt in the social, economic, natural, and changing environmental contexts for a sustainable future. This project enhanced the development as occupations by establishing guidelines to develop projects based on community cooperation, leading to job security, and increased income, in parallel with local environmental protection as true heritage for the next generation. It provided sustainability for those practicing agricultural occupation. It was the major component of good quality of life by espousing the royally initiated concept or the King's Philosophy for the maximum use of the areas, distribution of opportunities, upgrading of farmers' income, as well as rehabilitation of the eco-system.
- Drive the integration of the development of production and marketing with area based joint cooperation which includes processing, distribution, and selling of organic products (Dunn *et al.*, 2014) without overlapping, and with the maximum use of budget. Promotion was therefore integrated to produce agricultural products in the form of organic products in areas with potential and readiness to support farmers' self-reliance, job security, income generation for farmers, as well as creation of value-added for organic products, and robust health.
- Fertilizer management for organic farming. The country's organic farming development focused on soil improvement by mostly using organic matters in the form of organic fertilizer in parallel with bio-fertilizer which usually lacked plants' main nutrients such as nitrogen, phosphorous, and potassium. Therefore, relevant agencies should study the use of minerals and soil nutrients. Research had been conducted on the efficiency of plants' nutrients namely minerals and soil nutrients and enforcement of regulations on the export of these minerals to maximize the development of the country's organic farming.
- Transport process from farmer groups or members to markets of organic farming networks. A database must be managed to predict the customers' demand for production. The effect related to logistics transport included transport costs, utility service costs, and volatility of exchange rates.

2. Provision of the knowledge and innovation management consisted of the following:

- Research and development with major contributions such as increased potential for innovation-based entrepreneurs, research and development on systems, production and standards of organic products, promotion of the use of organic substances to reduce the use of chemicals in agriculture, support the research and development of in-depth foreign markets, etc. with government agencies such as Ministry of Agriculture and Cooperatives, Ministry of Commerce, and National Innovation Agency as the main agencies to drive the research and development.
- Public relations to enhance knowledge and understanding with major media campaigns to replace chemicals with organic substances and activities to promote knowledge of organic product marketing.
- Transfer of knowledge and develop potential of personnel with major contributions such as training for leaders of farmer groups and officials on the adoption of organic farming systems, workshops for local farmers in cooperation with lecturers from other agencies such as Ministry of Agriculture and Cooperatives.
- Compile and disseminate knowledge and innovation on organic farming for systematic knowledge management and beneficial dissemination to farmers and interested persons.
- Establish the center for organic farming knowledge management such as a center for local wisdom and the regional universities.

4. Conclusion

Factors affecting the development of organic farming on the path of growth for farmer's good quality of life consisted of sufficient production factor and management according to the organic farming standards, and with farmers' accessibility; efficient and appropriate production system management; potential in farming of organic vegetables; good attitude towards organic farming of both farmers and consumers; marketing for organic farming; attention to health and consumers' organic vegetables. Two major guidelines for developing organic farming according to the principle of sustainable environmental management in the EEC include: (1) promotion of production, marketing, logistics, and standards of organic products, e.g., pilot project and create networks of self-reliance; and (2) provision of knowledge and innovation management, e.g., R&D and a center for organic farming.

5. Suggestions

5.1 Policy Recommendations

The policy recommendations from the study consist of the following.

1. Ministry of Agriculture and Cooperatives should provide the opportunity for farmers and communities to participate in presenting their opinions on policy and planning, as well as systematic management of the projects related to organic farming policy.
2. Ministry of Agriculture and Cooperatives should formulate policy on the concrete and continual creation of knowledge about organic farming for operating officials.
3. Department of Agriculture should formulate policy on organic farming on the concept that good strategies must have diversities in order to respond to all groups of stakeholders.
4. Ministry of Agriculture and Cooperatives policy should systematically support organic farming such as production system, market system, consumption system, and standard system in parallel with the formulation of strategies to motivate farmers to shift from chemical-based farming to organic farming.

From 1 to 4 it can be noted that government policy is essential to drive and motivate organic farming in line with Kallas *et al*. (2009) identifying the policy changes that have been more relevant in motivating adoption of organic practices.

1. Database on organic farming should be clearly developed such as the number of organic farmers, plantation areas, and groups of organic farming.
2. Guideline to implement the government projects whereby it is not necessary to have major projects but rather well-planned small projects that can gain full access to the areas.
3. Assessment of the policies, projects, and activities should be disseminated to the public so that they are aware of the policies and acknowledge them.

5.2 Operational Recommendations and Information

1. The efficient development of organic farming should focus on the farmers themselves, and producers. The assessment or investigation of efficient production should take into consideration the quality of life of farmers. The consideration of more income from production cannot truly assess the efficient production of pesticide-free vegetables and organic vegetables.
2. Agricultural District should apply the principles of efficient organic farming management under the responsibility of the farmers themselves, their ability of self-reliance, grouping of farmers, planting planning, dissemination to the public, and farmers in various areas for appropriate application.
3. Relevant agencies both public and private such as Ministry of Agriculture and Cooperatives should conduct study to define standard criteria for inputs and success factors to develop organic farming so that farmers can use them as a guideline for self-assessment and improvement of efficient production of organic vegetables.
4. Marketing Organization for Farmers and private agencies should concretely place importance on development to strengthen organic farming in the EEC. The consideration of the trend of future situations reveals that farmers may face pollution problems due to industrial production. The government should foster confidence among consumers, assist in transferring knowledge to farmers, and operate projects to find accommodating markets.
5. Both public and private agencies related to production of pesticide-free vegetables and organic vegetables should participate in the development of organic farming. Government agencies should provide knowledge, certify standards, and disseminate knowledge about the projects concerning organic agricultural products for wider recognition. The private agencies should create markets to accommodate produces so that farmers can grow quality organic vegetables and sell them to consumers.

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Relative Profitability and Risk of Kansas Farms

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ABSTRACT

This study examined the relationship between return on equity for individual Kansas farms and the S&P 500 using data from 1996 to 2018. Return on equity was measured with and without the inclusion of capital gains on land. Results indicated that return on equity with capital gains on land adjusted for risk was 1.2 percent above S&P returns during the period. For most of the farms in the sample, the risk faced by individual farms was not related to risk incorporated into the S&P 500 index, suggesting that there are opportunities for farm operations to diversify their risk by investing in the stock market.

KEYWORDS: Return on Equity; Benchmarks; Risk Adjusted Returns

1. Introduction

In the corporate finance literature, a distinction is often made between systematic and unsystematic risk. Systematic or market risk corresponds to risk associated with economywide perils and for this reason is difficult to avoid. Unsystematic or unique risk reflects the fact that many perils that surround an individual investment or firm are specific to that investment or firm, and can thus be reduced through diversification.

The Capital Asset Pricing Model (CAPM) can be used to examine systematic and unsystematic risk (Fama, 1976; Barry and Baker, 1984). The CAPM model, described in more detail in the methods section below, computes alpha and beta values for individual investments or firms. A significant alpha value signifies that the return for a specific investment or firm differs from the returns for the market index (i.e., S&P index). Beta measures the sensitivity of an individual investment or firm to market movements. Investments with betas less than 1.0 tend to move in the same direction as the market index, but not as far. Investments with betas greater than 1.0 tend to have movements in returns that are greater than the overall movement of the market index.

A few previous studies have examined the relative profitability and risk of the agricultural sector. Daniels and Featherstone (2001) examined agricultural risk among U.S. states using the CAPM. Results suggested that profitability and risk varied among states. Tauer (2002) and Bigge and Langemeier (2004) examined the relative profitability and risk for New York and Kansas farms, respectively. Results documented a large difference in relative profitability among farms. For most of the farms, the risk experienced by individual farms was not significantly related to the market index. In other words, the beta values were not significantly different from zero.

Previous studies have been helpful in documenting the large differences in the profitability among farms and the low correlation between farm risk and the market index. However, these studies are quite dated and more importantly do not cover the post-2007 period in U.S. production agriculture, which is related to the rapid increase in ethanol production and exports of soybeans to China. Given the developments that have taken place since 2007, it would be useful to examine whether the results reported in previous studies have changed.

The objective of this study is to examine the relative profitability and risk of a sample of Kansas farms and the S&P 500. Measures are computed for each farm and compared among farms. Measures are also related to farm size.

2. Methods

The following regression can be used to estimate the CAPM model for each farm:

$$ROE_t - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + e \qquad (1)$$

where ROE is return on equity at time t, r_f is the risk-free rate at time t, α is the alpha value, β is the beta value, r_m is the average rate of return on the market index at time t, and e is an error term.

ROE is computed with and without the inclusion of capital gains on land. ROE is computed in two different ways to account for the fact that ROE with capital gains

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on land is more comparable with the stock market and ROE without capital gains on land is widely used as a financial performance benchmark. ROE with capital gains on land is computed as follows:

$$ROE = (NFI - UNPAID + CGLAND)/NW \quad (2)$$

where NFI is accrual net farm income, UNPAID represents unpaid operator and family labor, CGLAND is the capital gain or loss on owned land, and NW is average farm net worth. Because it includes unpaid operator and family labor, return on equity can be readily compared among farms with various levels of hired and unpaid labor.

The one-year Treasury bill rate is used to represent the risk-free rate in equation (1). Rates are obtained from the Federal Reserve Bank of St. Louis. The S&P 500 index is used to represent the market index in equation (1).

The distribution of alpha and beta values obtained using equation (1) for the return on equity with and without capital gains, as well as the difference in alpha and beta values between the two return on equity measures, will be summarized. T-tests will be used to determine whether there were significant differences between the average return on equity with capital gains, alpha values, and beta values among farm size quartiles measured using value of farm production as a measure of farm size. Significant differences in the return on equity and alpha values would be indicative of economies of scale and/or competitive advantage among farm size quartiles.

3. Data

The data used in this study came from the Kansas Farm Management Association (KFMA) databank. Specifically, KFMA farms with continuous data from 1996 to 2018 were used in the analysis. A total of 140 farms had continuous data over the time period.

The average and standard deviation of the return on equity measures, the return on the S&P 500 index, the return on T-bills, and value of farm production are summarized in table 1. As noted above in equation (2), the return on equity with capital gains was computed by subtracting unpaid operator and family labor and adding capital gains on land from net farm income and dividing the result by average net worth. The average return on equity with capital gains was 0.0381 or 3.81 percent. Approximately 15.0 percent of the farms had a negative average return on equity. The average return on T-bills and the S&P 500 index were 0.0218 and 0.0827, respectively. The standard deviation of the rate of return for the S&P 500 index was substantially higher than the standard deviations for the rates of return on farm equity and the rate of return on T-Bills.

The average value of farm production for the sample of farms was $395,481.[1] The first quartile had an average value of farm production below $205,000. The second and third quartiles had a value of farm production between $205,000 and $296,000, and $296,000 and $497,000, respectively. The fourth quartile, the farms with the largest value of farm production, had an average value of farm production that was greater than $497,000. The average value of farm production for farms in the fourth quartile was $817,572.

[1] At the time of this writing (late July 2020), $US1 was approximately equivalent to £0.77 and €0.85.

Table 1: Summary Statistics for Rates of Return and Farm Characteristics

Variable	Average	Standard Deviation
Rate of Return on Farm Equity		
With Capital Gains	0.0381	0.0946
Without Capital Gains	0.0089	0.0978
Rate of Return on S&P 500	0.0827	0.1454
Rate of Return on T-Bills	0.0218	0.0208
Value of Farm Production	395,481	329,644

4. Results

Table 2 presents the distribution of alpha values resulting from the estimation of equation (1) for each return on equity measure. Return on equity with capital gains is more analogous to comparisons between individual investments and the S&P 500 index, because of this the discussion below focuses on this measure. It is important to note that the alpha values in table 2 represent risk adjusted returns, so they account for the both average and standard deviation of rates of return. The average alpha value for the entire sample was 0.012. This suggests that on average the risk adjusted farm return was 1.2 percent above the return for the S&P 500 index. Approximately 42.1 percent of the farms had an alpha value that was significantly different from zero. The average alpha value for these farms was 0.018. Of the farms with an alpha value that was significantly different from zero, 16 farms had a negative alpha value. The average alpha value for these farms was -0.135. An alpha less than zero indicates that the farms are earning a risk adjusted return that is lower than the return for the benchmark, the S&P 500 index. The average alpha value for the 43 farms with a significant and positive alpha value was 0.075. The farms with a positive alpha value are earning a higher risk adjusted return than the S&P 500 index. Clearly, the farms with a significant and positive alpha value were performing extremely well during the sample period. The wide dispersion in relative profitability, as signified by the alpha values in table 2, is consistent with previous literature (e.g., Purdy et al., 1997; Tauer, 2002; Bigge and Langemeier, 2004; Yeager and Langemeier, 2009; Langemeier, 2011; Langemeier, 2013; Key, 2019).

The beta values resulting from the estimation of equation (1) indicate how risky a farm was relative to the market (i.e., S&P 500 index). Table 3 presents the range of beta values for return on equity with and without capital gains. The average beta value using return on equity with capital gains as the performance measure was 0.064. However, only 9 out of the 140 farms had a beta value that was significantly different from zero. None of the farms with a significant beta value had a beta value that was greater than one. A beta value less than one indicates that the risk of the farm was less than the risk of the market. The low beta values obtained in this study suggest that systematic risk was low for the individual farms, and that there are potential diversification

opportunities between production agriculture and the stock market. The average beta value in this study was consistent with the average value of 0.10 obtained by Baker et al. (2014) in their study of Indiana farmland, and with the average (0.068) obtained by Bigge and Langemeier (2004) using a sample of Kansas farms with performance data spanning the 1982 to 2001 period.

Land values for most of the years during the sample period increased. Thus, we would expect the alpha values obtained using return on equity with capital gains to be higher than the alpha values obtained without the inclusion of capital gains. The beta estimates for the two return on equity measures would not necessarily be either lower or higher than one another. Table 4 presents the difference in the alpha and beta estimates between the two return on equity measures. The difference was computed by subtracting the alpha and beta values for return on equity without capital gains from those obtained for return on equity with capital gains. The average difference in the alpha and beta values was 0.027 and 0.038, respectively. A vast majority of the differences were positive. Thus, including capital gains in return on equity measures increases relative profitability and risk.

Table 5 presents the average return on equity with capital gains, alpha values, and beta values by farm size quartile. Entries within a column with an unlike letter are statistically different at the 5 percent level. Return on equity with capital gains (ROECG) was significantly higher for the third and fourth farm size quartiles than it was for the first and second quartiles. More importantly, the alpha values for the fourth quartile were significantly higher than the alpha values for the first and second quartile, signifying the presence of economies of size and/or competitive advantage for the larger farms. It is important to note that return on equity and the alpha values are not measuring the same thing. Unlike return on equity, the alpha value is measuring return adjusted for risk. As such, comparisons of the alpha values across farm size quartiles are more pertinent. The beta values among the farm size quartiles were not significantly different from one another. Thus, the low beta value result obtained when examining all farms holds for each farm size quartile.

Table 2: Alpha Values for 140 Kansas Farms

Value	Without Capital Gains	With Capital Gains
Less than -0.20	8	8
-0.20 to -0.15	2	1
-0.15 to -0.10	6	3
-0.10 to -0.05	15	8
-0.05 to 0.00	43	25
0.00 to 0.05	44	56
0.05 to 0.10	18	29
0.10 to 0.15	1	6
0.15 to 0.20	0	0
Greater than 0.20	3	4

Table 3: Beta Values for 140 Kansas Farms

Value	Without Capital Gains	With Capital Gains
Less than -0.20	9	8
-0.20 to -0.15	8	5
-0.15 to -0.10	9	7
-0.10 to -0.05	13	9
-0.05 to 0.00	11	9
0.00 to 0.05	29	16
0.05 to 0.10	20	23
0.10 to 0.15	11	18
0.15 to 0.20	8	14
0.20 to 0.25	4	10
Greater than 0.25	18	21

Table 4: Difference in Alpha and Beta Values between ROE Measures[1]

Value	Alpha Values	Beta Values
Less than 0.00	2	9
0.00 to 0.01	20	18
0.01 to 0.02	33	7
0.02 to 0.03	37	12
0.03 to 0.04	22	18
0.04 to 0.05	14	19
0.05 to 0.06	5	25
0.06 to 0.07	2	6
Greater than 0.07	5	26

[1]The difference was computed by subtracting the values obtained using return on equity without capital gains from the values obtained using return on equity with capital gains.

5. Conclusions and Implications

This study examined the relationship between return on equity for individual Kansas farms and the S&P 500. Though the average rate of return on farm equity was substantially lower than the average rate of return for the S&P 500 index, after adjusted for risk, the rate of return for the sample of farms was comparable to that of the S&P 500 index. On average, return on equity with the inclusion of capital gains adjusted for risk for the sample of farms was 1.2 percent higher than the S&P 500. However, there was substantial variability in risk adjusted rates of return between farms, and approximately one-third of the farms had a risk adjusted rate of return that was lower than the S&P 500. For most of the farms in the

Table 5: Average Return on Equity (with Capital Gains), Alpha, and Beta by Farm Size Category[1]

Farm Size Category	ROECG	Alpha	Beta
First Quartile (VFP < $205,000)	-0.0120 a	-0.0315 a	-0.0372 a
Second Quartile ($205,000 < VFP < $296,000)	0.0222 a, b	-0.0102 a	0.1754 a
Third Quartile ($296,000 < VFP < $497,000)	0.0565 b, c	0.0339 a, b	0.0135 a
Fourth Quartile (VFP > $497,000)	0.0855 c	0.0573 b	0.1058 a

[1]Entries within a column with an unlike letter are statistically different at the 5 percent level.

sample, individual farm risk was not related to the risk associated with investing in the S&P 500.

The return adjusted for risk, as measured with the alpha value for each farm, was significantly higher for the largest farm size category than it was for the two smallest farm size quartiles. Moreover, the average difference in alpha values among the farm size quartiles was large. The smallest farm size quartile had an average alpha value of -0.031. The alpha value for the largest farm size quartile was 0.057. In contrast to the alpha value results, the beta values for the farm size quartiles were not significantly different from one another.

Bigge and Langemeier (2004) conducted a similar analysis to that in this paper using an earlier time period (i.e., 1982 to 2001). The relative risk results in this study were very consistent with those reported in Bigge and Langemeier (2004). Beta values are less than one, indicating that systematic risk is relatively low. However, relative profitability for the sample of farms in this study, which used data from 1996 to 2018, was much higher (-0.081 compared to 0.012) than it was in Bigge and Langemeier (2004). Given that the sample period used in the Bigge and Langemeier (2004) study included the mid-1980s, a period of financial stress in U.S. agriculture, and excluded the post-2007 U.S. ethanol boom, the lower alpha values reported in Bigge and Langemeier (2004) are not that surprising.

The results in this study have important implications for farm performance benchmarking. There are a substantial proportion of farms that have risk adjusted returns that are higher than the returns for the S&P 500 index. However, there are farms that have performance that is significantly below market returns. In fact, of the farms that have significant alpha values, 16 of the 59 farms had a negative alpha value, an indication of below market returns. The wide difference in relative profitability documented in this study illustrates the importance of benchmarking farm performance.

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A case study of longitudinal trends in biophysical and financial performance of spring-calving pasture-based dairy farms

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ABSTRACT

The objectives of the present study were to characterize the trends in production and profitability temporally, when ranked by the proportion of feed purchased, and when ranked by average operating profitability (i.e., net profit/ha). A dataset of 315 Irish pasture-based dairy farms with complete records for 8 consecutive years was used in this analysis. The farms were characterized by expansion and intensification during the 8-year study period, as evidenced by the annual increase in milk fat and protein yield per cow (+15%; $P < 0.001$); mean annual pasture DM consumed/ha also increased linearly (+19%; $P < 0.05$); production costs increased linearly ($P<0.01$) while net profit was highly variable between years. When ranked by proportion of feed purchased, production costs increased ($P<0.001$) with greater reliance on bought in feed. When ranked by quartiles (highest to lowest) for 8-year average net farm profit/ha, the highest profit quartile contained, on average, smaller farms with greater technical efficiency, measured by greater milk yield per cow and grass utilisation, that when affected simultaneously by a combination of milk price reduction and adverse weather experienced a greater reduction but highest nadir and fastest recovery in farm profitability.

KEYWORDS: dairy systems; pasture; profit; supplement

Introduction

Dairy farm systems are complex and represent the collective response of milk producers to remain viable and grow in the face of risk and uncertainty (Howden *et al.,* 2007). Dairy farming is widely acknowledged to be financially volatile, with an ever-changing landscape of milk and input prices, variable and overhead costs, milk yield, and other variables that affect farm financial returns (Horan and Roche, 2020). The challenge for farmers is to develop and implement operating systems that have the optimum combination of resources and activities to mitigate these risks and provide sustainable economic returns (Rougoor *et al.,* 1998).

There is increasing international interest in the multi-functional benefits of grazing systems (Dartt *et al.,* 1999; Dillon *et al.,* 2008; Ramsbottom *et al.,* 2015). Consumers often associate grazing with 'naturalness' and improved animal health and welfare (Kriegl and McNair, 2005). While the proportion of grass in the cows diet can vary considerably in pasture-based dairy systems (Washburn and Mullen, 2014), from an economic perspective, grazing systems of milk production have been reported to have lower variable and overhead costs as well as greater operating profit/ha (IFCN, 2018) when compared with the more heavily mechanised housed dairy systems. However, the ability of grazing systems to flex costs in response to milk price volatility is limited as the overhead costs associated with pasture production have already been incurred, and to changes in cow numbers, which are decided on the expectation of long-term average pasture production. The system is also heavily dependent on climatic repeatability for the provision of the majority of the cow's diet (Roche *et al.,* 2009). Therefore, for grazing systems, the two greatest challenges to resilience are milk price and climate variables that positively or negatively affect either the production or utilization of pasture.

Evaluations of financial performance must consider both the long-term average profitability of the business and the stability of farm profit over time. Economic sustainability has traditionally focused on the design and capability of systems to achieve a desired outcome (Folke *et al.,* 2002). More recently, however, the concept

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of system 'resilience' or 'robustness' has been applied to the evaluation of agricultural systems as a key aspect of economic sustainability (Peeters *et al.,* 2015). A number of different definitions of resilience are proposed, including: 1) the capacity of any system to absorb or mitigate the effects of changes and maintain essential function (Darnhofer *et al.,* 2008); 2) the capability to be both technically and financially efficient (Dillon *et al.,* 2008); or, 3) the ability to respond opportunistically to changing operational conditions (Rodriguez-Pinto *et al.,* 2011).

The objectives of the present study were to a) characterize the temporal trends in Irish dairy farm profitability; b) to quantify the effect of supplementary feed use on farm production and profitability over time; and c) to compare the temporal variability in farm profitability of high and low profit farms. For the purposes of the analyses, we focused on the capacity of farms to 'rebound' from unfavorable situations (Paton *et al.,* 2014) and, in particular, to recover economically from periods of both weather and milk price adversity.

Material and Methods

The seasonal-calving grazing system

The optimum management protocol for seasonal-calving grazing systems was described in detail by Macdonald and Penno (1998); Shalloo *et al*. (2004); Macdonald *et al.* (2008). Briefly, management protocols aim to have the cow directly harvest as much pasture as possible. Mechanical harvesting of silage is practiced when pasture growth exceeds herd demand. Cows are provided with concentrate feeds and/or conserved forages (i.e., supplementary feeds) when pasture growth is less than their energy requirements during winter.

In temperate grazing systems, there is minimal pasture growth during winter and early spring and a peak of pasture growth in late spring and early summer (Roche *et al.,* 2009). As a result, cows are offered conserved forage and supplementary feeds to minimize their requirements for fresh pasture during winter. They are then provided with a predominantly pasture diet between early spring and early winter. Compact spring calving and breeding protocols ensure that the maximum numbers of cows are in peak lactation to coincide with peak pasture growth (Roche *et al.,* 2017).

Farm physical data

Data used in the present study were obtained from the Irish national dairy farm database (eProfit Monitor, Teagasc, Republic of Ireland). The database was established in 2002 and contains farm physical and financial data for the dairy and other enterprises of approximately 4,000 individual dairy farmer users (Ramsbottom *et al.,* 2015). Dairy farmer users of eProfit Monitor are, on average, larger scale, stocked more intensively, and more profitable than the average dairy farmer surveyed annually through the National Farm Survey (NFS) (Hennessy *et al.,* 2015). In the present study, farm physical and financial performance data were extracted for 315 spring calving dairy farmers who were continuous users of the programme during each of the eight years between 2008 and 2015, inclusive.

Monthly numbers of cows, replacement heifers, and non-dairy stock per farm were averaged across each calendar year to determine average livestock units (LU) for each of the three respective livestock categories (>2 year old = 1 LU; 1-2 year old = 0.7 LU and 0-1 year old = 0.3 LU). Farm stocking rate was calculated by dividing the total number of LU by the number of hectares (ha) of forage area (pasture and forage crop area combined) farmed. The percentages of each type of livestock farmed were calculated by dividing the annual average number of LU in each category by the total number of LU on the farm in each year.

Total volume of milk produced on farm (both sold and consumed on farm by calves) per farm was divided by the average dairy cow livestock units present on the farm to calculate average milk yield/cow per year. Average annual milk fat and protein content were obtained from the milk processor and used to calculate per cow lactational yield of milk fat and protein. When referring to whole farm performance, per hectare calculations were obtained by dividing the relevant farm yield by the total number of ha farmed. When referring to the dairy enterprise performance, per hectare calculations were calculated by dividing the relevant farm yield by the number of ha assigned to the dairy enterprise. The number of ha assigned is calculated by dividing the number of dairy cow livestock units by the farm stocking rate.

Using the farm physical data, farms were categorized in each year by the percentage of annual feed and forage requirements purchased for the dairy enterprise. Systems 1, 2, 3, or 4 refer to farms where <10, 11-20, 21-30, or >30% of the cow's annual feed requirements were obtained from purchased feed. This categorization was considered to be representative of increasing levels of system intensification (as categorized by Ramsbottom *et al.* (2015)). Subsequently, farms were categorized as average System 1, 2, 3, or 4 by averaging the proportion of purchased feed over the 8 year period (2008-2015).

Farm financial data

All financial data are expressed in euro (€[1]) unless otherwise stated. Market values were used where animals were purchased or sold off farm. Where transfers from the dairy herd to the heifer or dry stock enterprises took place, standard monetary values per animal were used for all farms and years. Dairy cows were valued at €700 each; newborn replacement and beef calves transferred from the dairy enterprise were valued at €300 and €150, respectively. Similarly, the standard cost of €1,000 per head was used where replacement heifers were transferred at the point of calving to the dairy enterprise.

Farm gross revenue output was calculated by combining milk sales receipts, dairy and beef cattle sales and other sales such as crop or forage sales, and the standard value of calf transfers to beef and replacement heifer enterprises. The cost of purchased freshening dairy heifers and cows or the standard value of freshening heifers transferred from the farm's replacement heifer enterprises were deducted, and an adjustment made for stock inventory change, where applicable. Variable costs include feed and fertilizer, breeding and veterinary costs, and farm contractor costs, as well as other variable costs such as milk recording, parlor expenses, and bedding costs

[1] At the time of writing (mid-June 2019), €1 was approximately equivalent to £0.89, $US1.13, and $NZ1.72.

(detailed further in Teagasc (2011)). Most of the other variable costs were apportioned in the eProfit Monitor system on a percentage livestock unit basis. For example, if the dairy enterprise accounted for 60% of the farm's total livestock units, then 60% of the total livestock variable costs were allocated to the dairy enterprise.

Overhead costs include machinery running and lease costs, hired labor, repairs and maintenance, depreciation, electricity, phone and transportation expenses, as well as the costs of leasing land and milk quota (where applicable). For all enterprises, overhead costs were allocated in proportion to the percentage of the farm gross revenue output attributed to the enterprise.

Farm net profit was calculated by deducting total variable and overhead costs (excluding the imputed value of owner labour) from farm gross revenue output. Farm net profit/ha was calculated by dividing farm net profit by the total number of ha farmed. Dairy net profit/ha was calculated by dividing total dairy enterprise net profit by the total area farmed. Similarly, other enterprise net profit/ha was calculated by dividing the net profit of all other enterprises by the total area farmed. Premia payments, the farming subsidies paid to dairy farmers from the Irish Government and the EU to support farming income, were totaled and expressed on a per hectare basis by dividing the total amount by the number of ha farmed. These payments, established based on historical production levels, were excluded from the calculations of farm net profit.

Using the farm financial data, farms were ranked by the average net profit/ha over the 8 farm financial years (the calendar years 2008-2015) within each of five geographical regions that differ in their seasonal production of pasture and rainfall (see Ramsbottom *et al.,* 2015). The regions were farms located in county Cork (the Cork Region); farms from counties Cavan, Clare, Donegal, Galway, Leitrim, Mayo, Monaghan, Roscommon and Sligo (the Northwest Region); farms from counties Carlow, Kilkenny, South Tipperary, Waterford and Wexford (the South East Region); and, farms from counties Kerry and Limerick (the South West Region). Within region, farms were subdivided into four sub-groups for average farm net profit: highest 8-year average farm net profit/ha; next highest 8-year average farm net profit/ha; second lowest 8-year average farm net profit/ha; lowest 8-year average farm net profit/ha.

Data analyses

All analyses were undertaken using a mixed model framework in PROC MIXED (SAS, 2005), where herd nested within region was included as a repeated effect with a first order autoregressive covariance structure assumed among records within herd. The first analysis estimated the annual least squares means and also the longitudinal trends in physical and financial performance over time; fixed effects included in the model were year and region. The second series of analyses quantified the association between 8-year average system of milk production and the various physical and financial characteristics; fixed effects included in the model were year, region, 8-year average system (i.e. 1-4) as well as the interaction between 8-year average system and year. A third series of analyses were conducted to quantify the association between 8-year average farm net profit/ha (i.e., independent variable) and the various physical and financial characteristics (i.e., dependent variables); fixed effects included in the model were year, region, 8-year farm net profit/ha (as quartiles) as well as the interaction between 8-year farm net profit/ha (as quartiles) and year.

Output and input price indices, rainfall and income

Milk and cattle price indices, the agricultural input prices prevailing and average farm income on specialist grazing dairy farms (representative of all Irish dairy farms during the study period; 2008-2015) are presented in Figure 1. Clear variation is evident in the prices paid for both milk and cattle and the inputs consumed on farms during the

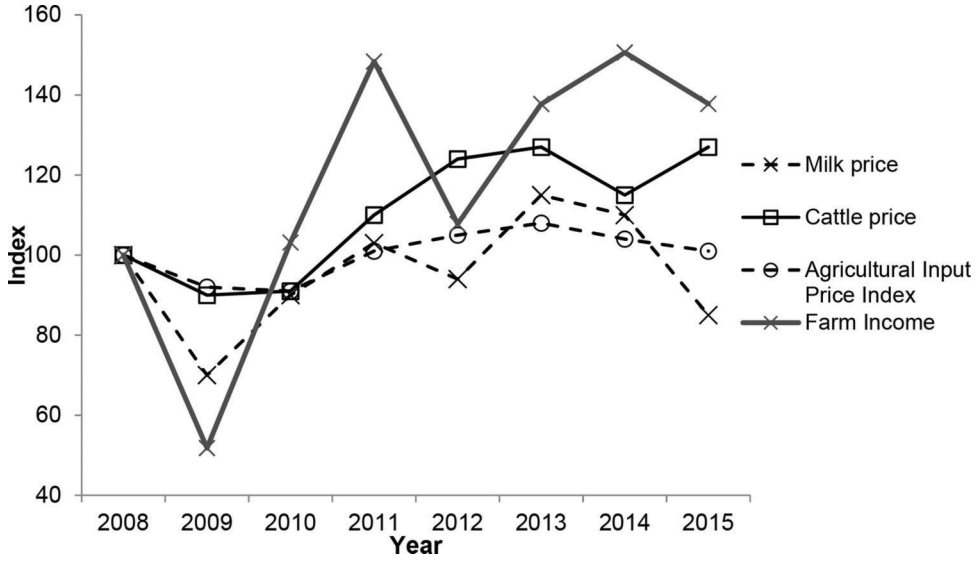

Figure 1: Index of average manufacturing milk price, cattle price, agricultural input price index, and annual farm income for pasture-based dairy farms during the 2008-2015 period (adjusted to 2008 = 100)[1].
[1]Sources: Milk and cattle prices (CSO, 2008-2015); agricultural input price indices (CSO, 2008-2015); farm income (Teagasc, 2008-2015).

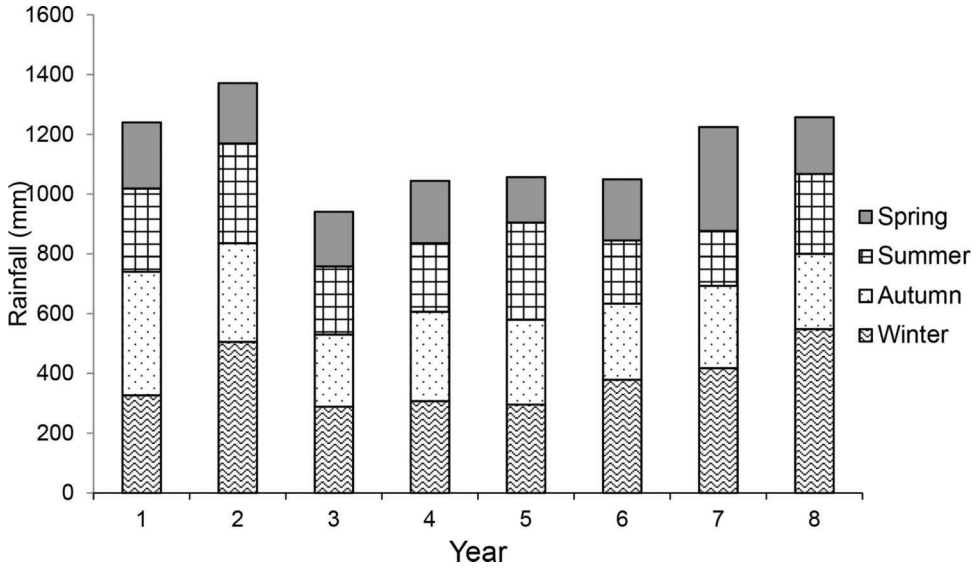

Figure 2: Annual total and seasonal[1] average rainfall for the 2008-2015 period for the entire Republic of Ireland (Met Éireann, 2018)
[1]Seasons: Spring – February-April; Summer – May-July; Autumn – August-October; Winter – January and November-December.

study period. The combination of high annual rainfall, (Met Office, 2008-2015), in particular during the summer grazing months, and low milk and cattle prices in 2009 was of particular interest in the present study to evaluate the capacity of grazing dairy farms to withstand and recover from a confluence of adverse events. The low national dairy farm income evident in 2009 (Figure 1) was an outcome of the combined effects of both low milk prices (Figure 1) and adverse weather (Figure 2) experienced by the whole of the Irish dairy sector.

Results and Discussion

Inter-year variability in production and profit on pasture-based dairy farms

Unlike most temporal datasets, which include a changing population of farms over time (Offerman and Lampkin, 2005; Arfini and Donati, 2013; DairyNZ, 2008-2015; Ramsbottom *et al.,* 2015; Teagasc, 2008-2015), the analyses in the current study represent temporal comparisons of economic performance on the same farms using a large consistent dataset of matched farms over an 8-year period. Consequently, this dataset permits a more thorough evaluation of the association between milk and input price and climatic challenges on farm biophysical characteristics and profitability as the farms managed variability and developed across the years.

Summary statistics for a range of performance parameters for the 315 spring-calving farms over an 8-year period are presented in Table 1. Expansion and intensification were features of most farms during the study period. The total area farmed and the area of the milking platform increased over the period by 9.7 ha to 71.6 ha and by 3.7 ha to 49.6 ha, respectively, while the scale of the dairy enterprise increased by 33.6 LU to 115.3cows. The proportion of dairy cows and replacements increased by 8% over the 8-year period and comprised 94% of all animals on the study farms in 2015.

Production increases were also achieved on the farms over the study period. Stocking rate increased linearly ($P < 0.001$) by 0.027 LU/ha to 2.3 LU/ha in 2015, while milk production increased linearly ($P < 0.01$) by 457 L/milking platform ha per year. Milk fat and protein yield increased ($P < 0.01$) by 4.4 and 3.0 kg/cow per year and 24.9 and 19.7 kg/milking platform ha per year, respectively. Furthermore, pasture DM utilized/ha increased linearly ($P < 0.05$) by 0.2 t DM/ha per year and was 19% greater ($P < 0.001$) in 2015 than in 2008.

Farm gross output and total variable and overhead costs increased linearly ($P < 0.05$) between 2008 and 2015 (Table 2). While average milk price was 33.8 c/L during the study, it ranged from a low of 23.7 c/L in 2009 to a peak of 40.5 c/L in 2013. Similarly, variable, overhead, and total costs/ha varied significantly between years, being lowest in 2009 (€945, €768, and €1,713, respectively) and greatest in 2013 (€1,604, €918, and €2,522, respectively). The least profitable and most profitable years were 2009 and 2014, respectively, with milk price and dairy net profit/ha differences of 16.2 c/L and €1,007/ha, respectively between the two years. Overall, farm net profit/ha averaged €1,109 during the study period and ranged from a low of €416 in 2009 to €1,400 in 2014. Of the total net farm profit, the dairy enterprise contributed on average 98%. Although declining by over 24% during the study period, premia payments contributed an additional €474/ha on average to total farm receipts. Net farm profit as a percentage of total farm receipts averaged 29.1% and ranged from 14.9% in 2009 to 33.3% in 2014.

There were increases in farming intensity, specialization, and scale during the 8-year study period. The general trends towards intensification and greater operational scale evident within the study period are similar to previous reports from both housed dairy production systems in the United States (Brown and Schulte, 2011) and the UK (AHDB, 2017) and pasture-based systems of milk production, such as those in New Zealand (DairyNZ, 2008-2015). With further specialization and continuing milk price volatility likely in future years, inter-year variability in farm profitability is likely to increase as a greater proportion of gross farm output is derived from the sale of milk.

Table 1: Least squares means for measured biological characteristics for a matched sample of seasonal spring-calving, pasture-based dairy farms (n=315) during the years 2008 to 2015, inclusive

Year	2008	2009	2010	2011	2012	2013	2014	2015	SE[1]	P value	Linear
Total farm (ha)	61.9^{a}	62.1^{a}	64.1^{b}	66.0^{c}	66.7^{c}	68.2^{d}	69.4^{d}	71.6^{e}	1.54	<0.001	<0.001
Owned land (ha)	45.9^{a}	46.3^{ab}	47.0^{bc}	47.5^{bc}	47.7^{c}	48.3^{cd}	48.9^{de}	49.6^{e}	1.32	<0.001	<0.001
Pasture (ha)	61.0^{a}	61.1^{a}	63.1^{b}	65.0^{c}	66.0^{c}	67.4^{d}	68.7^{d}	71.1^{e}	1.53	<0.001	<0.001
Milking platform (ha)	39.9^{a}	39.5^{a}	40.3^{b}	40.7^{b}	41.3^{c}	42.0^{d}	42.7^{d}	44.6^{e}	1.07	<0.001	<0.001
Stocking rate (LU/ha)	2.10^{a}	2.16^{b}	2.16^{b}	2.18^{b}	2.22^{c}	2.26^{d}	2.26^{d}	2.31^{e}	0.022	<0.001	<0.001
Supplement (kg DM/cow)	781^{a}	825^{b}	930^{c}	677^{d}	991^{e}	1,192^{f}	800^{ab}	786^{ab}	23.7	<0.001	0.66
Pasture DM used (T DM/ha)	8.3^{ab}	8.2^{a}	8.4^{b}	8.9^{c}	8.4^{b}	8.2^{ab}	9.1^{d}	9.9^{e}	0.10	<0.001	<0.05
Pasture used (% total DM)	83.6^{a}	82.1^{b}	80.8^{c}	85.9^{d}	79.3^{e}	75.5^{f}	83.6^{a}	84.6^{a}	0.46	<0.001	0.88
Dairy cows (LU)	81.7^{a}	86.5^{b}	91.3^{c}	95.6^{d}	97.0^{d}	101.9^{e}	104.7^{f}	115.3^{g}	2.28	<0.001	<0.001
Dairy LU (% of total LU)	65.8^{a}	67.1^{b}	68.1^{cd}	68.4^{c}	67.7^{bd}	68.5^{cd}	69.1^{d}	71.9^{e}	0.54	<0.001	<0.01
Milk yield (L/cow)	5,181^{a}	4,908^{b}	5,308^{c}	5,173^{a}	5,167^{a}	5,269^{c}	5,169^{a}	5,579^{d}	36.0	<0.001	0.10
Milk production (L/ha)[2]	11,333^{a}	11,303^{a}	12,600^{b}	12,703^{b}	12,768^{b}	13,378^{c}	13,374^{c}	14,995^{d}	58.2	<0.001	<0.001
Total production (L/farm)	420,275^{a}	420,476^{a}	480,499^{b}	488,575^{bc}	495,530^{c}	531,264^{d}	533,655^{d}	639,273^{e}	11,432.4	<0.001	<0.001
Fat content (%)	3.94^{a}	3.96^{b}	3.97^{c}	4.04^{d}	4.11^{e}	4.12^{e}	4.18^{f}	4.24^{g}	0.011	<0.001	<0.001
Protein content (%)	3.45^{a}	3.41^{b}	3.44^{a}	3.46^{c}	3.46^{c}	3.48^{d}	3.54^{e}	3.63^{f}	0.006	<0.001	<0.01

[a-h]Values in the same row not sharing a common superscript are significantly different ($P < 0.05$).
[1]Pooled standard error.
[2]Per milking platform hectare.

Table 2: Least squares means for measured financial characteristics for a matched sample of seasonal spring-calving, pasture-based dairy farms (n=315) during the years 2008 to 2015, inclusive

Year	2008	2009	2010	2011	2012	2013	2014	2015	SE[1]	P value	Linear
Milk price (c/L)[2]	34.7^{a}	23.7^{b}	31.2^{c}	36.0^{d}	33.1^{e}	40.5^{f}	39.9^{g}	31.8^{h}	0.09	<0.001	0.24
Gross output (€/ha)	2,945^{a}	2,129^{b}	2,877^{c}	3,322^{d}	3,235^{e}	3,841^{f}	3,730^{g}	3,547^{h}	43.2	<0.001	<0.05
Total variable costs (€/ha)	1,019^{a}	945^{b}	1,061^{c}	1,122^{d}	1,331^{e}	1,604^{f}	1,383^{g}	1,347^{e}	19.1	<0.001	<0.05
Total overhead costs (€/ha)	818^{a}	768^{b}	806^{a}	855^{c}	874^{c}	918^{d}	947^{e}	956^{e}	15.9	<0.001	<0.001
Total costs (€/ha)	1,837^{a}	1,713^{b}	1,867^{a}	1,977^{c}	2,204^{d}	2,522^{e}	2,330^{f}	2,303^{f}	29.5	<0.001	<0.01
Net profit (€/ha)	1,108^{a}	416^{b}	1,010^{c}	1,344^{d}	1,031^{c}	1,319^{d}	1,400^{e}	1,244^{f}	28.5	<0.001	0.12
Dairy net profit (€/ha)	1,075^{a}	411^{b}	994^{c}	1,308^{d}	1,006^{c}	1,353^{d}	1,418^{e}	1,204^{g}	25.8	<0.001	0.11
Other enterprise net profit (€/ha)	33^{a}	6^{b}	16^{ab}	77^{c}	25^{ab}	-34^{d}	-18^{d}	73^{c}	10.2	<0.001	0.95
Premia payments (€/ha)[3]	514^{a}	507^{a}	514^{a}	498^{ab}	486^{b}	451^{c}	432^{d}	391^{e}	9.0	<0.001	<0.001

[a-h]Values in the same row not sharing a common superscript are significantly different ($P < 0.05$).
[1]Pooled standard error.
[2]Average price paid per litre of milk sold to the processor.
[3]Premia payments are farm subsidies received from the Irish Government and the EU to support farming income.

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Inter-farm variability in farm feeding system and profit

Profitability and performance of pasture-based dairy farms are affected by many factors, and much inter-farm variability exists regardless of the planned feeding system. The proportion of farms in each feeding system varied between years in the present study. Farms appeared to change feeding strategies opportunistically, responding to changes in milk price and weather conditions. For example the number of farms in Systems 1, 2, 3 and 4 were 31%, 53%, 14% and 2% respectively in 2011 and 3%, 36%, 34% and 27% in 2013. Farms in System 1 were defined by larger milking platforms ($P < 0.001$) and herd sizes ($P < 0.001$), and they utilized more pasture/ha when compared with System 4 farms (Table 3; 24.8 ha, 58.1 cows, and 2.2 t DM/ha, respectively). In comparison, milk yield/cow and per ha were greater in the highest feed input systems (+855 L/cow and +3,124 L/milking platform ha in System 4 compared with System 1 farms; $P < 0.001$); but, milk fat and protein contents were less than in System 1 farms (-0.36% and -0.13%, respectively; $P < 0.001$; Table 3).

Farms in System 1 were characterized by lower gross output per hectare ($P < 0.001$), but also lower total production costs per hectare ($P < 0.001$). However, net profit per ha was not different for System 1 farms compared to System 3 farms (Table 4). There was a significant interaction of system and year for total costs/ha ($P < 0.01$; Figure 3). Ultimately the net profit of System 1 farms was €604/ha in 2009 compared with €432, €385, and -€35/ha for Systems 2, 3 and 4 farms, respectively ($P < 0.001$; Figure 3), highlighting this farming system's ability to buffer downturns in milk price, while adapting to a challenging weather year. Additionally the variation in net farm profit per hectare for farms in System 1 was €998/ha (ranging from €604 in 2009 to €1,602 in 2013) representing a proportional change of 77% in 8-year farm net profit per hectare. For

Table 3: Least squares mean for measured biological characteristics in seasonal spring-calving, pasture-based dairy farms categorized by system of milk production for the years 2008-2015, inclusive

System category[1]	1	2	3	4	SE[2]	P value
Number of farms	19	206	70	20		
Total farm (ha)	88.1^{a}	66.6^{b}	64.0^{bc}	51.4^{c}	4.18	<0.001
Owned land (ha)	67.1^{a}	48.1^{b}	46.8^{b}	37.5^{b}	3.58	<0.001
Pasture (ha)	87.8^{a}	66.2^{b}	63.2^{bc}	50.8^{c}	4.13	<0.001
Milking platform (ha)	57.4^{a}	41.6^{b}	39.1^{bc}	32.6^{c}	2.80	<0.001
Stocking rate (LU/ha)	2.20	2.18	2.26	2.17	0.056	0.42
Supplement DM fed (kg/cow)	436^{a}	742^{b}	1,140^{c}	1,713^{d}	26.4	<0.001
Pasture DM used (T DM/ha)	9.4^{a}	8.8^{ab}	8.5^{b}	7.2^{c}	0.23	<0.001
Pasture used (% total DM)	90.6^{a}	84.4^{b}	76.8^{c}	66.0^{d}	0.45	<0.001
Dairy cows (LU)	133.7^{a}	95.1^{b}	96.2^{b}	75.6^{c}	6.14	<0.001
Dairy LU (as a % of total LU)	68.8	67.4	70.1	70.0	1.37	0.14
Milk yield (L/cow)	4,892^{a}	5,117^{a}	5,425^{b}	5,747^{c}	88.8	<0.001
Milk production (L/ha)[3]	11,656^{a}	12,143^{a}	13,485^{b}	14,780^{b}	562.6	<0.001
Total production (L/farm)	629,891^{a}	483,445^{b}	539,782^{ab}	465,831^{b}	30,167.0	<0.01
Fat content (%)	4.16^{a}	4.08^{b}	4.04^{bc}	3.97^{c}	0.028	<0.01
Protein content (%)	3.53^{a}	3.49^{ab}	3.47^{b}	3.40^{c}	0.014	<0.001

[a-d]Values in the same row not sharing a common superscript are significantly different ($P < 0.05$).
[1]Systems1, 2, 3, and 4 refer to systems in which <10%, 10-20%, 20-30% or >30% of total annual feed requirements are purchased respectively.
[1]Pooled standard error.
[2]Per milking platform hectare.

Table 4: Least squares means for measured financial characteristics in seasonal spring-calving, pasture-based dairy farms and categorized by 8-year average system of milk production for the years 2008-2015, inclusive

System category[1]	1	2	3	4	SE[2]	P value
Number of farms	19	206	70	20		
Milk price (c/L)[3]	34.3^{a}	34.0^{a}	33.6^{b}	32.7^{c}	0.19	<0.001
Gross revenue output (€/ha)	2,990^{a}	3,079^{a}	3,468^{b}	3,363^{ab}	108.4	<0.001
Total variable costs (€/ha)	940^{a}	1,150^{b}	1,404^{c}	1,569^{d}	40.8	<0.001
Total overhead costs (€/ha)	766^{a}	840^{a}	931^{b}	980^{b}	37.9	<0.01
Total costs (€/ha)	1,707^{a}	1,990^{b}	2,335^{c}	2,545^{d}	69.5	<0.001
Net profit (€/ha)	1,297^{a}	1,097^{b}	1,124^{ab}	794^{c}	65.5	<0.01
Dairy net profit (€/ha)	1,229^{a}	1,067^{a}	1,139^{a}	859^{b}	59.8	<0.01
Other enterprise net profit (€/ha)	80^{a}	38^{a}	-11^{b}	-59^{b}	16.5	<0.001
Premia payments (€/ha)	478	465	478	536	20.6	0.17

[a-d]Values in the same row not sharing a common superscript are significantly different ($P < 0.05$).
[1]Systems1, 2, 3, and 4 refer to systems in which <10%, 10-20%, 20-30% or >30% of total annual feed requirements are purchased respectively.
[2]Pooled standard error.
[3]Average price paid per litre of milk sold to the milk processor.

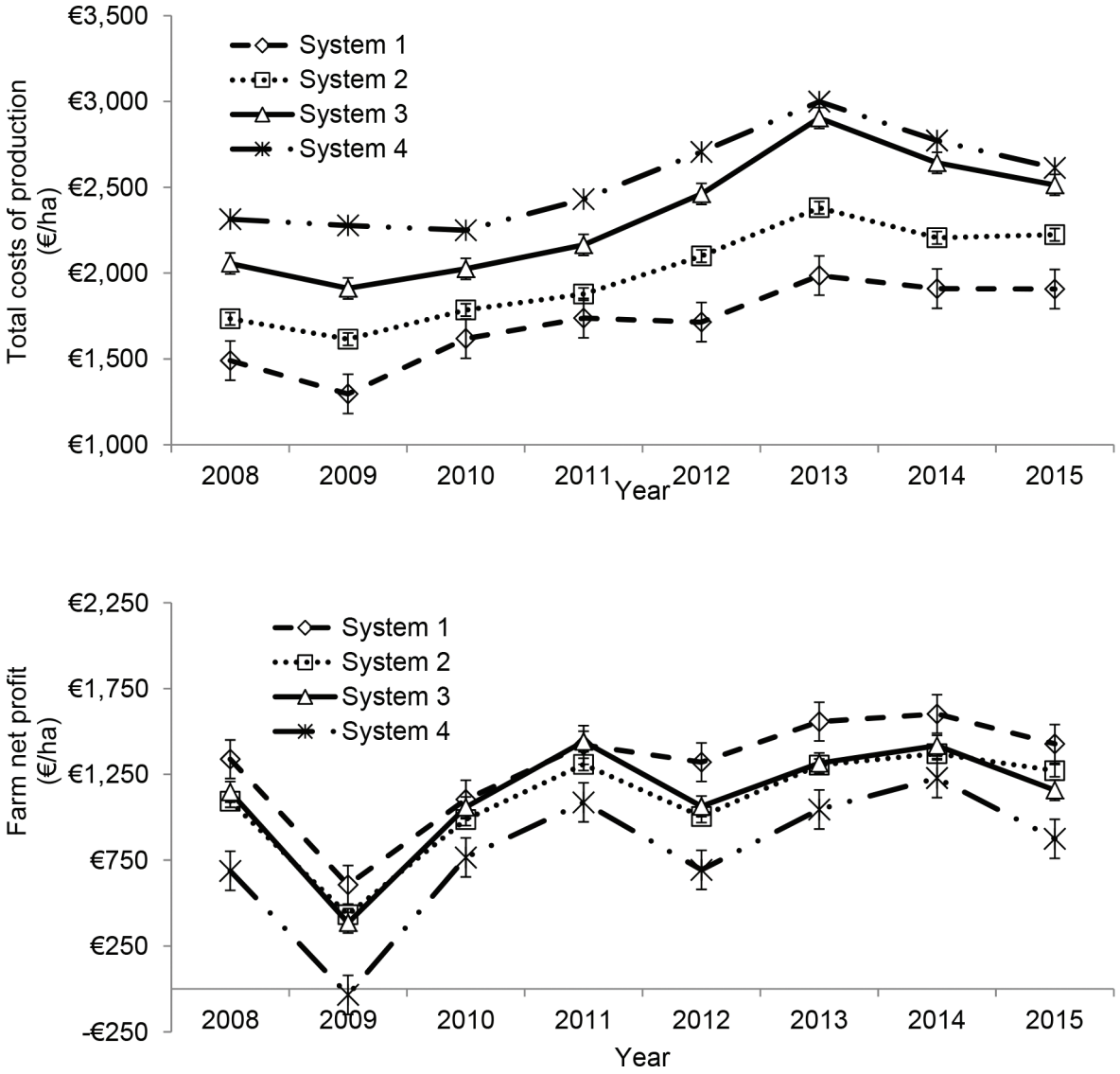

Figure 3: Annual mean (±SE) total costs of production (€/ha) and farm net profit (€/ha) in seasonal spring-calving, pasture-based dairy farms categorized by system[1] of milk production for the years 2008-2015, inclusive
[1]Systems 1,2,3 and 4 refer to Systems in which <10%, 10%-20%, 20%-30% or >30% of total annual feed requirements are purchased respectively.

farms in System 4, the respective values were €1,264/ha and 159%.

Herd mean milk production responses to increasing levels of feed supplementation was low to moderate, averaging 0.69 kg of additional (i.e., marginal) milk per kg of additional feed DM. The marginal milk production response to additional feed varied between 0.55 (2009) and 1.17 (2011) kg of additional milk/kg supplementary feed DM (between 33 and 70 g of milk fat and protein). Such responses are lower than the responses of between 0.8 and 1.2 kg milk/kg additional feed DM reported in controlled experiments (Coleman *et al.,* 2010; Macdonald *et al.,* 2017). Lower responses have been reported, however, in experiments investigating the importation of supplementary feed into grazing systems without altering the stocking rate (Roche *et al.,* 2006). The low marginal response effect is likely explained by a relatively high substitution rate of concentrate for pasture.

Previous studies have indicated that 85 to 90% of revenue on intensive pasture-based dairy farms consists of milk sales (Dillon *et al.,* 2008) and increasing milk production is a key strategy to increase profitability (Parker *et al.,* 1997) when milk price is above average. Across the years considered in the present study, greater levels of feed supplementation resulted in greater milk production; however, they were also associated with greater production costs, more so in higher milk price scenarios. In addition to greater feed costs/ha with greater amounts of purchased feeds, overhead and non-feed variable costs were also greater. These results are consistent with previous studies. Ramsbottom *et al.* (2015) and Neal and Roche (2020) reported that total costs increased by between €1.53 and €1.66 per €1.00 increase in feed costs. In Ramsbottom *et al. (*2015) these cost increases were due to increases in overhead (€0.35/€1 feed costs) and non-feed variable costs (€0.18/€1 feed costs) associated with higher input systems of milk production. These results are particularly relevant to pasture-based farmers and their advisors who might consider adjustments to their milk production system in response to variable milk prices. Although Ho *et al.* (2013) cautioned against using any partial efficiency measures to assess the

profitability of dairy enterprises due to the wide range of levels of technical efficiency and intensity, the results from the current study indicate that there are important system effects on farm production costs as currently implemented on Irish dairy farms. Our results do not support transitioning from low to high feed systems even in high milk price years.

Resilience - the interaction between year and farm profitability category

When ranked by quartiles (highest to lowest) for farm net profit/ha averaged across all 8 years, the highest profit quartile was characterized by smaller farms (19% smaller than the average of the two lowest profit quartiles) with better technical efficiency, including greater pasture utilized/ha, and milk produced/ha (+0.83 t DM/ha, and +2,461 L/milking platform ha farmed, respectively, between highest and lowest farm net profit quartiles; Table 5). The highest and second highest profit quartiles were the most specialized dairy farm categories, having the greatest ($P < 0.001$) proportion of dairy cows to total livestock units. The highest profit quartile achieved greater milk yield/cow compared with the second highest profit quartile (+237 L/cow; Table 5) ($P < 0.001$). Importantly there was no difference in the proportion of the diet coming from pasture across profit categories varying from 80.7% to 82.3% ($P = 0.28$; Table 5) which contrasts with both Ramsbottom *et al*. (2015) and Neal and Roche (2020) who found that increasing the proportion of pasture in the diet was associated with greater profitability. Consistent with the two previous studies however, greater profitability was associated with greater pasture use in this matched sample of dairy farms.

Profitability/ha was positively associated with total costs/ha ($P < 0.001$; Table 6). Total variable costs/ha were highest for the highest and second highest profit categories ($P < 0.001$; Table 6). Total overhead costs/ha were not affected by year or profit category. The magnitude of difference between profit quartiles observed is similar to previous financial evaluations internationally from countries as diverse as Australia (DairyAustralia, 2017), Finland and Norway (Sipilainen *et al.,* 2014), and the UK (AHDB, 2017). The results presented here are also consistent with previous reports on the profitability of high performance grazing systems based on medium levels of milk production/cow, high stocking rates (Macdonald *et al.,* 2001; Macdonald *et al.,* 2008), high levels of pasture utilization (Ramsbottom *et al.,* 2015), and low levels of purchased feed (Ramsbottom *et al.,* 2015; Macdonald *et al.,* 2017). While Neal and Roche (2020) did not find an association between proportion of imported feed and profit, they observed that higher use of imported feed increased average production costs.

Over the 8-year study period, 2009 was the year of lowest milk price coupled with greatest precipitation (i.e., greatest challenge for utilizing grazed pasture). The response of farmers to the especially low milk prices prevalent in 2009, coupled with significantly above average precipitation (30% greater in summer; 12% greater in autumn: and 32% greater in winter than average), reflects the capacity of individual farming businesses to manage adverse biophysical and financial conditions. Three elements of farm business resilience reported previously (Darnhofer *et al.,* 2010, Peeters *et al.,* 2015) were considered in the present study: 1) the magnitude of the decline in profitability arising from low milk prices and poor weather; 2) the nadir profit within each of the quartiles within the challenging circumstances of 2009; and, 3) the ability of farms to resume normal profitability subsequent to the milk price and poor weather challenges.

While farms in all profit quartiles declined in farm net profit/ha in 2009 compared with the previous year, the magnitude of the decline was greatest in the highest profit quartile category (Figure 4). The highest profit quartile also had the greatest decline in total gross output/ha

Table 5: Least squares means for measured biological characteristics in seasonal spring-calving, pasture-based dairy farms balanced for region and categorized into highest, second highest, second lowest, or lowest quartile for 8-year average farm net profit/ha (€) for the years 2008-2015, inclusive

Profit category	Highestprofit	Second highest profit	Second lowest profit	Lowestprofit	SE[1]	P value	Profit category * year
Number of farms	79	79	79	78			
Total farm (ha)	59.0^{a}	65.9^{ab}	68.5^{b}	71.5^{b}	2.88	<0.05	0.24
Owned land (ha)	45.4	48.4	48.6	50.6	2.47	0.52	0.72
Pasture (ha)	58.6^{a}	65.2^{ab}	68.1^{b}	71.0^{b}	2.85	<0.05	0.25
Milking platform (ha)	40.6	43.3	41.4	40.0	1.96	0.67	0.85
Stocking rate (LU/ha)	2.42^{a}	2.28^{b}	2.13^{c}	1.96^{d}	0.032	<0.001	0.11
Supplement DM fed (kg/cow)	887	896	862	905	33.0	0.81	0.20
Pasture DM used (T DM/ha)	9.9^{a}	9.0^{b}	8.3^{c}	7.4^{d}	0.12	<0.001	0.54
Pasture used (% total DM)	82.3	81.6	82.0	80.7	0.62	0.28	0.07
Dairy cows (LU)	99.5	103.4	95.0	87.8	4.35	0.07	0.13
Dairy LU (as a % of total LU)	71.6^{a}	69.6^{a}	66.3^{b}	65.5^{b}	0.89	<0.001	0.31
Milk yield (L/cow)	5,511^{a}	5,274^{b}	5,131^{b}	4,967^{c}	58.2	<0.001	0.38
Milk production (L/ha)[2]	13,944^{a}	13,409^{ab}	12,554^{b}	11,483^{c}	377.1	<0.001	0.12
Total production (L/farm)	546,509^{a}	538,709^{ab}	485,692^{bc}	437,411^{c}	20,833.3	<0.001	0.07
Fat content (%)	4.12^{a}	4.08^{ab}	4.05^{b}	4.04^{b}	0.019	<0.05	0.79
Protein content (%)	3.52^{a}	3.50^{a}	3.46^{b}	3.45^{b}	0.009	<0.001	0.14

[a-d]Values within rows not sharing common superscripts are significantly different ($P < 0.05$).
[1]Pooled standard error.
[2]Per milking platform hectare.

Table 6: Least squares means for measured financial characteristics in seasonal spring-calving, pasture-based dairy farms balanced for region and categorized into highest, second highest, second lowest or lowest quartile for 8-year average farm net profit/ha (€) for the years 2008-2015, inclusive

Category	Highest profit	Second highest profit	Second lowest profit	Lowest profit	SE[1]	P value	Profit category * year
Number of farms	79	79	79	78			
Milk price (c/L)[2]	34.3[a]	34.0[a]	33.6[b]	33.4[b]	0.13	<0.001	0.71
Gross revenue output (€/ha)	3,831[a]	3,376[b]	2,978[c]	2,553[d]	51.8	<0.001	<0.001
Total variable costs (€/ha)	1,345[a]	1,279[a]	1,185[b]	1,101[c]	28.9	<0.001	0.08
Total overhead costs (€/ha)	876	910	858	824	25.6	0.12	0.36
Total costs (€/ha)	2,220[a]	2,188[a]	2,042[b]	1,924[b]	48.7	<0.001	0.14
Net profit (€/ha)	1,611[a]	1,189[b]	937[c]	630[d]	18.0	<0.001	<0.001
Dairy net profit (€/ha)	1,561[a]	1,162[b]	928[c]	674[d]	18.4	<0.001	<0.001
Other enterprise net profit (€/ha)	69[a]	32[b]	27[b]	-40[c]	10.7	<0.001	0.51
Premia payments (€/ha)	502[a]	485[ab]	462[b]	447[b]	13.8	<0.05	0.19

[a-d]Values within rows not sharing common superscripts are significantly different ($P < 0.05$).
[1]Pooled standard error.
[2]Average price paid per litre of milk sold to the milk processor.

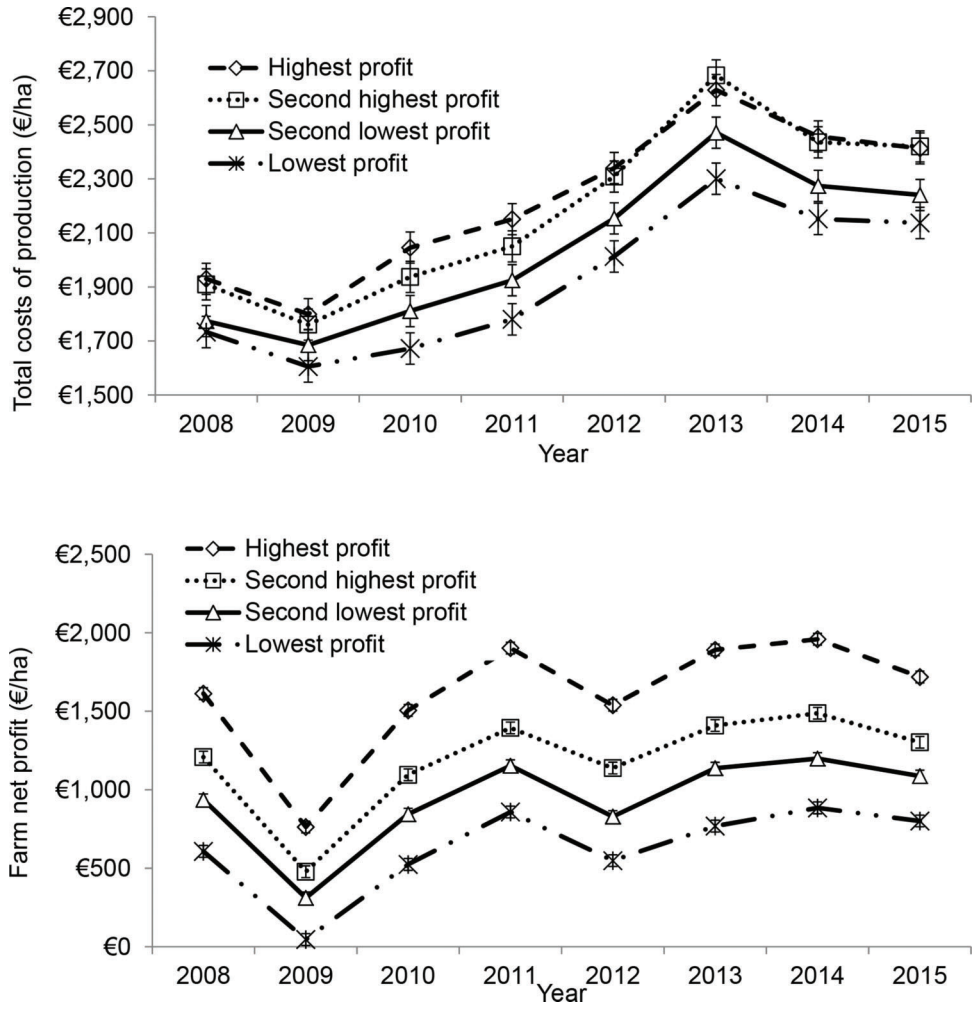

Figure 4: Annual mean (±SE) total costs of production (€/ha) and farm net profit (€/ha) in seasonal spring-calving, pasture-based dairy farms balanced for region and categorized into highest, second highest, second lowest or lowest 8-year average farm net profit/ha for the years 2008-2015, inclusive.

between 2008 and 2009 (€981/ha; $P < 0.001$). The comparably greater degree of dairy specialization within the higher profit quartiles probably contributed to the greater reduction in profitability. The fall in milk price between 2008 and 2009 affected more specialized farms to a greater extent than less specialized farms. Pasture management, as evidenced by greater pasture utilisation rates, was better on these farms; feed supply may, therefore, have been more adversely affected by the challenging year. Dairy cows accounted for 71.6% and 65.5% of all livestock

farmed on the highest and lowest profit farms, respectively (Table 5; $P < 0.001$). This study supports the results of Kelly *et al.* (2011), where they identified an increased risk to profit associated with increased farm specialization during periods of depressed milk prices. The marked inability of the highest profit quartile to reduce costs to a greater nominal or proportional extent than other quartiles was, probably, because of their already low total cost of production/L ($P < 0.001$) and, consequently, a reduced capacity to further lower production costs in 2009, without having a significant negative effect on farm biophysical performance.

When considering farm net profit/ha, dairy farms in the highest profit quartile remained the most profitable category even in years of low milk price and biophysical challenges (Figure 4). The net profit of farms in this quartile was €763/ha in 2009 compared with €478, €311, and €46/ha for the second highest, second lowest, and lowest net profit quartiles, respectively (Figure 4). The variation in profit from highest profit (2014) to lowest profit (2009) year was €1,196 and €838/ha for the highest and lowest profit quartiles, respectively. These results support Purdy *et al.* (1997), who reported that while mixed enterprise farms (such as the lower profit quartile farms in this study) have less variability in financial performance, they also had less average profitability. The greater use of pasture by the highest profit quartile (Table 5) is also consistent with Neal and Roche (2020) who identified maximizing pasture harvested as a key contributor to profitable pasture-based dairying. Similarly Peeters *et al.* (2015) reported that pasture-based systems of milk production appear to be more resilient to price crises than higher supplementary feed input systems. However, it is the greater utilization rather than the proportion of pasture in the cows' diet that is associated with greater profitability.

The results of the financial analysis also indicate that high profit, pasture-based dairy farms have greater capacity to recover after low milk price and challenging biophysical years. The net profit/ha of the high profit quartile increased by €743/ha between 2009 and 2010 compared with increases of €618/ha, €533/ha, and €478/ha for the second highest, second lowest, and lowest profit quartiles, respectively ($P < 0.001$; Figure 3). This recovery was underpinned by a substantial increase in the value of farm gross output/ha between the two years that varied from €990/ha to €545/ha for the highest and lowest profit quartiles, respectively.

Conclusions

Pasture-based production systems with a greater reliance on imported feeds had consistently greater farm production costs across a variety of milk prices over time, including during particularly unfavourable climatic years. Separately, the results also indicate that although low milk prices result in a comparably greater reduction in profitability within the highest profit cohort of dairy farms studied, these farms remained most profitable and most 'resilient' exhibiting greater average profitability and a greater capacity to recover after low milk price and challenging biophysical years. Further research is required to better understand the fluctuations within profit category and system of milk production between years. Finally, the results reinforce the economic importance of pasture utilization on farm profitability on pasture-based dairy farms.

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Brand Loyalty in Argentine Commercial Crop Seed Markets

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ABSTRACT

This paper focuses on identifying and characterizing different groups of producers based on their loyalty to seed brands in Argentina. Â In order to do so, we resorted to a two-step methodology: the first step identifies groups of producers in terms of their loyalty to seed brands, using a multivariate analysis. Then, to identify variables associated with brand loyalty, and have an initial group characterization, we use independency tests for qualitative variables.

Our findings show that almost 44% of Argentine producers consider themselves loyal to the seed brands they purchase. These producers are willing to buy the brand regularly, in spite of price increase. By contrast, only 21% of Argentine producers consider themselves disloyal, meaning that they are willing to try other products and would change seed brand if price increased in even a small proportion.

Our results have strong business implications, as they establish a clear profile of producers who are loyal to a brand in the heart of the Argentine Humid Pampa. Such findings can help ag input companies determine where to focus their attention and resources.

KEYWORDS: Agriculture producers; brand loyalty; seeds; Argentina; cluster analysis

1. Introduction and Motivation

The agricultural inputs markets for crop seeds, crop protection, animal health, animal breeding, and farm machinery are large, with global sales of more than 400 billion dollars by 2018 (McDougall, 2019). They are characterized by their oligopolist nature, large R&D expenditures, and increasing concentration in terms of firm and patent ownership. This puts pressure on companies in these markets on how to compete and differentiate their products in order to be profitable (Gazdecki, 2018; Sheldon, 2017).

Since the 1990s, there has been a high market concentration in ag input markets, and it has been particularly intense in the crop seed industry. The four leading global seed companies almost tripled their market share in 15 years, from 1994 to 2009 (Fuglie *et al.*, 2012; ETC Group, 2013). Nowadays, the sector is going through a new process of reorganization and consolidation. The 'big six' (Monsanto, Bayer, Dow, BASF, Syngenta and Dupont) are turning into four, through the acquisition of Syngenta by ChemChina, the Monsanto takeover by Bayer and the merger between Dow and Dupont (McDougall, 2019; OECD 2018; Anderson and Sheldon, 2017; Bryant *et al.*, 2016).

Seeds[3] are the means by which innovation in ag biotechnology is converted into higher yields, improved product quality, or cost savings for agricultural producers. The upstream seed markets compete for genetic traits (for example herbicide-tolerance and insect-resistance) and downstream markets for treated seeds (Moss, 2016; Moss 2013, Moss 2011). Obtaining crop seed traits is a long and complicated process; it is costly and presents a considerable risk at each stage of research and development (Shetty *et al.*, 2018; Fernandez-Cornejo *et al.*, 2014; Rothstein *et al.*, 2014). There are not only technical risks – the possibility of pre-launch failure – but also commercial risks. The deregulation of a seed trait is a milestone but does not imply successful sales.

Crop seeds in Argentina purchased in formal markets represents a significant share of agricultural producers' input costs and is also a key production input because the quality of seeds strongly influence yield potential. Although formal and informal seed markets coexist in Argentina, it is noteworthy that seed companies do not make large profits in the informal market. Corn and sorghum require cross-pollination and therefore, are mainly marketed in the formal channel, while soybean and wheat, two self-pollinated crops, prevail mostly in the informal market. Only 30% of soybean and wheat

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[3] This refers especially to transgenic seeds, which have been genetically modified to contain desirable traits (Shetty et al., 2018; Moss, 2011).

seeds are sold through formal channels (Craviotti, 2018; Bisang, 2017; Ministry of Agriculture, 2016). Foreign multinational crop seed firms are focused on hybrid seed (for crops such as corn and sorghum) where there is a 'natural' barrier against multiplication and agricultural producers are compelled to purchase crop seeds every planting season. On the other hand, soybean and wheat seeds are provided with genetic material of local origin[4] (Craviotto, 2018; Filomeno, 2014).

What distinguishes seed markets in Argentina, among the leading agriculture countries, is the low recognition of intellectual property rights for crop seeds. The legal framework in Argentina for plant varieties is, complex, and faces frequent changes, which creates uncertainty in seed firms (Gallo and Kesan, 2006). As well as Brazil, the Argentina's legislation does not allow patents for plants, and law grants the rights to agricultural producers to save seeds, and of breeders to employ existing protected varieties to develop new ones. However, Brazil's legislation provides a recognition for the protected varieties and the agricultural producers' right to save seeds is limited, while Argentine legislation does not allow this. Argentina is a particular market with poor patent protection and weak legal enforcement regime, so understanding local agricultural producers and defining strategies to keep them purchasing their brands is a double challenge for seed firms (Correa, 2020; Craviotto, 2018, Perelmuter, 2015).

A previous study (Feeney and Berardi, 2013) analyzed the Argentine seed market, dividing producers into market segments and explaining the factors that affect their seed buying decisions[5]. Four groups of Argentine producers were found, following the importance given to each purchasing factor (i.e., performance, price, balance, convenience). The results obtained showed the performance-oriented cluster as the largest, while in a similar work for the US (Alexander *et al.*, 2005) the largest segment was the balance-oriented. This study also revealed that Argentine producers tend to be more brand-loyal and have less price sensitivity than American producers.

The increasing global competitiveness in the seed market and high innovation costs make it crucial for companies not only to attract clients but also to establish long-term relations with them and differentiate their products from competitors. Brand loyalty is a concept that gains significant relevance for firms selling crop seeds, as a means of developing brands which producers can perceive and associate with as high quality, valuable and reliable products. In this way, firms would persuade agricultural producers to develop a greater inclination to purchase their products, increase sales and achieve profitability. According to experts (Fortes *et al.*, 2019), achieving customer brand loyalty is a key factor for companies facing markets with great rivalry and competition.

2. Problem Statement and Objectives

Input products such as crop seed, agrochemicals, and farm machinery compete far more through product differentiation than through price (Borchers *et al.*, 2012; Krause, 2011). As a differentiation strategy, brands and branding help agricultural producers identify the most productive crop inputs. A brand, according to Gajanova *et al.* (2019), is a name, symbol, or other characteristic that distinguishes a firm's product in the marketplace and differentiates it from those of competitors. It also has been conceptualized as the sum of perceptions and associations that are held about a person, a company or a product. Branding, on the other hand, is portrayed as the universe of the firm's undertaken actions that affects those perceptions by customers.

Firms need to build brands that have appeal for customers, so that they can evaluate similar products and/or services and perform an effective distinction among them. Thus, the survival and growth of a company is defined by its aptitude to retain its current customers, and to make them loyal to the brand. Brand loyal customers help firms creates barriers to entry and a capacity to counter threats of competitors, increase turnover and make customers less sensible to prices (Gajanova *et al.*, 2019; Ehsan *et al.*, 2016).

Branding is an important concept for agribusinesses, as thriving brands help businesses obtain a leading position in a highly competitive environment. Thus, in order to gain a competitive advantage, agribusinesses should be able to reach brand loyal customers and implement strategies that will keep these customers loyal (Wiese, 2014).

Due to the significance of brand loyalty in agribusiness, and the importance of distinguishing customers with different degrees of brand loyalty, this article examines how loyal Argentine producers are to crop seed brands sold in the formal seed markets and the main characteristics of producers included in each loyalty segment.

Therefore, the objective of this paper is to identify and characterize different groups of farmers based on their loyalty to crop seed brands available in the Argentinean formal or commercial markets. Specifically, the study seeks to: 1) identify brand-loyal agricultural producers in the Argentine commercial crop seed products, 2) describe the main characteristics of those producers who are loyal to crop seed brands, 3) provide insights to input providers seeking to gain a more in-depth knowledge of agriculture producers and design marketing strategies targeting them.

3. Literature Review

Brand loyalty has been described in the literature as an asset that companies possess (Bisschoff and Schmulian, 2019; Aganbi, 2017; Brahmbhatt, *et al.* 2017) since it represents a strategic resource that provides value to the firm. There is abundant literature that seeks to explain the factors that determine customer's brand loyalty (Fortes, *et al.* 2019; Ikramuddin *et al.*, 2018; Gupta *et al.*, 2017; Syahida *et al.* 2017; Bisschoff and Moolla, 2014; Coelho and Henseler, 2012; Evanschitzky *et al.*, 2006) and the ability of companies to profit from customer' brand loyalty once they have assured it (Khamitov, *et al.*, 2019; Watson *et al.* 2015; Coelho and Henseler, 2012; Moolla, 2010; Bourdeau, 2005).

Assessing customers' brand loyalty is not an easy task given the variety of concepts that it involves

[4] Two local companies, Don Mario and Nidera, hold a leading role in the soybean seed market, controlling between around 90% of the market. Nidera has been bought by the Chinese state-owned firm COFCO (Craviotti, 2018).

[5] In our literature review we identified some papers regarding agribusiness input market segmentation such as Borchers *et al.* (2012); Wang *et al.* (2017); and Baker *et al.* (2017). However, not specific additional papers were found referring to segmentation in the Argentine seed market.

(Mathews, 2019; Pan *et al.*, 2012; Dick and Basu, 1994) and the different ways it has been conceptualized (Ehsan *et al.*, 2016; Watson *et al.*, 2015; Moolla, 2010), as we synthesize in Table 1. Despite the variety of definitions, there is a consensus as to the relationship between brand loyalty and visible patterns of buying behaviors (repeated patronage), psychological attitudes, beliefs, and commitment towards the brand. Considering loyalty only from the point of view of buying behavior may be considered ''spurious loyalty'' (Watson *et al.*, 2015; Maseshwari *et al.* 2014; Bourdeau, 2005; Møller Jensen and Hansen, 2006).

Several studies focused on measuring the impact of different dimensions on brand loyalty. Moolla (2010) identified 12 key brand loyalty influences, which he applied to fast-moving consumer goods, such as toothpaste, soaps, and detergents. He tested the strength and relationship of these influences on brand loyalty for these types of goods. The results show that the most important influences are commitment, brand effect, and brand relevance; while the least important are brand trust, brand performance and customer satisfaction. Even though the model was originally developed to measure brand loyalty in the fast-moving consumer goods sector, its validity was confirmed across several industries such as pharmaceutical products (Du Plooy, 2012), the banking industry (Scholtz, 2014), and farming/agribusinesses, as we will see below.

Wiese (2014) and Bisschoff and Wiese (2014), as well as Hill (2018), adapted the framework developed by Moolla (2010) to measure brand loyalty in the farming/agribusiness environment in two different regions of South Africa. The results of these studies were quite similar, as brand trust, customer satisfaction, repeated purchase, brand relevance, perceived value and involvement appear as the most important factors when agricultural producers are considering their brand loyalty toward agricultural business brands.

Narayandas (2005) developed a loyalty ladder. The author hypothesizes that customers display their loyalty to companies in a predictable way, as they move up the loyalty ladder: from customers wanting to grow their relationship with the company's brand, to endorse the product, resist the competitors' cajolery, willing to pay premium prices, seek to collaborate with the company to develop new products, and finally as a higher level of loyalty, invest in the firm.

Holland *et al.* (2014) measured loyalty levels of US large agricultural producers to agribusiness input suppliers, applying the loyalty ladder framework, developed by Narayandas (2005). In particular, the results for seed brands show that the more the agricultural producer tends to use hired custom fertilizer services, the more loyal he would be to seed brands. On the other hand, the more the agricultural producer uses hired custom harvesting services and the more years of education he has, the least he would tend to be loyal to seed brands. Non-family members and spouses are positive influences on the primary decision-maker to be loyal to seed brands.

Bianchi *el al.* (2014) established that brand trust has a direct effect on brand satisfaction but not on brand loyalty. Therefore, the authors conclude that brand trust indirectly influences brand loyalty through brand satisfaction. These findings challenge previous research supporting a direct connection between brand trust and loyalty.

Bisschoff and Schumulian (2019) applied Moolla's brand loyalty framework to measure consumers' brand loyalty to poultry products (chicken pieces and whole birds) in the province of KwaZulu-Natal in South Africa. They found that the most important influences on poultry brand loyalty are brand trust, customer satisfaction, and perceived value, while those of the least importance are culture and relationship proneness. These results established the validity of Moola's model (2010) to measure brand loyalty for poultry brands and identify the most important brand loyalty factors.

As firms need to identify customers with different levels of brand loyalty, studies on loyalty-based segmentation attempt to identify the types of relationships between customers and brands and classify customers

Table 1: Previous Brand Loyalty Conceptualizations and Approaches

Aaker (1991)	As a measure of emotional involvement.
Dick and Basu (1994)	As a relationship between relative favorable attitude and repeated patronage.
Assael (1998)	As repeated purchase under high involvement.
Oliver (1999)	As a multidimensional concept involving cognitive, attitudinal, affective, conative and action disposition towards brands.
Oliver (1999); Bourdeau (2005); Maseshwari Lodorfos, and Jacobsen (2014)	As a deeply held commitment to a firm/brand.
Narayandas (2005)	Loyalty defined as increasing stages or rungs: The loyalty ladder.
Jones and Taylor (2007)	As a multidimensional concept applied to services.
Harbor (2006); Harbor, Martin, and Akridge (2008)	Assessing Agricultural Input Brand Loyalty among US Producers.
Moolla (2010); Moolla and Bisschoff (2012 a,b,c); Bisschoff and Moolla (2014)	Brand loyalty measurement of fast-moving consumer goods.
Bianchi, Drennan, and Proud (2014)	Brand loyalty in wines: brand trust, customer satisfaction, and brand loyalty.
Holland, Delgado, Widmar, and Gunderson (2014)	Measuring levels of brand loyalty of US large commercial producers.
Wiese (2014); Bisschoff and Weise (2014); Hill (2018)	Measuring brand loyalty in agribusiness.
Watson, Beck, Henderson, and Palmatier (2015)	As a mix of attitudes and behaviors that favors a firm relative to its competitors.
Ehsan, Warraich, and Sehribanoglu (2016)	Multidimensional brand loyalty in the context of a product.
Mohanty and Kumar (2017)	Measures farmer's satisfaction and brand loyalty toward fertilizer brands.
Bisschoff and Schmulian (2019)	Measuring brand loyalty for chicken brands.
Gajanova, Nadanyiova, and Moravcikova (2019)	Brand loyalty and customer segmentation.

according to the intensity or type of loyalty. Gajanova *et al.* (2019) tested the use of demographic and psychographic segmentation of customers to distinguish between more and less brand loyal customers. Marketing segmentation aid companies to define their marketing mix strategies, enabling them to target customers with specific profiles and needs in each segment.

Applying some of these ideas to agribusiness, Harbor *et al.* (2008) studied the prevalence and determinants of brand loyalty to agricultural input products. They understand brand loyalty as 'the commitment of a customer to choose to purchase a preferred branded agricultural input product or service now and in the future, despite situational changes and marketing efforts that may have the potential to cause switching' (Harbor *et al.*, 2008, p. 18). In the buying process, producers prepare themselves to buy an input and take into consideration different factors, including their perceptions, attitudes, and views; the buying process ultimately influences buying behaviors. Also, Borchers *et al.* (2012) analyzed the relationship between different types of agricultural producers and brand loyalty to crop seeds, crop protection and capital equipment products, dividing producers into balance-oriented, price-oriented, performance-oriented, and convenience-oriented.

Mohanty *et al.* (2017) examined the agriculture producers' brand loyalty to fertilizers in India, testing the relationship between customer satisfaction and brand loyalty. In this study, customer satisfaction is influenced by constructs such as perceived quality, expectations, perceived value and the firm's image. The results show that the model can be used to make benchmark studies among fertilizer companies and could also be extended to other agriculture input industries to measure producers' brand satisfaction and brand loyalty.

3. Loyalty Dimensions and Analysis Framework

The conceptual model of brand loyalty developed by Harbor (2006) and Harbor *et al.* (2008) for agricultural inputs includes a wide variety of factors – suggested by previous research – as important determinants of brand loyalty. The authors classify these factors into four dimensions: *a) producers and farms characteristics; b) producers*' beliefs and attitudes; c) product characteristics, and *d) media exposure.* Other similar studies, such as Holland *et al.* (2014), only use socio-demographic and few farm characteristics to explain agricultural producers' brand loyalty. Borchers *et al.* (2012) studied brand loyalty of different types of US agriculture producers, as a part of a segmentation study. Mohanty *et al.* (2017) only include agricultural producers' brand satisfaction as an influencer of brand loyalty.

However, Harbor *et al.* (2008) conceptual framework is more comprehensive than the above-mentioned studies, in terms of the multiplicity of variables included and its systematization. Thus, Harbor *et al.* (2008) will be used as a benchmark to characterize different brand loyalty groups among Argentine producers, including some of the variables proposed by the authors and adding some others. This paper aims at verifying whether the expected results are met in the Argentine case.

The first dimension, *demographics and farm characteristics*, includes variables such as age, income, farm size, and education. While age positively impacts on expendable input brand loyalty (Funk and Vincent, 1978), it may have no impact for the case of seed brands (Holland *et al.*, 2014). Previous studies for the US market report conflicting findings on the association between brand loyalty and incomes (Holland *et al.*, 2014; Harbor *et al.*, 2008). According to Harbor (2006) gross income positively influences loyalty until income surpasses one million dollars. However, beyond this level of sales, the probability of being loyal to brands of expendable input products falls. In general, education appears to be negatively related to brand loyalty (Holland *et al.*, 2014) and farm size (Funk and Vincent, 1978). This may be explained by the fact that the more educated and the larger the producer, the more he investigates before buying his inputs; and thus, is less brand loyal. Furthermore, this paper includes the 'residence' variable to characterize groups of loyalty. In the Argentine context, larger and wealthier producers tend to live in big cities, far away from the farm, which probably affects their buying behavior. As larger producers tend to be more disloyal to input brands, it can be expected that the farther the producer lives from the farm, the less loyal he tends to be.

Producers' attitudes and beliefs can often lead to brand loyalty. For example, past studies show that perceived brand differences encourage brand loyalty among agriculture producers (Borchers *et al.*, 2012; Harbor *et al.*, 2008, Harbor, 2006). Borchers *et al.* (2012), found that only 11% of performance-oriented producers (those who placed a large emphasis on product performance) consider seed brands more or less the same, while for balance-oriented producers (those who consider all of the input supplier's criteria to be equally important) 21.5% consider brands more or less alike. In Harbor (2006), the most loyal producers tend to be the ones who most disagree that input brands are all the same. Thus, we can expect that producers who believe in the existence of differences between expendable and branded inputs tend to be loyal to seed brands.

The third dimension proposed by Harbor *et al.* (2008) refers to the *attributes of agricultural input products*. The three key components of a product by which firms can create competitive advantages are price, product performance, and supplier relationship (Treacy and Wiersema, 1995). Agricultural input performance refers to the agronomical or technological performance of the input, which can be time-consuming and hard to assess. An alternative to ensure a good quality agronomic product would be the advice given by a supplier the producer trusts, or 'supplier relationship'. We know from previous research that quality and service (Funk and Tarte, 1976), and performance (Harbor, 2006; Funk and Vincent, 1978), impact on brand loyalty. Therefore, we can expect that the more the producer values seed performance the more likely he tends to be loyal to seed brands. We can also expect that the relationship between brand loyalty and price, as well as that between brand loyalty and the relationship with the dealer/retailer are negative, that is the more the producer values price and the relationship with the dealer/retailer, the less loyal he tends to be.

Finally, *media exposure* may prove to be an effective path for generating brand loyalty and improving relationships in agricultural markets (Harbor, 2008). Advertising and media exposure are connected to brand loyalty (Terui *et al.*, 2011; Tellis, 1988). According to Harbor (2006), media exposure positively influences brand loyalty for expendable inputs, with some few exceptions. TV and radio agriculture shows, for example, have a positive influence, as well as agriculture-oriented newspapers. At the same time, general agriculture publications do not influence brand loyalty. Dülek *et al.* (2019) also established a positive link between the use of social media and brand loyalty for products. However, while the use of social media is growing among agricultural producers and is expected to have a positive impact on how producers purchase and perceive brands in future, adoption of social media is slower in rural areas than in urban communities (Pew Research Center, 2019). Thus, we would expect that more media coverage is positively related to seed brand loyalty, although the relationship between social media and brand loyalty would not be so clear up to now.

The level of exposure may influence brand loyalty, and there may be effects based on the type of exposure. Since seed sales are of a very special and technical type (Magnier *et al.*, 2010), companies tend to approach producers through traditional farm channels (farm shows, farm magazines, TV, radio.) Personal communication (field days, meetings) are the two most prevalent ways that companies use to contact Argentine producers. We would, therefore, expect that more exposure to more common media formats (traditional and personal) would positively impact on brand loyalty. The relationship between social media and seed brand loyalty, is incipient up to now; therefore, it is hard to predict its outcome.

4. Data and Methods

Data collection

The primary source of information for this paper is ''The Needs of the Argentine Agricultural Producer 2017'' survey, carried out by Universidad Austral during June and July 2017. A total of 818 producers were surveyed in the country's main agricultural provinces[6]. These producers are representative of approximately 85% of the soybean production, roughly 80% of corn, and almost 90% of the wheat production in Argentine[7]. The aim of this survey is to analyze the argentine agricultural producer's purchasing behavior and comprehend their underlying preferences in such decisions. The survey is based on 58 questions, which were responded in personal interviews conducted with agricultural producers, and one of the questions directly refers to crop seed brand loyalty.

Question number 40 in the survey asked producers about their loyalty to the crop seed brands they purchase. This question is based on the loyalty ladder developed by Narayandas (2005)[8] and has also been used by Holland *et al.* (2014). Farmers were asked to express their agreement with the following statements related to their first-choice brands (it was possible to select more than one option):

a. *I will do more business with this brand.*
b. *I endorse this brand to my neighbors.*
c. *I try products other than this brand.*
d. *I would switch to another brand for 5% savings.*
e. *I would switch to another brand for 10% savings.*
f. *I am loyal to this brand (I would not change brand if the price increases 10%).*

As previously stated, a complete definition of loyalty can relate to behavior, but should include attitudinal aspects; otherwise, it may reflect spurious loyalty (Watson *et al.*, 2015). Question 40 was designed to reflect a balance between options associated with attitudes or beliefs (*a, b, c*), and options associated with a more particular decisional aspect that reflect changes in behavior associated to changes in prices (*d, e, f*).

In interpreting the results, options *c, d,* and *e* are associated with *factors associated with disloyalty*, since they show a disposition to switch brands (even when this switching may not happen in practice). On the other hand, options *a, b* and *f* are *factors associated with loyalty,* since they imply the producers' certain involvement with the brand (by not switching even with higher prices, by recommending the brand to neighbors or seeking to do more business with it).

Some 54 individuals were excluded from the 818 in the sample due to inconsistencies in their responses. The results then derived from the answers recorded from the remaining 764 farmers. The questionnaire provided the opportunity to draw the producers' socio-demographic and purchasing behavior data, which can be used to describe the socio-demographic background of producers with different seed brand loyal profiles.

Methods

We resorted to a two-step methodology: the first step identifies groups of producers in terms of their loyalty to seed brands, using a multivariate analysis of conglomerates or cluster analysis. Then, to identify variables associated with brand loyalty, and have an initial group characterization, we use independency tests for qualitative variables.

A conglomerate is understood as a set of statistical individuals (entities, persons, objects) that have similar characteristics (Johnson and Wichern, 1998; Díaz and Morales, 2012). To partition a finite set of individuals into groups, there are two well-known and differentiated classes of algorithm: non-hierarchical methods (e.g. k-means), that begin with a number of groups defined a priori; and hierarchical methods, which begin with the calculation of the distance matrix, forming groups through agglomerative or divisive techniques.

In this study, we worked with a hierarchical agglomerative procedure, where each one of the individuals begins forming a conglomerate, or unitary groups. Nearby groups are mixed successively until all similar individuals are within the same conglomerate. In order to do that, we employ the Euclidean binary distance, since the variables selected to carry out the cluster

[6] These provinces are Buenos Aires, Cordoba, Santa Fe and Entre Rios, in which producers obtain high yields for their crops. We are not dealing in this study with producers in marginal productive areas.

[7] Secretary of agriculture, Argentina, agricultural estimates, period 2018-2019. http://datosestimaciones.magyp.gob.ar/reportes.php?reporte=Estimaciones.

[8] With certain adaptations, as we shall see below.

Table 2.a: Cluster solution with two seed brand loyalty groups.

	Total		Cluster 1		Cluster 2			
	N=764		N=333		N=431		t-test	
Characteristic	Mean	Sd	Mean	Sd	Mean	Sd		
I will do more business with this brand	0.86	0.35	0.82	0.38	0.88	0.32	2.45	**
I recommend this brand to other farmers	0.52	0.50	0.85	0.36	0.27	0.44	-19.95	***
DID NOT SELECT I try different brands of this product	0.40	0.49	0.70	0.46	0.17	0.38	16.88	***
DID NOT SELECT I would change brand if the price increases 5%	0.79	0.41	1.00	0.05	0.62	0.48	15.83	***
DID NOT SELECT I would change brand if the price increases 10%	0.50	0.50	0.99	0.11	0.12	0.33	51.10	***
I am loyal to this brand (I would not change brand if the price increases 10%)	0.32	0.47	0.74	0.44	0.00	0.00	-31.12	***

Levene test for equality of variances was performed for each variable and was significant at $p<0.01$
Note: T-mean sample comparison test with unequal variances. ***$p<0.01$ **$p<0.05$ *$p<0.1$

analysis are all qualitative, with only two categories of response to each one.

The hierarchical agglomerative method of linkage by the intra-group average proposed by Sokal and Michener (1958), allows us to combine groups looking for the least possible average distance. Thanks to this method, the distance within two clusters A and B is defined as the average of the distances for all the resulting pairs of individuals in case the two groups A and B were joined; that is:

$$d_{AB} = \frac{1}{c}\sum_{i,jC} d_{ij} \quad (1)$$

Where:

c being the total number of possible comparisons for pairs of individuals i, j of the new cluster C, constructed through the union of the individuals in group A and B.

As we are in the presence of an agglomerative method, in the first step of the algorithm, two of the closest individuals are joined; that is, two individuals i, j such that their binary Euclidean distance d_{ij} calculated through (1) is equal to the origin, or at least a very small value. In each step of the process we can group together either individual cases, previously formed conglomerates, or an individual case with a previously formed conglomerate. Therefore, individuals are grouped into increasingly larger and more heterogeneous conglomerates until the last step, in which all the sample is grouped into a single global conglomerate.

Once the groups of individuals have been established based on their brand loyalty to seeds, we use an independency test to check the statistical relationship of brand loyalty to each of the variables that can influence the producer's behavior, following the framework proposed in Harbor et al. (2008).

5. Results

We start by presenting the tentative identification of the number of clusters. Furthermore, we show and analyze the proposed clusters and their validation, based on the producers' disposition to seed brand loyalty. Next, we check a group of variables based on their association with brand loyalty to draw an initial characterization of producers in different clusters.

Identification of loyalty groups

As explained in the methodology section, the identification of groups of loyalty is based on a hierarchical agglomerative process. Since hierarchical methods do not define *a priori* the number of clusters, it is essential to determine when to stop the agglomeration process and the number of clusters to be finally obtained. According to the positive conglomerate coefficient values, we work with two and three clusters. We also check whether the groups obtained are significant, not only statistically but also commercially. For further details, see Annex A.1.

Tables 2.a and 2.b show the results in two and three clusters, respectively. In the first case, we have the first cluster with 333 individuals, where 82% of producers would continue doing business with the seed brand they presently buy; they recommend that brand to their neighbors (85% of answers), and would stay with the brand even with a 10% price increase (74% of answers). Only 30% of the producers included in this group indicate that they would try different products, none of them would change brand even with a 5% increase in price, and 99% of them would stay with the brand even if prices increase 10%. Thus, we can say that this is the cluster that includes the group of producers who show loyalty.

On the other hand, the second cluster includes 431 individuals. They also indicate their willingness to doing more business with the brand they are currently buying (88% of answers). However, most producers in this category claim that they would try different products (83% of answers) and change the brand if prices increase 10% (88% of answers) or even 5% (38% of answers). Finally, none of them say that they would continue buying the product if prices rise more than 10%. Therefore, we can say this cluster reveals the group of producers who do not show loyalty.

As shown in Table 2.a, t-test for mean sample comparison (considering unequal variances) indicates differences for each variable between both groups that are statistically significant (see Annex A.2 for more details regarding t-test).

Table 2.b: Cluster solution with three seed brand loyalty groups.

	Total		Cluster 1		Cluster 2		Cluster 3			
	N=764		N=333		N=269		N=162		F-value	
Characteristic	Mean	Sd	Mean	Sd	Mean	Sd	Mean	Sd		
I will do more business with this brand	0.86	0.35	0.82	0.38	0.92	0.27	0.82	0.38	7.4	**
I recommend this brand to other farmers	0.52	0.50	0.85	0.36	0.30	0.46	0.21	0.41	192.4	***
DID NOT SELECT I try different brands of this product	0.40	0.49	0.70	0.46	0.23	0.42	0.07	0.25	161.1	***
DID NOT SELECT I would change brand if the price increases 5%	0.79	0.41	1.00	0.05	1.00	0.00	0.00	0.00	48,555.6	***
DID NOT SELECT I would change brand if the price increases 10%	0.50	0.50	0.99	0.11	0.20	0.40	0.00	0.00	1,182.1	***
I am loyal to this brand (I would not change brand if the price increases 10%)	0.32	0.47	0.74	0.44	0.00	0.00	0.00	0.00	626.3	***

Note: ANOVA test for differences in multiple means. ***p < 0.01 **p < 0.05 *p < 0.1

We consider a scenario with 3 clusters (as shown in Table 2.b) and check changes in the above analysis. We have a loyal group (cluster 1) with the same number of individuals and results as in the two-cluster solution. As explained before, this group includes producers who are loyal to the seed brand.

Cluster 2 in the analysis above (disloyal cluster), consists of two sub-clusters. Sub-cluster 1 includes 162 individuals. Every single producer in this group claims that they would change brands if prices increase 5% or 10% whereas 93% said that they would try different brands. As we can see, compared to the disloyal cluster in the two-cluster solution, this group shows a deeper and more emphatic disloyalty, almost no loyalty to the seed brands and would not tolerate any price increase.

The second sub-cluster consists of 269 agricultural producers and seems to be an 'intermediate' group. 92% of producers answered that they would continue doing business with the brand they are currently buying, and none of them would switch brands if prices increase 5%. Nonetheless, 80% of the agricultural producers in this group would switch brand in case of a 10% increase, and none of them would stay attached to the brand if prices increase more than 10%. 77% of these producers try different seed brands, and 30% of them recommend the brand to their neighbors. As we can see, this group likes and is satisfied with the brand they presently use. They show a certain degree of loyalty and would tolerate a small/moderate increase in price. However, this loyalty would not last forever: they are willing to change brand if prices increase significantly. This means that they like the brand but are not willing to 'marry' the brand.

As shown in Table 2.b, analysis of variance (ANOVA) test for differences in multiple means is significant so we confirm there are statistically significant differences between means in the three groups (see Annex A.2 for more details).

This three-cluster solution is more refined, in the sense that it shows the two 'empirical' groups conformed in the previous solution, the 'disloyal' and the 'loyal' clusters (with a much more emphatic disloyalty group). This solution also includes an intermediate group whose members share loyalty and disloyalty traits. Summarizing, the 'two clusters' solution, with one loyal and another disloyal group, was transformed into a 'three cluster' segmentation of agriculture producers: one 'loyal group', as before, and two new ones: a 'pure disloyal group' and an 'intermediate group' with a blend of loyal and disloyal traits. As there are significant differences in the responses of the agriculture producers in each cluster, we have a new way of segmenting argentine agriculture producers according to their brand loyalty to seeds. Therefore, we can now take this outcome to advance in the characterization of each loyalty group considering different types of variables.

Characterization of loyalty groups

The second stage of our analysis includes a first exploration of the characteristics of those individuals in the clusters identified. We provide an initial description of the producers' profile for each brand loyalty group. This is an ex-post, non-conditional analysis, aimed at exploring relationships between a group of selected variables and brand loyalty. We identified variables based on their relevance to explain brand loyalty. Besides, we test whether there exists a significant relationship between each variable and brand loyalty. The variables are 11, divided into 4 dimensions, following the framework developed by Harbor *et al.* (2008).

We can observe the results in Table 3. The results corresponding to the *first dimension (the farm and the producer*'s characteristics) show that loyal producers tend to be younger (higher share of producers under 44) and rent a larger proportion of their land, than the other two clusters. Disloyal producers manage larger farms and sale volumes than those in the intermediate and loyal clusters (higher share of large producers, and sales above U$D 1,000,000). Disloyal producers also show higher levels of education than those in the other two clusters and live farther from the farm (higher share of producers who live more than 50 kilometers away).

The results corresponding to the *second dimension (producers*' beliefs and attitudes) include the belief that there are differences between expendable and branded

Table 3: Independence Chi-Square test for selected variables

			Cluster 1 Loyal	Cluster 2 Intermediate	Cluster 3 Disloyal					
			N=333	N=269	N=162	Pearson Chi-Square		Log-Likelihood		Df
Dimension 1=Farm and Farmer Characteristics										
Education	High School or Less	% of total	36.0	29.4	19.1	14.90	***	15.55	***	2
	More than High School	% of total	64.0	70.6	80.9					
Age	⩽44	% of total	60.7	36.4	30.2	66.56	***	65.15	***	4
	45-54	% of total	21.9	32.3	48.1					
	⩾55	% of total	17.4	31.2	21.6					
Residence	In the facilities	% of total	8.1	5.2	2.5	10.15	**	10.69	**	4
	Less than 50 kilometers away	% of total	59.5	65.4	58.6					
	More than 50 kilometers away	% of total	32.4	29.4	38.9					
Size	Mid-size	% of total	63.1	70.3	63.0	7.93	*	7.65		4
	Commercial	% of total	26.4	21.2	21.6					
	Large	% of total	10.5	8.6	15.4					
% of rented land	Less than 50%	% of total	46.2	71.7	58.6	39.74	***	40.44	***	2
	50% or more	% of total	53.8	28.3	41.4					
Gross Sales (U$D)	⩽499,999	% of total	49.2	50.9	34.0	24.24	***	24.50	***	4
	500,000- 999,999	% of total	24.6	31.2	29.0					
	⩾1,000,000	% of total	26.1	17.8	37.0					
Dimension 2= Farmer beliefs/attitudes										
Diff. between expendable and	Strongly Disagree - Disagree	% of total	14.7	58.7	61.7	161.49	***	172.96	***	4
branded-products	Partially Disagree	% of total	16.8	10.8	8.6					
	Partially Agree - Agree - Strongly Agree	% of total	68.5	30.5	29.6					
Dimension 3= Product Characteristics										
Price	Least Important/Neutral	% of total	81.1	68.0	60.5	26.43	***	26.72	***	2
	Most Important	% of total	18.9	32.0	39.5					
Performance	Least Important/Neutral	% of total	31.5	53.2	64.8	56.65	***	57.63	***	2
	Most Important	% of total	68.5	46.8	35.2					
Relationship	Least Important/Neutral	% of total	88.0	79.2	75.3	14.56	***	14.83	***	2
	Most Important	% of total	12.0	20.8	24.7					
Dimension 4= Media Exposure										
Media Sources	Traditional	% of total	53.5	48.3	33.3	95.13	***	97.33	***	4
	Personal Communication	% of total	31.5	14.1	13.0					
	Social Media	% of total	15.0	37.5	53.7					
Mean Valoration by Cluster (value min = 0, value max = 6)			3.69	3.25	3.11	F-value = 3,25	***			
Mean Valoration by Cluster without Social Media (value min = 0, value max = 6)			3.94	3.54	3.23	F-value = 3,34	***			

Note: ANOVA test for difference in multiple means. ***$p<0.01$ **$p<0.05$ *$p<0.1$

Table 4: Dimensions of Brand Loyalty. Conceptual model versus results

Dimension	Variable	Conceptual model proposed by Harbor et al. (2008)	Results for Argentine Farmer
Farm and farmers' characteristics	Sales	(+/-)	(-)
	Age	(+)	(-)
	Education	(-)	(-)
	Farm Size	(-)	(-)
	Location	(+/-)	n.a.
	Search activity	(-)	n.a.
	Residence (distance to farm)	n.a.	(-)
	% of rented land	n.a.	(+)
Farmers beliefs and attitudes	Value of time	(+)	n.a.
	Positive attitude to innovations	(+)	n.a.
	Perception of brand differences	(+)	(+)
Product characteristics	Price	(-)	(-)
	Performance	(+)	(+)
	Relationship	n.a.	(-)
Media exposure	Exposure to media sources	(+)	(+)
	Traditional media & personal comunication	n.a.	(+)

products. The differences are clear and confirm the result previously expected: most loyal producers tend to consider that there are significant differences, while most neutral and disloyal producers do not.

In the *third dimension (product characteristics),* we include three variables that reflect three different dimensions of the seed product: price, performance and relationship with the dealer/supplier. These variables were converted into three dummy variables that separate those producers who selected one dimension as the most important (#1), from those who rank such dimension in second (#2) or third (#3) place. There is a relevant relationship between these variables and brand loyalty.

Loyal producers are more performance-oriented than their colleagues in the disloyal and intermediate cluster. Some 68.5% of loyal producers indicate performance as the most important product dimension, compared to 35.2% in the disloyal category and 46.8% in the intermediate one. Producers in the loyal group do not rank price and relationship first in importance among product dimensions; 81.1% consider price and 88% mention relationship as the least important/neutral factor. Loyal producers are more focused on product performance, and they care much less about price and relationship than their colleagues in the other two clusters.

Finally, the *fourth dimension (media exposure)* includes the level and the type of media exposure. The mean exposure value for loyal producers is higher and significantly different from intermediate and disloyal producers.

Concerning the type of exposure, we classified the sources of information into three groups: traditional (farm shows, farm magazines, agricultural TV or radio shows), social media (social networks and YouTube), and personal communication (field days or meetings with retailers). The results show a meaningful relationship between preferred media sources and brand loyalty. Loyal producers prefer, first of all, traditional sources (53.5%) followed by personal communication (31.5%). While disloyal producers rank social media in the first place (53.7%) and traditional communication second (33.3%), more intermediate producers give priority to traditional means (48.3%) followed by social media (37.5%).

In summary, this section focuses on producing an initial description of those producers grouped in different brand loyalty clusters. There is a statistically significant relationship between brand loyalty and the 11 variables that explain seed brand loyalty. Producers in different brand loyalty clusters have different profiles based on their farm and farming characteristics, beliefs and attitudes, preferences for product characteristics, and media exposure. As previously stated, it is important to note that the results drawn from this analysis are descriptive and do not predict class membership. Annex 3.A synthesizes the different profiles of loyal, intermediate, and disloyal producers.

Conclusions

Companies in the crop seed markets face increasing competition, market restructuring and consolidation, and high innovation costs, which puts pressure on these firms to find ways to attract customers and differentiate their products from competitors. Brand loyalty is a concept that gains crucial relevance for firms selling crop seeds, as a means of developing brands which agricultural producers can perceive and associate with as high quality, valuable and reliable products; and in this way, help firms become more competitive and profitable.

This paper intended to identify and characterize different groups of producers based on their loyalty to crop seed brands sold in formal markets in Argentina. The specific objectives were to identify the agriculture produces who are loyal to crop seed brands, characterize them, and provide some insights to agricultural input providers who aim to gain a more in-depth knowledge of argentine producers and design marketing strategies to sell their products.

This identification and characterization may be helpful to understand producers' purchasing behavior, especially for companies and organizations selling agricultural inputs such as seed crops. The argentine crop seed markets are characterized by poor patent protection and a weak legal enforcement regime, as well as strong competition as Argentina is a relevant crop producer, which makes it difficult for firms to make profits (Correa, 2020; Craviotto, 2018). At the same time, Argentine

producers tend to be more brand loyal than US producers (Feeney and Berardi, 2013). Thus, it is meaningful for seed companies to understand their buyers' buying behavior and set strategies to retain them as loyal customers in such a complex market. Such understanding and strategies would minimize companies' commercial risks.

Thanks to cluster analysis, we identify and describe the main characteristics of those producers *who are loyal* to seed brands. Our first finding is that approximately 44% of Argentine producers consider themselves loyal to the crop seed brands they buy. These producers are willing to buy the brand regularly, despite price increase. They declare that they would continue purchasing the brand if prices increase 5% (or even 10%), and most of them would continue buying the brand even if there is a price rise of more than 10%. However, loyal producers exhibit not only behavioral loyalty to the seed brand they purchase but also attitudinal loyalty or commitment to the brand. Many loyal producers would recommend the brand and would not try different brands.

By contrast, only 21% of Argentine producers consider themselves *disloyal*, meaning that they are willing to try other products and would change seed brand if price increased 5% or more. Nevertheless, most *disloyal* producers state that they would continue buying their preferred brand but would try other products. Furthermore, in most cases, they would not recommend this brand to other producers. These disloyal producers do not show behavioral or attitudinal loyalty to seed brands.

We also identified a third segment of producers, which we called *intermediate*, as they combine some characteristics of loyal and disloyal producers. They want to do more business with the brand and are willing to tolerate slight price increase, but they would not buy the brand if prices rise more than 10%. Intermediate producers claim they would try other products and, in most cases, would not recommend this brand to other producers. Intermediate producers display some degree of behavioral and attitudinal loyalty, however, limited: they like the brand and would like to continue using it under the present conditions, but they would not 'marry' to the brand.

The 'two clusters' solution, with one loyal and another disloyal group, was transformed into a 'three cluster' division of agriculture producers with one 'loyal group', and two new ones: a 'pure disloyal' and an 'intermediate group'. Thus, this paper presents a new way of segmenting argentine agriculture producers according to their brand loyalty to crop seeds sold in formal markets.

To draw an initial characterization of these groups based on their brand loyalty, we used the conceptual framework proposed in Harbor *et al.* (2008). This conceptual framework is more comprehensive than most studies reviewed, in terms of the multiplicity of variables included and its systematization. It associates brand loyalty with different variables grouped into four different dimensions. Out of the 11 variables we used to test brand loyalty, 8 are common with this conceptual model: sales, age, education, farm size, brand differences, price, performance, and media exposure.

Our results match those in Harbor *et al.* (2008) for 7 of the 8 variables. Age is the only variable where our results differ from those expected, based on the model. In our study, younger producers (under 44 years) tend to be loyal to seed brands, while in Harbor *et al.* (2008) US producers over 54 and under 35 are disloyal, and those in between (35-54) tend to be loyal.

This paper has included some variables that are absent in the benchmark model, such as residence, rented land, relationship with the dealer/retailer and type of exposure to media communication (traditional and personal communication).

Our results show that traditional media and personal communication have a positive association with brand loyalty, while the association with social media is negative. Harbor *et al.* (2008) did not establish such a relationship since, at that time, social media and the Internet was not as extended as nowadays. Besides, loyal farmers tend to rent a larger proportion of the land they farm when compared to disloyal farmers. The relationship with the supplier appears as negatively related to brand loyalty. Regarding the producer's residence, it was found that the farther a producer lives from his farm, the more likely he is disloyal to seed brands.

Table 4 summarizes the main differences and similarities shown by our results between the two studies for the US and Argentine producers.

Our results have strong business implications, as they establish a clear profile of producers who are loyal to a brand in the heart of the Argentine Humid Pampa, the main agricultural area of the country. Our findings can help ag input companies determine where to focus their attention and resources. A loyal producer is a very special type of customer: young, technically focused, operates in a small/medium scale, value product performance, and prefer traditional and personal channels of communication. Seed companies should be aware of these characteristics, not only to retain their current customers but also to set marketing strategies that may attract potential customers.

Personal interviews we made with seed industry experts in Argentina tend to confirm the profile of a typical loyal producer[9]. First, industry experts claim that a rather large segment of producers traditionally tends to be loyal to seed brands. They also confirm that loyal producers tend not to be large ones. Loyal producers are usually mid-size or commercial; they value product performance and are not highly sensitive to price. Price discounts and fidelity programs work in the short-term, but producers would stick to the brand that shows the best performance in the long-term.

This analysis of seed brand loyalty among Argentine producers expands the work done by Harbor *et al.* (2008), Borchers *et al.* (2012) and Holland *et al.* (2014), and, to our knowledge, is the first to deal with crop seed brand loyalty in Argentine, with a novel way of segmenting and characterizing agricultural producers. This paper is, therefore, a contribution to the literature on agriculture marketing. This paper, however, has a limitation: the results apply only to the Humid Pampa, the main agricultural area of Argentina, are descriptive and do not predict class membership. This work could be expanded to other products, such as agricultural machinery and expendable inputs. Furthermore, it may be interesting to perform a comparative analysis between brand loyalty and dealer/distributor loyalty.

[9] Three personal interviews with managers of seed companies of around one hour each.

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Annex A1.

The Software Package for Social Sciences (SPSS) 15.0 produced the results presented in the Annex, which correspond to the positive conglomerate coefficients. For summary purposes, we only present the coefficients calculated last that differ from the origin, as we can see in the Table A.1.

The third column reflects the distance between the coefficient of the *i* -1-th element of the cluster and that of the *i*-th element. We can see that except for the first coefficient, the others are mathematically negligible in magnitude. Therefore, it is very reasonable to consider a total of two clusters in principle. However, since the distances that follow are very small, due to the successive closeness between the values of the respective conglomeration coefficients, it is statistically convenient to consider at least one more group.

A.1: Conglomerate Coefficients.

Clusters (i)	Agglomeration Coefficient (ci)	Distances (di = ci-1-ci)
1	1.464	
2	1.124	0.340
3	1.027	0.097
4	0.945	0.082
5	0.835	0.110
6	0.723	0.112
7	0.721	0.002
8	0.666	0.055
9	0.609	0.057
10	0.496	0.113
11	0.485	0.011
12	0.480	0.005
13	0.459	0.021
14	0.456	0.003
15	0.409	0.047
16	0.408	0.001
17	0.334	0.074
18	0.300	0.034
19	0.274	0.026
20	0.191	0.083
21	0.186	0.005
22	0.169	0.017
23	0.166	0.003
24	0.143	0.023
25	0.129	0.014
26	0.100	0.029
27	0.085	0.015
28	0.070	0.015
29	0.026	0.044

Annex A.2.

A.2.1: Validation for cluster solution with two brand loyalty groups.

		Levene Test for Equality of Variances		T- test for mean difference	
		F	p-value	t	p-value
I will do more business with this brand	Equal Variances	25.3	0.000	2.5	0.012
	Unequal Variances			2.5	0.014
I recommend this brand to other farmers	Equal Variances	63.6	0.000	-19.4	0.000
	Unequal Variances			-19.9	0.000
DID NOT SELECT I try different brands of this product	Equal Variances	73.3	0.000	17.3	0.000
	Unequal Variances			16.9	0.000
DID NOT SELECT I would change brand if the price increases 5%	Equal Variances	4255.7	0.000	14.0	0.000
	Unequal Variances			15.8	0.000
DID NOT SELECT I would change brand if the price increases 10%	Equal Variances	174.7	0.000	46.1	0.000
	Unequal Variances			51.1	0.000
I am loyal to this brand (I would not change brand if the price increases 10%)	Equal Variances	1364.3	0.000	-35.4	0.000
	Unequal Variances			-31.1	0.000

A.2.2. Validation for cluster solution with three brand loyalty groups.

ANOVA		Sum of squares	df	Quadratic Mean	F	p-value
I will do more business with this brand	Inter-group	1.8	2	0.9	7.43	0.001
	Intra-group	92.4	761	0.1		
	Total	94.2	763			
I recommend this brand to other farmers	Inter-group	64.0	2	32.0	192.39	0.000
	Intra-group	126.7	761	0.2		
	Total	190.7	763			
DID NOT SELECT I try different brands of this product	Inter-group	54.6	2	27.3	161.14	0.000
	Intra-group	128.9	761	0.2		
	Total	183.4	763			
DID NOT SELECT I would change brand if the price increases 5%	Inter-group	127.2	2	63.6	48555.62	0.000
	Intra-group	1.0	761	0.0		
	Total	128.2	763			
DID NOT SELECT I would change brand if the price increases 10%	Inter-group	144.5	2	72.2	1182.09	0.000
	Intra-group	46.5	761	0.1		
	Total	191.0	763			
I am loyal to this brand (I would not change brand if the price increases 10%)	Inter-group	104.2	2	52.1	626.28	0.000
	Intra-group	63.3	761	0.1		
	Total	167.5	763			

Annex 3.A.

A.3: Producers' profiles based on their seed brand loyalty. 4 Loyalty dimensions.

	Loyal	**Intermediate**	**Disloyal**
Farm and the producer's characteristics	Mostly under 44 years old. Lower sales than disloyal. Highest share of rented land among the three clusters.	Oldest producers' segment. Smallest average size and sales. Produces more on owns more land than the other two clusters.	Mostly aged 44-54. Highest share of producers with high school or moreLargest cluster in size and sales. On average, live farther from farm than the other two clusters.
Producers' beliefs and attitudes	Perceive differences between branded and expendable products.	Less perception of differences between branded and expendable products.	Less perception of differences between branded and expendable products.
Product characteristics	More focused on performance than on price, relationship oriented.	Less focused on performance and more on price, relationship centered.	Less focused on performance and more on price, relationship centered.
Media exposure	They place a higher value on information from media sources. Ranking of media sources: First, traditional sources and second, personal communication.	Ranking of media sources: First, traditional sources and second, social media.	Ranking of media sources: First, social media and second, traditional media.

REFEREED ARTICLE

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Analysing the Links Between Index-Based Crop Insurance Adoption and Agricultural Investments in Burundi

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ABSTRACT

This paper analyses the links between index-based crop insurance (IBI) adoption and agricultural investments based on a cross-sectional sample of 40 crop insurance adopters and 40 non-adopters from two communes located in Gitega province in Burundi. Analysed agricultural investments variables included use of fertilizers, applying crop diversification, and use of land and crop management practices in the most recent year and in the year before IBI implementation started. The results from multivariate analysis indicate that adopters use 36% more chemical fertilizers and invest 18% more in chemical fertilizers than non-adopters ($p \leqslant 0.01$). Adopters apply more land management practices also, in which they invest 15% more than non-adopters ($p \leqslant 0.01$). Furthermore, adopters change crop management practices over time by 38% and their knowledge in crop management practices increased by 23% ($p \leqslant 0.01$). Differences between adopters and non-adopters are however not statistically significant for crop diversification strategies and for the use of organic fertilizers. Hence, in order to be more effective and beneficial to farmers, other actions are also needed to encourage farmers to invest in their farm. Particularly promising in Burundi in this respect is to empower and train farmers by means of the Integrated Farm Planning approach, as well as to enhance farm inputs availability and to promote smart agri-entrepreneurial programs. In order to enhance agricultural development, the Burundi government should have a more prominent role in fostering farmers' agricultural investments and in supporting IBI adoption.

KEYWORDS: Index-based crop insurance; adoption; agricultural development; smallholder farming; Burundi

1. Introduction

Weather-related shocks are a major threat to the livelihoods of vulnerable farmers in low-income, arid and semi-arid regions of the world (Jensen, Mude, & Barrett, 2018). In response, crop insurance products have been piloted in, for example, Sub-Saharan Africa (SSA) to protect low income farmers against climate related risks (Churchill, 2008, Ntukamazina *et al.*, 2017). However, implementing traditional indemnity-based crop insurance schemes in a viable way with substantial outreach is hampered by information asymmetry (causing moral hazard problems and adverse selection) as well as associated transaction costs to address those problems. Agricultural index-based crop insurances (IBIs) tackle this moral hazard and adverse selection, given that they are based on a verifiable and independent measurement of a variable that impacts crop development (Sinha & Tripathi, 2016). Hence, the advantage of an IBI is that farmers are paid-out based on indices rather than appraised losses. IBIs are therefore considered as a potential solution to the long-standing problem of low rates of crop insurance adoption, especially in risk-prone regions of SSA (Carter *et al.*, 2015).

Nevertheless, the main challenge of the IBI lies in the method of compensation in the event of a climatic shock. This arises partly from the spatial discrepancy between the measured risks at a specific meteorological station and the occurrence of weather shocks at the location of the insured farm. For instance, it may rain more than the trigger level for drought insurance at the meteorological station but not at the insured location, with the result that a farmer is not compensated for incurred losses due to drought. In this case, no payments are done (or payments are lower), even though the farmer has paid the insurance premium (Carter *et al.*, 2014). More spatial targeted IBIs can be designed by using satellite-based information (to limit spatial basis risk), but some elements of basis risks still remains. The basic risk is the

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difference between actual loss and the pay-out on an insurance contract (Fisher *et al*., 2019).

Most farmers appear to be reluctant to opt for an IBI with inherent basic risks (Smith & Goodwin, 2006). Yet the growth of IBIs, primarily weather-index insurances but also area-yield index crop insurances, has been remarkable in the developing world over the past decade (Bobojonov, *et al.,* 2013, Sinha & Tripathi, 2016). An IBI is regarded as a major innovation that could revolutionize access to formal insurance for millions of farmers and related individuals in the near future (Carter *et al.*, 2014). However, ambiguous evidence feed the debate on IBIs and to what extent they represent an opportunity for development, especially in a dynamic and changing environment (Sabatini, 2017).

An insurance program enables farmers to take more risk, which they would not have taken in the absence of it (Aditya, Khan, & Kishore, 2019), leading farmers to invest more in viable activities and use more inputs (He, *et al.* 2016). Increased investments have been found in several empirical IBI studies. For example, Karlan *et al.* (2014) investigated the impact of an IBI on income enhancing agricultural investments in a randomized control trial in Ghana and found a strong response. Also in a field study in Kenya IBI uptake contributed to investments in chemical fertilizers and adoption of improved seeds, as well as to higher yields (Sibiko & Qaim, 2017). Studies in the Philippines (He *et al*., 2016) and in the USA (Chang &Mishra, 2012; Claassen *et al.*, 2017) also revealed a positive effect of IBI adoption on the use of chemical fertilizers. In a review study comprising several field studies in developing countries it was shown that farmers with an IBI increased agricultural investments (Carter *et al.* (2014).

However, there are also studies that find no effect or even the opposite. Babcock and Hennessy (1996) found that farmers in Iowa (USA) with a yield and revenue insurance are likely to use less chemical fertilizers. Similar effects were found in Kansas (USA) where farmers with an index-based insurance used fewer inputs such as chemical fertilizer (Smith & Goodwin, 1996) and improved seeds (Sibiko & Qaim, 2017). Furthermore, also in the USA, Quiggin *et al.* (1993) in a study on a multi-peril crop insurance found an insignificant effect of the insurance on the use of chemical fertilizers.

Although there are many studies that analyse the effect of crop insurances on fertilizer use, there are only few that focus on their effects on the use of land or crop management practices. Prokopy *et al.* (2019) studied adoption of agricultural conservation practices in the USA and found that a crop insurance is sometimes correlated with conservation practice adoption. However, findings from Beckie *et al.* (2019) revealed that the short-term nature of a crop insurance, being an annual expense, does not directly incentivize (more long-term) best management practices.

In summary, how insurance adoption affects input use and land management on the farm is still under debate. This paper aims to fill this gap by analysing the links between IBI adoption and agricultural investments in rural Burundi.

2 Methodology

Context

This study was performed in two communes of Gitega province, namely Bukirasazi and Makebuko, located in the central part of Burundi. Annual and perennial crops are cultivated during the three main agricultural seasons: in the two rainy seasons A (from September to January) and B (from February up to May) and the dry Season C from June up to September (when crops are cultivated only in the marshlands).

Participatory meetings were organized with farmers to discuss the design of the insurance to be implemented. Farmers preferred the weather-based crop insurance rather than a conventional insurance (i.e., indemnity-based multi-peril crop insurance) since implementation was expected to be easier, cheaper and eliminated moral hazard problems. Moreover, a mutual approach was followed in which farmers are the insured and insurers at the same time. The mutual IBI is implemented and coordinated by a Micro-insurance and Finance Cooperative (MAFICO), which is an independent micro-insurance that promotes an agricultural insurance, a health insurance, and micro saving and credit schemes. It is owned and managed by farmers, who are also represented in the executive board (Ndagijimana *et al*., 2017).

The IBI was launched in season B 2017 in the aforementioned two communes. Farmers were targeted on the basis of specific criteria such as belonging to a village saving and loan association (VSLA) with a high adoption level of land management practices, and a subscription to the health insurance scheme. As a result, only VSLAs with at least 60% of the members having implemented land management practices were allowed to participate in the insurance program. Although the VSLAS' main objective is to promote savings and service loans to their members, it also constituted to save 30% of the contributions for an agricultural insurance (premium payment). Next to these savings for premium payments, VSLA members were trained on how to increase farm productivity through the implementation of the so-called Integrated Farm Planning (PIP) approach, which was introduced in the study area by the project ''Fanning the Spark'' in 2013. The approach implies that families make a visionary integrated farm plan (the PIP) which is developed and drawn on a map, and which aims at transforming small-scal subsistence farm households into more productive and sustainable farms, based on sound natural resource management (Kessler *et al*., 2016). The PIP approach works to some extent like a theory of change (Taplin *et al.*, 2013), since it defines long-term goals and then maps actions to achieve the planned changes. The PIP approach focuses on the household and the farm as a 'farming system', where integration of practices and a diversity of crops and activities are crucial to make the household more resilient.

Agricultural investments analysed in this study

The term ''investment'' in this study includes both monetary and non-monetary expenditures. Thus, farm investment is the monetary value spent by the farmer to obtain certain farm inputs and the cost of implementing the farm practices based on the time used to do so. Four types of investments are considered for this study, namely investments in fertilizers, crop diversification, land management and crop management:

- Fertilizer investments comprise organic and chemical fertilizers. Organic fertilizers are either manure from own livestock or purchased. In the study area, most

farmers possess big and/or small livestock which provides manure. Chemical fertilizers are purchased mainly from the communal or provincial extension services (as part of a subsidized public policy).

- Crop diversification investments comprise nine annual crops: beans, cassava, maize, potatoes, peanuts, peas, rice, soybean and sweet potatoes. These are the main staple crops in the study area, but also at national level, and are seasonally grown (mainly in season A and season B). Furthermore, eight vegetable crops were considered: amaranth, cabbage, carrots, marrow, onion, pepper, spinach, and tomato. Most of these crops are grown around the homestead in a vegetable garden, as well as in marshlands during season C (dry period). Finally, eight perennials were considered: avocado, banana, coffee, citrus/lemon, Japanese plum, mango, maracuja, pineapple. Most of these crops are cash crops and commercialized on the local market.
- Land management investments considered eight land management practices: agroforestry, basic compost pits (traditional, unroofed), improved compost pits (well-designed and roofed), mulching, ploughing along the contour line, trenches on the contour lines (with or without vegetation on the bunds), and vegetative borders (hedges).
- Crop management investments covered eight crop management practices: kitchen gardens, continuous ridges, planting in triangle form, adequate crop spacing, crop rotations, mixed cropping, row cropping, and relay intercropping.

Sampling and data collection

The sample comprised 40 farmers who started with the IBI in 2017 and 40 farmers who were not involved. Farmers in both groups were randomly selected from VLSAs in the same areas to minimize the heterogeneity of agro-ecological characteristics which could influence farmers' decisions on the four types of agricultural investments as above mentioned. Furthermore, some control variables were taken into account (i.e. gender, age and education of the respondent, and whether or not the respondent runs his/her farm with the PIP approach). Quantitative information was collected through a household survey with a structured questionnaire, which was administered by trained enumerators in May 2019. The farm-level household survey was complemented with focus group discussions (FGD) to interpret and strengthen individual information provided by farmers. In total, four focus group discussions were organized, with in each commune, one FGD for the IBI adopter group and one for the non-adopter group.

Description of variables and empirical analysis framework

By means of a cross-sectional survey with recall estimates, we were able to consider two time periods, i.e. the time before the IBI implementation (T_0=2016) based on recall estimates of the farmer and more recent estimates three years after IBI implementation (T_1=2019). First a simple Difference-in-Difference (DD) test was used to analyse differences between the adopters and non-adopters. The DD model which estimates the average IBI effect was estimated for each agricultural investment under analysis by the following formula based on Shahidur *et al.* (2010):

$$DD = E(Y_1^T - Y_0^T \mid T_1 = 1) - E(Y_1^C - Y_0^C \mid T_1 = 0) \quad (1)$$

Y_t^T and Y_t^C are respectively adopters and non-adopters in time T_1 (=1) denoting the presence of the insurance program, and with T_1 (=0) the time before the IBI started. The superscripts ^{T} and ^{C} represent beneficiary group (treatment) and non-beneficiary group (control).

The univariate regression equation is as follows:

$$Y_j = \beta_0 + \beta_1 insurance_j + E_j \quad (2)$$

Y_i is the dependent variable representing changes in the amount or costs of one of the agricultural investment (i.e fertilizers, crop diversification, land and crop management practices) used by farmer j between 2019 and 2016 and E_j is the error term. Insurance is a dummy variable indicating whether insurance was adopted or not.

Subsequently, by means of multivariate analysis control variables were taken into account in addition to insurance, The equation based on He (2016) becomes as follows:

$$Y_j = \beta_0 + \beta_1 insurance_j + \beta_j X_j + E_j \quad (3)$$

Xj is a vector including farmers' and farm management characteristics (control variables) that can potentially affect input use.

- Gender of the respondent (1= Male, 2= female)
- Age of respondent (number of years)
- Education of respondent 0=illiterate, 1=attended primary school, 2=attended secondary school, 4= attended university)
- PIP approach (1= farmer runs his/her farm with PIP approach, 0 otherwise).

We assume that IBI adoption has a positive effect on agricultural investments above mentioned. The four agricultural investments under analysis were assessed as follow:

- Changes in fertilizer used in this study cover both chemical and organic (either 'purchased' or 'own production') and were rated by farmers with a three point Likert scale (1=used less, 2= no change, 3= used more). The expenditures associated to purchasing fertilizers were derived from the market prices (normally fixed by the government through government's fertilizer subsidy program) and the amount purchased (kg). The amount of fertilizer used in this study refers to seasons A and B in 2019 to minimize errors from farmers who might not remember how many kg was purchased a long time ago.
- Changes in crop diversification investments were obtained by asking farmers for each crop if it was grown in 2016 and 2019, and if they had invested in new seeds/plants. The outcome could therefore be either a score of -1 if the crop was grown at T_0 and no longer at T_1; a score of 0 if no change happened between T_1 and T_0; or a score of 1 if the crop was grown at T_1 whereas it was not at T_0. Then, mean scores were calculated based on these three outcomes

[-1, 0, 1] concerning the changes over the study period (T_0 and T_1).

- Land management investments were analysed by evaluating (i) changes in different measures before (T_0) and after (T_1) the start of the IBI, and (ii) the costs associated to land management implementation. These costs were derived either by multiplying the cost of a daily manpower and the total number of days spent to implement the practice or multiplying the size of the implemented practices by the cost per unit. For the same reasons as with fertilizers, the cost of the land management implementation refers to the year 2019.
- Crop management investments were analyzed by (i) the change in use of a given practice between T_0 and T_1, as well as (ii) the change in knowledge of practices since the start of the IBI (1 = no change, 2 = some increase in knowledge level, 3 = substantial increase in knowledge level).

3. Results

Fertilizer investments

Total fertilizer use changed over time ($p \leqslant 0.05$) between non-adopters and adopters as estimated in the univariate DD analysis. Approximately 26.1% of the adopters used more fertilizers compared to 17.8% of the non-adopters between T_0 and T_1, while 18.1% of the adopters used less fertilizer compared to 34.1% of the non-adopters (Table 1).

Concerning organic fertilizers, the non-adopters did not significantly differ from the adopters, mainly because farmers in the study area predominantly used organic fertilizer produced by owned livestock rather than purchasing it. For chemical fertilizers the results from Table 2 indicates that the adopters were significantly different ($p \leqslant 0.01$) from the non-adopters: BIF 56,370 (US$ 30.84)[1] versus BIF 37,755 (US$ 20.65), i.e. a difference of BIF 18,615 (US$ 10.19).

Crop diversification investments

By comparing adopters and non-adopters at T_0 (Table 3), 67.2% of adopters cultivated all nine annual crops versus 57.2% of the non-adopters. By using the difference-in-difference test for analysing the degree of crop diversification in disaggregated form (annual crops, perennial crops, and vegetable crops) during the two periods (T_1 and T_0), the results of the ''mean investment scores'' indicate that adopters replaced some annual (DD=-0.05) and perennial crops (DD=-0.05) by vegetable crops (DD=0.01). However, changes over time between adopters and non-adopters showed no statistically significant differences (not only at disaggregated form but also as a whole).

Land management investments

Over time, significant differences were found between the adopters and non-adopters in overall land management practices ($p \leqslant 0.01$) meaning that adopters were 8% more likely to apply land management practices than the non-adopters. Of the individual practices the use of vegetation borders and ploughing along counter lines were the most significant ones ($p \leqslant 0.01$) (Table 4).

[1] At the time of writing BIF (Mid-June, 2019): 1 US$ was approximatively equivalent to BIF 1827.929.

However, the results show also that the number of non-adopters applying basic compost pits and contour line without vegetation decreased at T_1 compared to T_0 (the mean investment scores are negatives). This suggests that these two 'basic' practices have been replaced by the more 'modern' ones i.e. basic compost pits were replaced by improved compost pits and contour lines were planted with vegetation.

The cost associated to the implementation of these land management practices was also found statistically significant between both groups ($p \leqslant 0.01$). Adopters invest more in land management (BIF 14,728; US$ 8.05) than non-adopters (BIF 7,434; US$ 4.06), hence a difference of BIF 6,843 (US$ 3.99). These results show that, in general, the implementation of land management practices in the study area requires little investments. This is linked to the average size of the farm (cultivated area) which is small in Burundi (74.3 acres per household) and in the study area (73.5 acres per household) (ISTEEBU, 2015).

Crop management investments

The overall analysis of crop management investments reveals that adopters have doubled ($p < 0.01$) these practices over time (42.6% in T_0 versus 84.5% in T_1), while investments were less profound for non-adopters (Table 5). Findings from the DD test indicate that adopters are 38% more likely to invest in all crop management practices together ($p \leqslant 0.01$). Specifically, adopters are significantly different from non-adopters in the use of crop spacing ($p \leqslant 0.01$), crop rotation ($p \leqslant 0.05$), mixed intercropping ($p \leqslant 0.05$), continuous ridges ($p \leqslant 0.01$), use of triangle ($p \leqslant 0.10$), and row intercropping ($p \leqslant 0.05$).

Crop management knowledge has significantly improved for all practices for the adopters (positive mean knowledge score) based on the results from Table 6. On average, 55% of the adopters recorded substantial changes in knowledge compared to only 6.5% of the non-adopters ($p \leqslant 0.01$). Furthermore, only 27% of adopters stated to have the same knowledge level, while 81% of non-adopters remained on the same level as in 2016.

Links between index-based insurance on agricultural investments

Multivariate linear regression models were used to determine the link between the IBI adoption and considered agricultural investment variables. Tests revealed a good fit of the models as indicated by for example Chi-square coefficient and R^2_{adj} (Table 7). IBI adoption was found to have a positive and significant effect on the fertilizer investments (in amount as well as the cost of fertilizers), on land management (in change of practices as well as the cost associated to the implementation of these practices), and on crop management (in change of practices and knowledge). The findings indicated that adopters used more chemical fertilizers with 36%-point ($p \leqslant 0.01$) and invest 18% more than non-adopters ($p \leqslant 0.01$). In addition, adopters were found to be more likely to change land management practices (12% higher, $p \leqslant 0.01$) and increased their investments by 15% (i.e. BIF 15 for BIF 100 invested) for the implementation of land management practices ($p \leqslant 0.01$). Adopters were more likely to change crop management practices (38% higher, $p \leqslant 0.01$) and their knowledge in crop management practices can be expected to increase by 23% ($p \leqslant 0.01$).

Table 1: Differences in the fertilizers use between adopters and non-adopters in 2019 (T_1) compared to 2016 (T_0)

Category of respondent	Changes Fertilizers (T_1-T_0)	Frequency (%)	Mean score	Std. Dev.	DD
Adopters			1.70**	0.88	0.01**
	Used less	18.1			
	No changes	58.8			
	Used more	26.1			
Non-adopters			1.69**	0.75	
	Used less	34.1			
	No changes	48.1			
	Used more	17.8			

Test T_1-T_0, DD: *p⩽0.05, **p⩽0.01. N=80 (adopters=40, non-adopters=40)

Table 2: Differences in fertilizer investments between adopters and non-adopters in 2019

Fertilizers	Category of respondent	Mean	Std. Dev.	DD
Organic fertilizer: quantity purchased (in kg)	Adopters	2.50	27.38	0.83
	Non-adopters	1.67	18.25	
Organic fertilizer: quantity own production (in kg)	Adopters	1,099	1,594	392.74
	Non-adopters	706.26	1,342	
Organic fertilizer: cost (in BIF)	Adopters	100	1,095	33.33
	Non-adopters	66.67	730.29	
Chemical fertilizer: quantity used (in kg)	Adopters	49.36	52.07	19.71**
	Non-adopters	29.65	39.88	
Chemical fertilizer: costs (in BIF)	Adopters	56,370	55,231	18.62**
	Non-adopters	37,755	50,210	

DD: **p⩽0.01. N=80 (adopters=40, non-adopters=40)

Table 3: Differences in crop diversification between adopters and non-adopters in year 2019 (T_1) and 2016 (T_0)

		Frequency (%)				
Type of crops	Category of respondent	T_0	T_1	Mean investment score	Std. Dev.	DD
Annual crops	Adopters	67.2	63.1	-0.04	0.09	-0.05
	Non-adopters	57.2	58	0.01	0.33	
Perennial crops	Adopters	37.8	35.9	-0.02	0.25	-0.05
	Non-adopters	26.3	26.6	0.03	0.27	
Vegetable crops	Adopters	30.6	33.4	0.03	0.01	0.01
	Non-adopters	20.9	22.5	0.02	0.12	
All types of crops	Adopters	45.2	44.1	-0.01	0.18	-0.02
	Non-adopters	34.8	35.7	0.01	0.12	

N=80 (adopters=40, non-adopters=40)

Furthermore, male-headed households invested 16% and 5% less in fertilizers and in land management respectively (p⩽0.05) than female-headed households. Since Burundian men are not as much involved in field activities as women, they are less receptive to problems related to agriculture and therefore invest less in agriculture. Moreover, highly educated respondents applied more crop diversification (p⩽0.05) than lower educated respondents. Finally, farmers who run their farm with a PIP approach were more likely to increase the amount of fertilizers (p⩽0.05), with the amount of fertilizers used being 22% higher for farmers running their farm with a PIP approach as compared to others who don't have a PIP.

4. Discussion

This study explored the links between IBI adoption and agricultural investments in Burundi by comparing adopters and non-adopters. It was hypothesized that adopters invest more than the non-adopters in fertilizers, crop diversification, land and crop management practices.

The findings indicated that IBI adopters invest much more in chemical fertilizers. However, The IBI adoption did not show any significant difference between adopters and non-adopters in terms of investment in organic fertilizers. This is due to the fact that farmers in the study area predominantly used organic fertilizer produced by owned livestock rather than purchasing it. Other constraint is hampering farmers to invest in organic fertilizers, such as its limited local availability as reported during the FGD meetings.

The effect of IBI adoption on crop diversification is not conclusive to prove that adopters diversify crops (particularly annual and perennial crops) more than non-adopters. Farmers in the FGD meetings (adopters and non-adopters) stated that the reason why they diversify vegetable crops more than annual and perennial crops is due to the fact that vegetable crops mature quickly (from one up to two months) and require less space. In addition, vegetables are more lucrative than annual crops because customers are available all year round regardless of the growing season. Furthermore, some awareness-raising campaigns on the promotion of vegetable crops

Table 4: Differences in land management investments between adopters and non-adopters in year 2019 (T_1) and 2016 (T_0)

		Frequency (%)				
Land management practices	**Category of respondent**	**T_0**	**T_1**	**Mean investment score**	**Std. Dev.**	**DD**
Agroforestry	Adopters	51.7	87.9	0.36*	0.48	0.16*
	Non-adopters	51.9	72.2	0.20*	0.49	
Basic compost pit	Adopters	79.3	84.5	0.05	0.46	0.07
	Non-adopters	67.9	66	-0.02	0.29	
Improved compost pit	Adopters	40.4	78.9	0.38*	0.4	0.18*
	Non-adopters	28.8	46.3	0.20*	0.49	
Contour lines only	Adopters	34.5	38.2	0.04	0.47	0.09
	Non-adopters	27.1	22	-0.05	0.39	
Contour lines + vegetation	Adopters	60.7	94.6	0.34	0.51	0.05
	Non-adopters	17.9	56.1	0.39	0.49	
Mulching	Adopters	26.3	48.3	0.21	0.41	0.11
	Non-adopters	16.9	27.1	0.10	0.3	
Ploughing along contour line	Adopters	50	90	0.40**	0.50	0.34**
	Non-adopters	0	6.3	0.06**	0.25	
Vegetation borders	Adopters	29.6	44.4	0.15**	0.35	0.15**
	Non-adopters	20	20	0.00**	0.00	
All land management practices	Adopters	50.7	68.1	0.17**	0.43	0.08**
	Non-adopters	34.9	44.2	0.09**	0.37	
Cost of land management practices (T_1) (BIF)	Adopters			14,278**	43,800	6,844**
	Non-adopters			7,434**	30,248	

Test T_1-T_0 and DD: *p⩽0.05, **p⩽0.01. N=80 (adopters=40, non-adopters=40)

Table 5: Differences in crop management investments between adopters and non-adopters in year 2019 (T_1) and 2016 (T_0)

		Frequency (%)				
Crop management practices	**Category of respondent**	**T_0**	**T_1**	**Mean investment score**	**Std. Dev.**	**DD**
Crop spacing well-used	Adopters	50	94.7	0.45**	0.50	0.39**
	Non-adopters	21.9	28.1	0.06**	0.25	
Crop rotations well-planned	Adopters	52.5	90	0.38*	0.49	0.25*
	Non-adopters	29	41.9	0.13*	0.34	
Mixed intercropping well-planned	Adopters	31.4	54.3	0.23*	0.43	0.18*
	Non-adopters	14.6	19.5	0.05*	0.22	
Use of kitchen garden	Adopters	89.7	94.9	0.05	0.22	-0.01
	Non-adopters	13.9	19.4	0.06	0.23	
Use of continuous ridges	Adopters	41.5	82.9	0.41*	0.5	0.35**
	Non-adopters	24.2	30.3	0.06*	0.24	
Use of triangle	Adopters	50	82.5	0.33*	0.47	0.18*
	Non-adopters	6.1	21.2	0.15*	0.46	
Row intercropping well-planned	Adopters	33.3	42.4	0.09*	0.29	0.09*
	Non-adopters	4.5	4.5	0.00*	0.00	
Relay intercropping well-planned	Adopters	27.3	33.3	0.06	0.24	0.06
	Non-adopters	2.3	2.3	0.00	0.00	
All crop management practices	Adopters	42.6	84.5	0.42**	0.49	0.38**
	Non-adopters	12.7	17.2	0.04**	0.23	

Test T_1-T_0 and DD: *p⩽0.05, **p⩽0.01. N=80 (adopters=40, non-adopters=40)

were organized for farmers who participated in training courses as part of the PIP approach. The reason that annual crops are less diversified, according to farmers in the FGDs, is that in each cropping season particular annual crops are grown, and variation is therefore more difficult. Overall, the link between the IBI adoption and crop diversification was not clearly proven with these results, and hence, crop diversification is influenced by other factors among others farmer's motivation or preferences, seed availability and agro-ecological conditions. These results are partly consistent to the results from Carter *et al.* (2015) who stated that there are a number of agro-ecological and economic environments in which an index insurance is unlikely to have an impact on the adoption of agricultural technologies, either because risk is intrinsically low or high.

The results also revealed that the adopters invest much more in land management practices than non-adopters. Furthermore, the number of farmers using the basic compost pits and contour lines without vegetation by non-adopters has dropped over the study period and these were replaced by improved compost pits and

Table 6: Differences in crop management knowledge between adopters and non-adopters in year 2019 (T_1) and 2016 (T_0)

Changes in knowledge of crop management	Category of respondent	T_1-T_0	Frequency (%)	Mean knowledge score	DD
	Adopters			2.28**	0.23**
		No changes	27.4		
		Some changes	17.6		
		Big changes	55.0		
	Non-adopters			2.05**	
		No changes	81.5		
		Some changes	12.1		
		Big changes	6.5		

Test T_1-T_0, DD: $p \leqslant 0.01$, N=80 (adopters=40, non-adopters=40)

contour lines with vegetation respectively. This transition from the more basic to the more modern land management practices observed for both adopters and non-adopters can be explained by the fact that improved land management practices were already promoted by the PIP approach before the start of the IBI implementation. This means that a considerable part of the farmers considered in this study (both adopters and non-adopters of the IBI) were already trained in the PIP approach and with the knowledge how to implement good agricultural practices, as well as improve existing ones. The PIP approach is strongly based on farmer-to-farmer learning, and during participatory discussions non-adopters stated that they have strengthened some farming practices due to the good examples demonstrated by adopters within the implementation of land management practices. This ''spill-over effect'', which refers to a process in which people adopt a new product or practice when they come in contact with others who have adopted it (Young-Peyton, 2009; Rogers, 2003), is enforced and accelerated by the IBI implementation and adoption, as IBI adopters even faster recognize the benefits of better land management in terms of yield increase. During the FGD meetings with insured farmers, participants declared that the IBI has increased their commitment in land management because yield losses are lower for those who protected their lands than for those who didn't. Farmers refer to the excessive rainfall in Gitega in the first insured year, where - though all were paid-out the same amount (for the same event) - farmers confirmed that they noticed a net income difference between farmers who had protected their land by contour-lines (trenches) and others who did not. The first received pay-outs and were also able to harvest some of the crop, the latter received only pay-outs.

It was also found from this study that adopters changed crop management practices over time and their knowledge increased more than non-adopters. Farmers in FGD meetings reported that they have acquired some knowledge in land and crop management during the PIP approach introduction, but with the mutual crop insurance approach, their knowledge has improved even more because every time the insured farmers came together, they exchanged experiences and strengthened their knowledge. Farmers from group discussions said that learning through farmer groups (group learnings) allowed learners to better understand the practices as well as the best way to implement them. Furthermore, group learnings stimulated the use of improved farming techniques particularly land management as well as crop management. Group learning sometimes takes more time before getting tangible results for diffusion and adoption of practices. Young-Peyton (2009) said that people adopt once they see enough empirical evidence to convince them that the innovation is worth adopting, where the evidence is generated by the outcomes among prior adopters. In the community, IBI adopters are considered champions since they started and keep running an innovative program that didn't exist before and are convinced and self-confident to continue with it. In the FGD meetings they expressed that they want to demonstrate the difference with the rest of the community in terms of land and crop management. They argued that with these considerations, they want that their farms become like the farmer field schools where other community members will come to learn.

Looking at all investments made by farmers, according to the results from this study there is evidence of a causality effect between IBI adoption and agricultural investments, with adopters investing more in agricultural practices than the non-adopters. However, reverse causality could also be the case, i.e. that farmers who already invest in different farming practices are more willing to adopt the IBI. This can however not be verified with the results from this study. The fact that the early adopters were chosen on the basis of precise and specific criteria (i.e. selective method) could lead to an interpretation bias on reverse causality between the two variables i.e. agricultural investments and IBI adoption. Given the current setting it was not feasible to conduct a randomised control trial to estimate the impact more robustly.

5. Conclusion

Using cross-sectionally data from a household survey, this study analysed the links between index-based insurance (IBI) and agricultural investments in Burundi. By analysing the findings, three main lessons were learnt.

Firstly, IBI adoption increases investments in chemical fertilizers, as well as in land and crop management practices. Therefore, if well organized, the IBI could be a good tool to stimulate agricultural investments as it helps farmers to mitigate the adverse effects of weather risks.

Secondly, during the IBI implementation, the IBI non-adopters also invested substantially in farming practices, which is the result of the PIP approach being there before and the spill-over effect which is a result of the peer learning method that has enabled farmers to improve these farming practices. The PIP approach builds the foundation for sustainable change, with farmers becoming

Table 7: Results of multiple regressions analysis between adopters and non-adopters in year 2019 (T_1) and 2016 (T_0)

	Chemical fertilizer		Crop diversification	Land management		Crop management	
	Quantity (%)	Cost (%)	Change in use T_1-T_0 (%)	Change in use T_1-T_0(%)	Cost (%)	Change in use T_1-T_0(%)	Change in Knowledge (%)
Constant	1.02	1.11	-5.35	-4.50	2.35	0.01	1.25
Insurance adoption	0.36** (0.02)	0.18** (0.140)	0.02 (0.01)	0.12** (0.04)	0.15** (0.04)	0.38** (0.04)	0.23**(0.56)
Gender of the respondent	-0.08 (0.28)	-0.16* (8009)	-0.02 (0.01)	-0.02 (0.38)	-0.05* (0.03)	-0.04 (0.03)	-0.03(0.06)
Age of the respondent	0.05 (9.01)	-0.10 (0.24)	-0.01 0.01	-0.04 (0.01)	-0.04 (0.01)	0.32 (0.02)	0.27(0.08)
Education level of the respondent	-0.01 (0.80)	0.10 (0.35)	0.05* (0.01)	0.09 (0.03)	-0.003 (0.01)	-0.06 (0.02)	0.13(0.05)
Having a working PIP	0.22* (0.63)	0.13 (0.22)	-0.05 (0.01)	0.06 (0.02)	0.01 (0.02)	-0.032 (0.05)	0.86**(0.06)
R^2_{adj}	0.719	0.72	0.01	0.09	0.02	0.6	0.39
Prob > Chi^2	0.00	0.00	0.18	0.01	0.00	0.03	0.00
Log likelihood	-101.84	51.16	0.15	40.30.	57.41	12.10	69.02
Wald chi2 (8)	15.77	4.72	1.50	2.99	5.04	8.86	9.84

*$p \leq 0.05$, **$p \leq 0.01$. N=80 (adopters=40, non-adopters=40). *The first row of each variable is made up of coefficients and the second row with numbers in brackets represents the standard errors*

curious and willing to learn from others, because they are more aware and want to improve their investments. Once well organized and all having implemented a PIP, the peer learning method would be a key factor in the diffusion of innovation in the community; this should be promoted, because teachers and learners are familiar with each other and the knowledge transmission becomes easier and more cost-effective.

Thirdly, although IBI is a tool with a high potential to stimulate agricultural investments, the adoption of IBI has not had significant effects on certain farming practices such as crop diversification and the use of organic fertilizers. These practices require either more substantial investments (for crop diversification) or the limited local availability (as is the case of organic fertilizers). Therefore, the IBI has its limitations and does not necessarily result in an overall improvement and progress towards more sustainable agriculture. Hence, next to an IBI, additional activities are needed to further and more quickly transform Burundian agricultural towards sustainability.

In that respect, in this paper we have seen that scaling-up the PIP approach is a promising option, as it enhances farm inputs availability and encourages farmers to invest more in land and crop management, including crop diversification. This requires action from the Burundi government and other partners involved in land and crop management, and supporting IBI adoption by farmers can play an important role in agricultural development.

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Going Organic: Empirical Study on Awareness of Organic and Aquaponically Grown Vegetables

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ABSTRACT

In a world of constantly changing dynamics of lifestyle and health-culture, it has become necessary for individuals to constantly keep a check on their diet and its contents. Increasing levels of pollution and stress negatively affects both, the health and longevity of an individual. Owing to a decline in average health, more and more people today have started looking for alternatives that could make their diet cleaner and healthier. One such alternative identified is organic produce, which is 100% chemical free, and therefore healthier than conventionally produced food products. However, organic produce is highly expensive, making it less attractive to the masses. Aquaponics, is one such technique of producing organic vegetables in a sustainable manner, thereby reducing its cost. This paper aims to understand the awareness levels of Aquaponics as a technique of organic agriculture. The study performs various tests in order to understand the levels of awareness of Aquaponically grown organic produce within the country. The findings of the study prove that factors such as the prices of organic vegetables, their availability and brand recognition play a major role in influencing the purchase decision made by consumers. On the other hand, factors such as education levels of the consumers or their income levels do not have a major impact on their purchase patterns of organic vegetables. Further analysis revealed that greater awareness about Aquaponics in general, and increased production of organic vegetables through Aquaponics also has a positive impact on the purchase of such vegetables.

KEYWORDS: aquaponics; organic; awareness; proximity; purchase pattern

Introduction

Agriculture in India has survived for centuries; it has stood the test of time and thrived well even in extreme circumstances. It has undergone various changes to keep up with the fast pace of technology, opportunity and sustainability. For thousands of years, agriculture in India was practiced without the use of any chemicals. The advent of technology helped increase produce on a massive scale with the help of fertilizers and pesticides*(Government of Punjab – Human Development Report, 2004; Section – ''The Green Revolution'')*. This produce, although helped India become self-sufficient, stripped our lands of the essential nutrients required for plant growth, thereby demanding greater quantities of chemical fertilizers and pesticides. India today, ranks at 76 of 113 major countries in the world in terms of Food Security *(Food Security Index, 2018)*.

The agricultural sector of India is the single largest employer in the country, accounting for about 50% of the total working population of our nation, as of 2018*(Madhusudan L)*.This sector contributes to about 18% to the country's GDP, with an ever growing rate of production *(Department of Economics and Statistics)*. Agriculture and allied activities have witnessed major changes in terms of the White Revolution, the Green Revolution, the Blue Revolution and the Yellow Revolution, as an effort to promote growth in the various sectors of Agriculture in the country *(Indian Government)*.However, due to the depleting qualities of soil and increasing levels of chemical in food produce, farmers wish to shift back to primitive methods of food production that are chemical-free *(Indian Government – Department of Agriculture)*, and such chemical free produce is called 'organic' produce. The state of Kerala *(The Hindu, 2016)*, and Sikkim *(The Hindu, 2012)*, were the first in the country, to shift to being 100% Organic in their agricultural techniques. Although Organic Food products have started making an appearance in the Indian Market, the underlying question is 'How much of the market is

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aware of the presence, health and environmental benefits of Organic Products?'

Various articles presented in different forums state that the Indian Population is highly unaware of Organic Food Products. As much as we are aware of the existence of organic products, most Indians only know about the fact that organically grown plants are healthier. People are not aware of the factors that make such produce more fit for consumption and neither do they know the reasons behind the high prices of such produce. Organically grown produce is better for both, the land and the people who consume such produce. It is economically sustainable and helps in nurturing the soil on which such produce is grown. Organically grown produce provides both, food quality and safety *(Suryatapa, Annalakshmi, Tapan Kumar; 2020)*. Presently, Indian farmers have been hesitant towards organic farming due to reasons involving its high costs. Soil that has been fertilized using chemicals for decades takes time to heal and provide similar quality of output when fertilized using organic products, the costs of organic seeds is higher and the absence of supportive policies towards the same is a major setback.

The Indian economy accounts for 20% of the entire population in the world; however, it represents less than 1% of the world's total Organic Consumption *(Pankaj Agarwal, 2018)* despite having a large Organic Farmland. An independent study carried out in the Trichy district of Tamil Nadu concludes that about 76% of the respondents have prior knowledge about Organic Products and about 63% of them purchase Organic Food Products on a regular basis *(Rock Britto, Puhalenthi, Gayathri; 2017)*. On the other hand, a research carried out on such awareness in the city of Coimbatore, Tamil Nadu states that only 14% of a population of 550 respondents surveyed have high levels of knowledge about Organic Products *(M. Jayanthi, 2015)*. As according to N Balasubramanian, CEO of 24 Organic Mantra, the market for such produce is expected to increase at a rate of about 25% as more and more people become aware about the necessity of lifestyle changes. He believes that people would be willing to pay a premium of up to 40-50% for such products in the near future *(SayantanBera, May 2018)*.

The technique of aquaponics allows farmers to grow vegetables year-around using comparatively lesser quantities of both land-space and water. This technique of farming is highly energy efficient and makes it possible to grow a variety of crops in regions where conventional farming would not be a possibility *(2017)*. Furthermore, the system produces its own nutrient-rich fertilizer from the excreta of the fish and also requires substantially less labor, making it more efficient *(2018)*. The system and produce are both environmentally sustainable, and helps consumers improve their overall health. The produce does not use any chemicals in the form of fertilizers or pesticides and also enables agriculturalists to produce more quantity than that produced in conventional farming *(David, Jillian, Laura; 2014)*.

Literature Review

Owing to the changes in lifestyle patterns, Organic consumption is becoming increasingly popular within the country. More and more consumers are shifting to chemical-free products, not only for direct consumption, but also for indirect consumption in the form of beauty products, textile and food-garnishing. Organic farming in India has been encouraged by the government through various schemes, due to which large amounts of land have been dedicated to organic cultivation *(EY – The Indian Organic Market)*. India currently has about 3.56 million hectares of land under organic cultivation, making the land area under cultivation, the ninth largest in the world *(FIBL & IFOAM, Year Book 2018)*. In the year 2017-18, India produced about 1.7 million metric tons of certified organic produce; India thus ranks first in the number of organic producers in the world *(Agricultural and Processed Food Products Export Development Authority)*. At the same time, consumption in the country has improved in the past five years due to various factors such as the fast paced growth in the e-commerce sector and the low-cost availability of internet services, coupled with higher literacy rates and awareness *(RishabhChokhani, CEO Naturevibe Botanicals, 2018)*.

With an increase in disposable income, consumers have started shifting to healthier options in order to improve their health and lifestyle *(Justin Paul, Consumer Behaviour and Purchase intention for organic food)*. The Indian Organic Consumer Market is currently estimated at INR40,000 million and is expected to experience an increase of up to INR100,000 to 120,000 million by 2020, with a similar growth in the export sector *(Dilip Kumar Jha, Business Standard 2017)*. One reason for the upward trend in the organic sector in terms of production is the profit margin of up to 40% as compared to conventionally produced food products *(Arpita Mukherjee, Promoting Organic Food Products and Exports, 2017)* that encourages producers and suppliers to enter this sector.

It has been identified that most farmers in the country shift to organic cultivation majorly due to the premium prices, and the additional health benefits available with the same. On the other hand, lack of knowledge and awareness and institutional support are discovered to be the barriers to organic cultivation *(Panneerselvam, Niels Halberg; 2011)*. Consumers of organic produce state that the various factors that affect their purchases to be the reputation of the retailer, the utility of organic produce, and availability of certification related information *(SomnathChakrabarti, Factors Affecting Organic Purchase in India)*. Most consumers understand the benefits of organic produce in terms of lower concentrations of pesticides required for production as compared to traditionally produced crops *(Marcin Baranski, Effects of Organic Food Consumption on Human Health, 2017)*, which in turn reduces the health risk of organic produce *(Only Organic, Organic News; 2014)*. What few consumers realise is the benefit of organic production on the environment in terms of improvement in soil quality, conservation of water and biodiversity and an improved carbon footprint that significantly reduces green gases *(Food and Agriculture Organization of the United Nation)*. Given these understandings among the community of consumers, the Organic packaged foods and beverages market has been emerging in the country with a market of INR533 million in the year 2016, growing at a rate of 17% per year *(Seetharaman, 2017)*. India has also been

increasingly exporting organic products to other countries worth about US $299 million (2015-16), majorly to the United States, Canada, Europe and New Zealand *(Agricultural and Processed Food Products Export Development Authority)*.

Organic cultivation has for the past few years been encouraged in the country. Various individuals and organizations have taken up the responsibility of educating farmers of all age-groups on the benefits and techniques involved in organic agriculture *(Surabhi, Rachel; 2012)*. Studies suggest that organic agriculture is economically sustainable as it allows for greater reliance on human and natural resources. It ensures growth of plants in areas of lesser rainfall and insufficient soil fertility. It also ensures better health of consumers and is hence accepted by consumers more easily *(Prabha, Mohan; 2005*).

Aquaponics is a system of agriculture that thrives on a symbiotic system between fish and plants using aerobic mineralization to convert fish excreta into plant absorbable nitrates *(Waterfarmers Aquaponics)*.Aquaponics is a sustainable system integrating the processes of aquaculture and hydroponics in order to produce fruits and vegetables for consumption *(Maria Jose Palma, Urban Forestry and Greening, Vol 20, 2016)*. It reuses water and nutrients for cultivation making it a very promising alternative to traditional agriculture *(Shafeena T, 2016)*. As a system, Aquaponics uses 90% less water and also has a significantly lower carbon footprint *(Waterfarmers Aquaponics),* and is also scalable since it can be set up almost in every land type and terrain*(The Aquaponic Source)*.There are various techniques that can be followed for Aquaponic production; including Deep Water Culture, Nutrient Film Technique, Media Beds and Vertical Aquaponics; each of which enable the cultivation of different varieties of fruits and vegetables *(The Aquaponic Source)*. Various initiatives of Aquaponics have been identified across the globe in various terrains, land types and weather conditions, thus providing evidence to its versatility, and scalability. Systems have been set up in both, domestic and commercial spaces thereby making it a flexible operating system *(Relevance of Aquaponics in New Zealand, John Hambrey, 2013)*. Aquaponics, all in all is both energy efficient, and water efficient; it allows production all through the year and promotes the cultivation of diverse crops making the system efficient on its own.

Aquaponics has been identified as a sustainable technique of cultivation (*SimonGoddek, Challenges of sustainable and commercial Aquaponics, 2015)* with reference to the definition as given by *Lehman and Francis* who respectively state that sustainable forms of agriculture are those that do not deplete any natural, non-renewable resources that prove to be essential and of material nature in order to sustain agriculture and its processes; and those systems of production that can be designed such that they provide a closure to nutrient cycles. Aquaponics, as a system of agriculture allows for the reuse of various resources such as soil and water, thereby saving humungous amounts of both; it uses about $1/8^{th}$ of land and $1/10^{th}$ of water that would be required in traditional cultivation *(Farming for the Future – Aquaponics in India)*. The technique of recirculating water in Aquaponics, allows for water reuse of about 95-99%, eliminating only the amount that gets evaporated (*SimonGoddek, Challenges of sustainable and commercial Aquaponics, 2015)*. Aquaponics, therefore is highly sustainable and is a lucrative technique of food production.

Aquaponic systems, along with saving water and soil, enable the harvest of a larger number of crops with greater harvest cycles throughout the year, thereby increasing production manifold as compared to traditional farming. Aquaponic cultivation requires one acre of farmland for six acres required in traditional farming *(Jackson McLeod, Dresden)*. Aquaponics is a highly futuristic farming technique that contributes to regional and national self-sufficiency, ensures greater sustainability through 0% emissions, 100% water conservation, 0% residue and 100% chemical-free produce *(GiriDayakar-Jagmohan, 2017)*.

In order to understand better, the trend in the Organic Market, and to establish a pattern in the Aquaponics sector, the researchers have conducted a study on the awareness of Organic Products in order to answer the following questions:

1. What is the level of awareness of Organic Products among the Indian citizens?
   It is evident from previous literature that Indian consumers have minimal knowledge about organic products and the reason why they are better than those grown conventionally. Therefore, it becomes necessary to understand the degree of awareness about the availability of such consumables in the market and the willingness of consumers to accept such produce for their daily consumption needs. The level of awareness and the depth of knowledge possessed by Indian consumers will raise further questions with regards to what aspects of organic produce they are aware about and whether they would want to expand their knowledge on this subject. Furthermore, it is essential to identify key factors that the consumers are unaware of but are of material importance in making their purchase more valuable. Therefore, this question is a window to the perception of the consumers of India.
2. What are the various factors that affect the purchase of organic products?
   Among consumers of daily grocery, it is essential to understand the various factors that have an impact on their purchase decision. Key factors such as price of the produce, its quality, availability and brand value play an important role in altering the mindset of the consumer and hence need to be understood. Most consumers today refrain from purchasing organic products because they feel that such products are highly priced but hold similar nutritional value. This is also a major reason as to why farmers hesitate form producing organic vegetables; they incur higher costs of production, but consumers are unwilling to purchase at such high prices. Therefore, it is necessary to understand the various factors that impact the purchase of organic products.
3. How strong is the influence of these factors on the purchase of Organic products in the country?
   Once the factors affecting purchase decision have been identified, it is necessary to rate them in an order to understand the degree to which each factor impacts purchase decision. This enables us to formulate strategies in order to control the impact of

each factor and to educate the consumers about them. The degree of impact also allows us to study the nature of these factors and the psychological impact of each of them, thereby enabling a deeper understanding of why and how each factor influences the purchase decision of a potential consumer.

4. What is the level of awareness of Aquaponics in India?
   Aquaponics being a relatively new technique of agriculture is not very widely known in our country. This is why it is difficult to market aquaponically grown produce as the concept hasn't yet reached the masses. This study focuses on understanding the degree of awareness of aquaponically grown produce or the technique of aquaponics. This data will help establish alternate methods of marketing so as to educate the consumers and to bring the product into the market.
5. Is Aquaponics a feasible and scalable technique of cultivation for the future?
   Finally, it is essential to understand whether a technologically advanced method of farming that requires heavy setting up expenses would be feasible and scalable for the future. Being environmentally sustainable, it is evident that such a method of farming would allow the country to make progress and would also provide sustainable income to the farming community. However, the setting up expenses may refrain farmers from using this technique for production. This dilemma is one that needs to be solved one step at a time. Therefore, this research shall provide the base for further study in this field – a study that might help analyze how feasible modern agriculture would be for a country like ours.
   This research aims to understand the extent to which Indian consumers have knowledge on organic produce. This paper strives to determine the various factors that influence the purchase decisions of consumers. Hence, the hypotheses must revolve around such possible factors that may alter the decisions of consumers. These may include income of the consumer, price of produce, quality of produce, and brand value in the minds of consumers.

Hypotheses Development

A theoretical framework has been developed in order to assess the role of factors influencing the demand of organic vegetables in the market, and more specifically, the demand of Aquaponically produced vegetables in the Indian market. The various factors influencing the demand are divided into demographic, knowledge-related and financial factors. These factors are further divided into the following:

- Demographic factors are divided into age levels of consumers, availability of organic products and perceived reliability of the produce,
- Knowledge related factors are divided into education levels of consumers, and methods to spread awareness about the produce
- Financial factors include costs of the produce and income levels of consumers.

The theoretical framework of this study has been derived through a thorough analysis of the literature review. A study of the various factors affecting the purchase of organic vegetables and the factors contributing to the spread of awareness about Aquaponics as a technique of production, have led to the development of the following hypotheses.

H1: Availability has a positive impact on the purchase of organic vegetables.

Availability of organic produce refers to the proximity between the place of sales and the consumer. It has been identified that ease in availability of organic vegetables has made people comparatively more attracted to trying out the product rather than when it is not conveniently available. Therefore, it is reasonable to believe that a vendor selling organic vegetables closer to residential areas would record more sales than one who does not. Such proximity to the store would induce in people, the drive to experiment on a product that claims to be better than its traditionally produced counterparts, thereby positively influencing purchases.

H2: Reliability on selling brand has a positive influence on the purchase of organic vegetables.

Brand recognition often plays a vital role in creating and/or altering the perception of potential consumers about a particular product. The more recognized and popular a brand is, the higher is likely to be the trust of consumers on its products. Consumers tend to incline their preferences towards more popular brands as they are aware of their reach and also believe that a greater reach can be achieved only through greater reliability. Thus, it can be stated that brand recognition depends heavily on the reliability quotient of the brand; and such reliability, renders a positive influence on the purchase of organic vegetables.

H3: Education levels of consumers have a positive impact on purchase of organic vegetables.

Education in the broader sense refers to the degree of awareness and knowledge possessed by potential consumers. Higher levels of education, drives humans to gather greater information through research and analysis in order to understand and discover better and more efficient ways of living. It has been studied and proved by many, that higher levels of awareness motivate people to accept new ideas, products and technology. Furthermore, such acceptance leads to purchase and true utilization of new products and technology.

H4: Income levels of the consumer have a positive effect on the purchase of organic vegetables.

The earning capacity of an individual often determines his lifestyle. The greater the earnings, the higher is the standard of living, the motivation to care about one's health and longevity, and the more expensive are the means to achieve good health. It has been repeatedly observed that the rich, more often than the poor are motivated enough to pay a premium on the purchase of such a basic necessity as food. Therefore, it would be reasonable to believe that the upper middle class and the rich are the consumers of organic vegetables in

the narrow sense and organic products in the wider perception.

H5: Prices of the products positively influence the purchase of organic vegetables.

The selling price of a commodity is what truly defines the buyer it attracts – prices of materials have more often than not, played a decisive role in the purchase of any commodity. The higher the price of a commodity, the lesser its demand; is true, in most of all cases, indicating why organic products currently have only a few buyers. The entire study on consumer behaviour emphasizes on one common trait of a majority of buyers; to look out for the least expensive product with the highest quality. This, in light of other evidences effectively indicates a relation between price of a commodity and purchase behaviour of consumers.

H6: Aquaponic production will positively impact purchase of organic vegetables.

Aquaponics as a technique of production is expected to increase the volume of production and at the same time, to reduce costs. This theory has been validated in the various existing Aquaponic farms across the globe. Aquaponics does reduce expenses of production, which in turn would have a direct impact on the selling price of these products. As the prices of Aquaponically grown organic vegetables begins to fall below that of traditionally produced organic vegetables, more and more people get attracted to it therefore increasing purchases. Thus, it is reasonable to believe that increase in production of organic products using the technique of Aquaponics will have a positive impact on the purchase of final organic vegetables.

Table 1: Age of respondents

Age	No. of Respondents
15-30	140
30-45	72
45-60	36

H7: Awareness about Aquaponics will positively impact purchase patterns of individuals.

Increasing awareness among citizen about the various products available in the market enables consumers to make better judgements regarding the same, thereby ensuring quality in decision making. Education and awareness about products available in the market, helps create a better understanding about the same, and thus impacts the decisions related to purchase. A positive opinion about products creates in the minds of consumers, the urge to experiment with a purchase.

Methodology

The present study is descriptive in nature. Convenience sampling was used to contact the sample respondents with the intent of generating more responses. An online questionnaire was forwarded to potential respondents along with a reminder in order to ensure speedy response. A response rate of 62% has been recorded with 248 out of 400 responses.

The questionnaire was divided into three sections: Section A consisted of closed-ended questions relating to demographic variables, Section B included the questions on awareness and purchase of organic products, while Section C had questions on awareness of aquaponically grown vegetables. Both the sections B and C used 5-Point Likert scale (1-Strongly Disagree, 5 – Strongly Agree) for developing options for the statements.

Results and Discussion

The participants of the study belong to different parts of the country thereby ensuring a variety of responses that are not restricted to limited boundaries. The study sample has been represented in Table 1. A majority of the respondents as recorded belong to the age group of 15 to 20 years accounting for the informed population of our country.

Among the 248 respondents, it has been observed that 48% were males and 54% of the respondents have

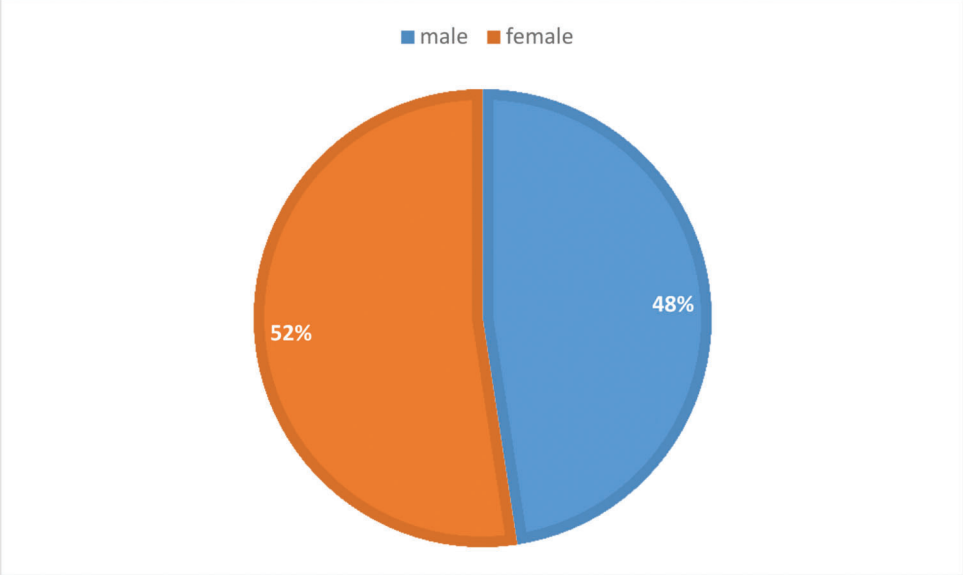

Figure 1: Gender count of respondents

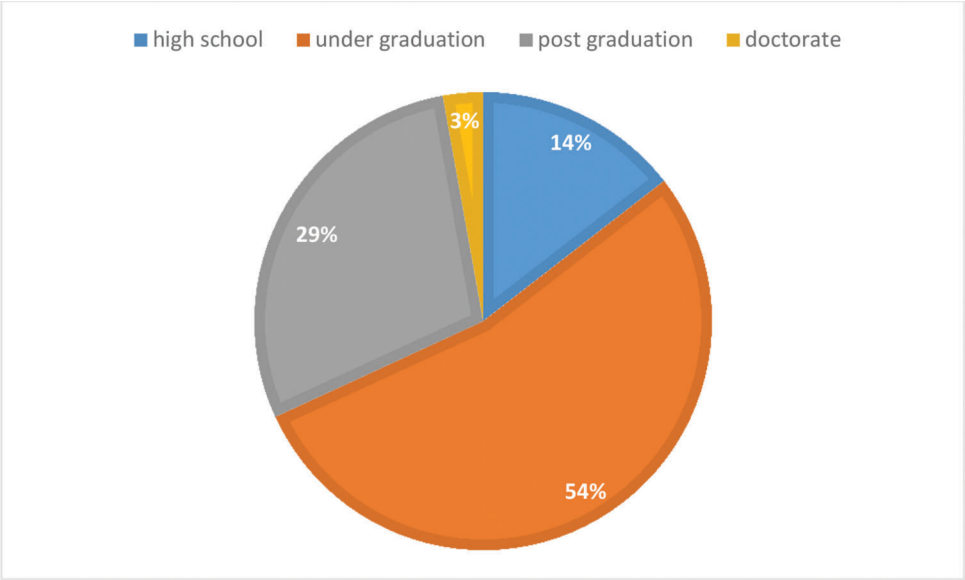

Figure 2: Educational qualification of respondents

Table 2: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.486[a]	.237	.214	.855

a. Predictors: (Constant), Awareness, Pricing, Availability, Educational Qualification, Brand Recognition, Monthly Income, Aquaponic Production

acquired at least an under-graduation certificate. 95.6% of our respondents have some knowledge about organic products thereby ensuring authenticity of responses.

The questionnaire used for the study was drafted post an extensive analysis of the existing and past market conditions for organic products. Variables have been assigned such that conclusions can be drawn with an ease of understanding. Questions regarding the wide organic market and the specific technique of Aquaponics were included in order to provide a better understanding to our respondents and to ensure real responses.

The questionnaire was drafted post consultation and was corrected for any sensitive and redundant information. It was then circulated through email and other online platforms. The responses have been discussed in order to understand its quality.

Testing of Hypotheses

Multiple regression model was employed for testing the hypotheses stated above. The relationship between multiple independent variables (predictor variables) and one dependent variable (criterion variable) is best explained by the multiple regression model. In our study, an attempt is made to explain the relationship between the purchase of organic products (Dependent Variable) and the predictor variables availability (Proximity), Brand Recognition, Education levels, Income levels, Prices of products, Aquaponic production and Awareness about the products. The model is arrived at using SPSS Version 21 Software.

Table 2 indicates how well a regression model fits the data. A value of 0.486 in the R column indicates a good level of prediction. The R square column represents the proportion of variance in the purchase of organic products (dependent variable) that can be explained by the independent variables availability (Proximity), Brand Recognition, Education levels, Income levels, Prices of products, Aquaponic production and Awareness about the products. We can see from our value 0.237 that our independent variables explain 23.7% of the variability of our dependent variable.

The F-ratio in the ANOVA table 3 tests shows that the overall regression model is a good fit. The independent variables availability (Proximity), Brand Recognition, Education levels, Income levels, Prices of products, Aquaponic production and Awareness about the products statistically significantly predict the dependent variable purchase of organic products with the values $F(7,240) = 10.621$, $p < 0.05$.

The general form of the equation to predict 'Purchase of organic products' from 'availability(Proximity)', 'Brand Recognition', 'Education levels', 'Income levels', 'Prices of products', 'Aquaponic production' and 'Awareness about the products', is:

Predicted 'Purchase of organic products' = 3.003 + (0.150 x availability) + (0.349 x Brand Recognition) – (0.039 x Education levels) + (0.021 x Income levels) + (0.122 x Prices of products) – (0.012 x Aquaponic production) – (0.252 x Awareness about the products)

This is obtained from the Coefficients table 4 as shown below. However, from the table 4 it is found that educational qualification and monthly income are not statistically significant predictors of the Organic Products Purchase.

Cohen et al., 2003; Pedhazur, 1997; Pedhazur & Schmelkin, 1991 have argued on the possibility of comparing the beta coefficients of the predictors with each other. According to them, it is possible to say that predictors with larger beta weights contribute more to the prediction of the dependent variable than those with smaller weights, based on the visual examination of the equation.

Table 5 indicates the results of hypothesis testing:

Table 3: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	54.351	7	7.764	10.621	.000[b]
	Residual	175.451	240	0.731		
	Total	229.802	247			

a. Dependent Variable: Purchase of Organic Prdts
b. Predictors: (Constant), Awareness, Pricing, Availability, Educational Qualification, Brand Recognition, Monthly Income, Aquaponic Production

Table 4: Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	3.003	.404		7.440	.000
	Availability	.150	.075	.115	1.994	.047
	Brand Recognition	.349	.063	.334	5.585	.000
	Educational Qualification	-.039	.088	-.029	-.446	.656
	Monthly Income	.021	.041	.035	.525	.600
	Pricing	.122	.061	.113	1.987	.048
	Aquaponic Production	-.12	.083	-.010	-.149	.008
	Awareness	-.252	.084	-.218	-2.984	.003

a. Dependent Variable: Purchase of Organic Products

Table 5: List of hypotheses

Hypothesis	Sig. value	Status
Hypothesis 1: *Availability has a positive impact on the purchase of organic vegetables*	.047	Accepted
Hypothesis 2: *Reliability on selling brand has a positive influence on the purchase of organic vegetables.*	.000	Accepted
Hypothesis 3: *Education levels of consumers have a positive impact on purchase of organic vegetables.*	.656	Rejected
Hypothesis 4: *Income levels of the consumer have a positive effect on the purchase of organic vegetables*	.600	Rejected
Hypothesis 5: *Prices of the products positively influence the purchase of organic vegetables*	.048	Accepted
Hypothesis 6: *Aquaponic production will positively impact purchase of organic vegetables.*	.008	Accepted
Hypothesis 7: *Awareness about aquaponics will positively impact purchase patterns of individuals.*	.003	Accepted

This study was aimed at understanding the behaviour of consumers towards organic vegetables as compared to the more economically priced traditionally cultivated vegetables. This study is of value to producers and retailers who can develop a better understanding of consumer psychology towards organic vegetables.

The analysis states a positive relationship between availability of organic vegetables and purchase patterns of consumers, thereby stating the importance of proximity from the consumer's place of residence on their purchase preferences. Most consumers believe that a relatively expensive purchase is worth the money only if the product is easily available. Availability has a strong positive impact on the purchase of organic vegetables.

Similarly, the price of such vegetables also has a major impact on purchase decisions. Highly priced organic products are purchased occasionally as compared to the more economically priced traditionally produced vegetables. Brand recognition also indicates a direct relationship with the motivation to purchase among consumers. A recognized brand name provides consumers with security and allows them to regard the payment of a premium as fruitful and worthy. The study provides ample evidence of the influence reliability has on the purchase pattern of consumers.

On the other hand, the study denies a positive influence of income levels upon the purchase of organic vegetables. Most consumers have stated that income levels of the family do not restrict them from purchasing organic vegetables, although such purchases might not be on a regular basis but may happen occasionally. The study also states that education levels do not pose as a barrier to the purchase of quality edibles. Such purchase does not require a consumer to acquire formal education.

Implications of the Study

This study contributes significantly to the existing body of literature on the production and marketing of organic vegetables while shedding significant light on a relatively new technique of organic production called Aquaponics. This study fosters an understanding of the emerging demand for organic edibles and also analyses the various factors that influence the purchase patterns of such products. In this context, the study offers meaningful insights to producers and retailers of organic vegetables as it allows them to understand the intricacies of

consumer behaviour when it comes to the purchase of organic vegetables that are generally priced at about 20% higher than traditionally grown vegetables. The existence of direct, positive relationships between the availability, reliability and prices of organic vegetables to the purchase of such vegetables indicates the various opportunities available to producers and retailers to maximize sales.

Further, the focus on Aquaponics as a modern method for the production of organic vegetables that can replace traditional methods of cultivation at lower expenses and greater productivity represents a novel value addition to the existing research on organic edibles. Aquaponics, in itself represents a self-sustainable model involving minimum quantities of water, land and absolutely no amounts of chemical pesticides, thereby opening a window of opportunity towards a modern revolution in agriculture. This study indicates a positive influence of greater education and awareness of Aquaponics as a technique of production on the opinions and future purchase decisions of consumers. The study also reveals that employment of Aquaponics for cultivation would open up new avenues for sustainability and would revolutionize the agricultural sector of India. The findings of this study benefit agriculturalists, and retailers by allowing them to understand the behaviour of their target markets and thereby improving sales.

Conclusion and Scope of Further Research

This study was aimed at understanding the behaviour of consumers towards organic vegetables as compared to the more economically priced traditionally cultivated vegetables. This study is of value to producers and retailers who can develop a better understanding of consumer psychology towards organic vegetables.

The analysis states a positive relationship between availability of organic vegetables and purchase patterns of consumers, thereby stating the importance of proximity from the consumer's place of residence on their purchase preferences. Most consumers believe that a relatively expensive purchase is worth the money only if the product is easily available. Availability has a strong positive impact on the purchase of organic vegetables.

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A limitation to this study is the sample size selection from the research population. This study has been conducted with limited participants whose preferences may or may not be representative of all Indian consumers. Furthermore, this study tries to create an understanding of the degree of awareness about organic and aquaponic produce. It does not dive in deeper into the subject, which makes it a strong and potential base for future research on the topic. Further study on the feasibility of introducing tech-based agricultural techniques on a large scale in the country would help understand the potential of the agricultural sector of the country. Moreover, an analysis of the degree of sustainability achieved due to the existing tech-based agricultural setups would help the country make informed decisions in the same field.

This study lays the foundation for research in the field of consumer behaviour towards organically produced vegetables, and provides insights into such behaviour towards the more recently developed technique of organic production, Aquaponics. A further continual research on Aquaponics and its efficiency in the Indian geography can be carried out in order to understand the feasibility of this technique of production in the Indian geographical and climatic conditions, thereby to revolutionize the Indian agricultural sector in order to direct the production activities of the nation towards sustainable methods.

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The Drivers of the Double Cropping System Adoption in the Tropics

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ABSTRACT

The practice of the double-cropping system (DCS), whereby farmers plant two different crops in the same field, in succession, within the same crop year, has been growing in the tropical regions of Brazil for the last 40 years. The DCS, also known as the ''safrinha'' system, has been responsible for an important revolution in cropping production in the tropics, a region historically challenged by low agricultural productivity. The system allows the intensification of land use, raises total production per hectare per year, and improves asset use efficiency, for example machinery, facilities, and human capital. The goal of this paper is to better understand the DCS system for tropical agricultural managers. Specifically, the manuscript achieves that goal by exploring the decision-making by farm managers through direct semi-structured interviews with experienced DCS managers. The direct engagement is unique as it intentionally complements previous more indirect survey-based and econometric methodologies. The setting is Mato Grosso Brazil, the center of DCS farming in the tropics. The findings directly apply to producers in other tropical regions of the world, where some of the poorest countries reside. Policymakers and investors can integrate the findings from this paper to better design farming systems to improve productivity and profitability among small and medium sized farmers operating in the tropics.

KEYWORDS: Brazil; maize; management; Mato Grosso; soybean

1. Introduction

The practice of the double-cropping system (DCS), whereby farmers plant two different crops in the same field, in succession, within the same crop year, has been growing in the tropical regions of Brazil for the last 40 years (Cruz *et al.*, 2019). The wide window of rainfall season and favorable temperature in Mato Grosso, located in Brazil's tropical Center-West region, allows farm managers to lead the nation in DCS application (APROSOJA, 2019). The DCS, also known as the ''safrinha'' system, has been responsible for an important revolution in cropping production in the tropics, a region historically challenged by low agricultural productivity. The system allows the intensification of land use, raises total production per hectare per year, and improves asset use efficiency, for example machinery, facilities, and human capital (Silva, 2012; Goldsmith and Montesdeoca, 2018).

In terms of total grain production in Brazil, Mato Grosso state now leads the nation by producing 28.2% of the soybean and 31.6% of the maize (CONAB, 2019c). The soybean crop, alone, is responsible for the 49.2 % of annual grain production in Brazil (CONAB, 2019b). The DCS system has become an essential feature behind the productivity improvements and rural economic development in Brazil where farmer's incomes are growing at 4.28% per year. Farmer productivity too shows improvement at a compound pound annual growth rate of 3.1% between 2008 and 2018 in terms of grain production per hectare (Brazil, 2018).

As a result, the goal of this paper is to better understand the DCS system for tropical agricultural managers. Specifically, the manuscript achieves that goal by exploring the decision-making by farm managers that operate the DCS in Mato Grosso, Brazil. The DCS, which still is relatively new, has great potential to address the rapidly increasing demand for food as global population and incomes rise. So understanding the managerial features of this new system can support the private sector elevate productivity in other regions of the world. Finally, there are direct applications to producers in other tropical regions of the world, where some of the poorest countries reside. Policymakers and investors can integrate the findings from this paper to better design farming systems to improve productivity and profitability among small and medium sized farmers operating in the tropics.

2. Literature Review

Double cropping or succession cropping is one practice that belongs to a wider group called multi-cropping. Multi-cropping refers to several ways producers can use

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a particular piece of land in a single period of time, usually, a growing season or calendar year. In general, multi-cropping comprises the following main kind of practices: a) double/succession cropping; b) cover cropping; c) integrated crop-livestock systems; d) woodland-based systems (Borchers *et al.*, 2014), and e) intercropping, where two crops occupy simultaneously the same piece of land during part of the life cycle of each (Hexem and Boxley, 1986).

The double/succession term refers to the sequential growing of crops. Farmers plant and harvest a second and or even a third crop within the same calendar year. Conventionally, double or triple cropping involves irrigation, and matching crops in terms of growing period length, agronomic complementarity to optimize yield, and overall profitability. The system in Mato Grosso, strictly speaking involves double cropping without irrigation, which involves much higher levels of uncertainty and risk.

Double cropping is synonymous with intensification of production, which may relieve pressure to develop less productive land for agricultural uses (Phalan *et al.*, 2011). Or others argue incentivizes farmers to expand their production and clear new lands (Cohn *et al.*, 2014). While double cropping presents economies of scope in terms of input and capital use (Goldsmith and Montesdeoca, 2018), intensification can also promote more intensive use of pesticides, herbicides, fertilizers, and water resources, which have negative environmental impacts (Heggenstaller *et al.*, 2008; Borchers *et al.*, 2014). In Mato Grosso, the safrinha two crop system principally involves rain-fed production, rather than irrigation, due to the long rainy season in the region (Shapiro *et al.*, 1992)

Double cropping in Brazil has expanded due to rising global demand for key commodities such as maize, soybean, and cotton, as well as technology improvements in the area of farm equipment and machinery, and advances in agronomy and plant breeding (Hexem and Boxley, 1986; Shapiro *et al.*, 1992). The practice more efficiently uses mechanization and labor, which reduces fixed costs per unit of land and raises overall profitability of the farming enterprise (Goldsmith and Montesdeoca, 2018; Beuerlein, 2019). With advanced managerial practices safrinha maize production now exceeds first crop maize production in Brazil. Mato Grosso not only now leads the nation in maize production, but makes Brazil one of the world's largest maize exporters (Cruz *et al.*, 2019; CONAB, 2019a).

It should be noted that while the dominant DCS involves soybean followed by maize, the second crop can be cotton, sunflower, or sorghum due to changing weather, economic, and managerial conditions, (Silva, 2012). Producers' decisions in any year depend on their expectation of the costs and returns of double-crop production, associated with the realities of variable rain patterns. In general, the double cropping becomes feasible when rains arrive early to successfully establish the first crop, and then sustain long enough to allow the planting and maturation of the second (Hexem and Boxley, 1986).

Double-crop farming presents greater production risks than single cropping because the weather tolerances are narrower when striving to utilize all the rain optimally that the season presents. Greater risks translate into greater pressure on managers to effectively plan for the cropping year, and then execute that plan under changing weather and pest pressures. Drought management for example, becomes central at both ends of the cropping season, as farmers may replant and adjust varietal choice several times when early rains are spotty and plants fail to establish, and then hurrying to get the second crop fully flowered and seed set before the rains cease and the dry season begins. Additionally, the choice of early-maturing varieties, row spacing, and plant population become key decision variables for both crops when managers optimize their double cropping (Hexem and Boxley, 1986; Watt, 2019).

In the context of Mato Grosso, farmers have dramatically expanded double cropping practice over the last 20 years as they successfully adapted their management to the agro-ecological conditions (Goldsmith *et al.*, 2015). The tropical location of Mato Grosso allows the double-cropping soybean-maize system to increase significantly the amount of protein, starch, and oil produced per hectare compared with temperate and subtropical regions (Goldsmith *et al.*, 2011). However, the tight operating window of the soybean-maize succession system also creates important post-harvest loss management considerations for the first crop (soybean) (Goldsmith and Montesdeoca, 2018). Managers optimize grain production and profitability across both crops, which leads to higher post-harvest losses and poor grain quality of the first crop (soybean), as farmers expedite harvest in order to assure sufficient growing time for the second crop ahead of the impending dry season (Goldsmith *et al.*, 2015).

The study presented in this paper provides new insights into this complex decision space for managers in the tropics by leveraging the case study method. A better understanding of the safrinha system becomes particularly important in a rural economic and social development context because agricultural productivity in tropical regions, such as Mato Grosso can be so transformative (Richards *et al.*, 2015; Goldsmith, 2018).

3. Research Data and Method

We employ the case study method to derive a deeper understanding of the planning and decision processes of double crop managers. Case studies allow an understanding of the ''why'' and, or, ''how'' things happen, rather than trying to measure a phenomenon's frequency (Yin, 1998). In this way case studies allow an understanding of phenomena and their context. Case studies utilize both primary and secondary sources, as well as quantitative and qualitative data (Yin, 1998). Even though case studies can involve the gathering and analysis of quantitative data, the approach mainly relies on the analysis of testimony and descriptions of phenomena by actors through the use of content analysis (Butterfield *et al.*, 1996; Burnett and Badzinski, 2000). The benefit of using qualitative research method relates to the flexibility and freedom for an in depth exploration of the phenomenon of interest (Strauss and Corbin, 1990).

Following Yin (1998), we used the above literature review to inform the construction of a semi-structured interview instrument (Appendix 1). We tested the instrument on a subset of farmers. The final interviews took place via telephone in Portuguese (Brazil's official language) by a native speaker with experience in farm management in the tropics. The enumerator recorded each interview with the farmer's permission. The research team initially analyzed each interview for clarity, completeness, and theoretical

saturation to see if a follow up call was necessary (Strauss and Corbin, 1990). The non-probability sampling method was used to choose cropping farmers belonging to a list of all farmers provided by Aprosoja (Brazilian Soybean and Maize Farmers' Association). Diversity across a number of variables guided researchers in terms of their sampling, such as a farmer's age, cropping region inside Mato Grosso, number of years practicing DCS, and cropping area (hectares). The researchers sequentially conducted the interviews, initial analysis, and final analysis individually for each farmer. Doing so incrementally built a body of understanding to a point where additional interviews began to show repetition and added little to the understanding of safrinha management. The team conducted a total of 16 interviews between November 2017 and November 2018 (Table 1).

The interview instrument design sought to provide insights into ten questions related to managerial decision making:

i. What is the essential element that allows you to engage in the DCS?
ii. What would be a second, or next most important element for you when thinking to engage the DCS?
iii. What are additional benefits of engaging in the DCS?
iv. How do planning for the first and second crop differ?
v. What role does the previous cropping season play in planning for the current year?
vi. What challenges are there when selecting your DCS crop combination?
vii. Are there particular challenges to first crop management, specifically soybean, when thinking about the second crop?
viii. Are there particular challenges to second crop management, specifically maize?
ix. Under the DCS system you harvest the first crop in the middle of the rainy season. Are there challenges maintaining grain quality?
x. Describe the unique risks when you adopt the DCS.

The research team transcribed each audio interview file into a text file for analysis using the MaxQDA (2019) software package. The content analysis followed the coding process suggested by Miles & Huberman (1984). In this process, the researcher establishes "codes" based on key-words suggested by the research objectives and literature review. The coding process involves categorizing the text (interview content) into the code structure. The principle behind the coding process is the "pattern-matching" approach, in which the issues related to the research are identified and stored for the analytical stage of the research process.

The 16 interviews produced a total of 1,550 different words ranging in usage from a singular use to 160 times (soybean). The research team employed pattern matching to six categories relevant to the subject matter: weather; crops; safrinha management; economic decision making; general management; and quality. As expected most words (71%) or 4,749, were not relevant and fall outside the six categories of interest. The words of interest comprise 29% or 1,978 text units.

4. Results and Discussion

The research's general focus is to understand the complexities of the decision making setting facing DCS managers, as expressed by the managers themselves (Figure 1). The use of interviews for data gathering is an important strategy to understand the context of a phenomenon, as it provides flexibility through the semi-structured interview format to explore important gaps in the literature. The enumerator follows the unique direction taken during each interview without the constraints of a structured survey, which in turn allows for a clear understanding of the inquiry by the respondent, a thorough elaboration of context, and greater data richness.

It is also important to highlight that in the interviewees' quotations cited in this document, the presence of text between brackets "[ ]" indicates extra information added by the researchers to improve the readers' understanding. The interview quotations were translated from Portuguese into English. As with any translation, nuance, context, and interpretation become essential in order to derive the full meaning of the response. So the

Table 1: List of farmers interviewed in the research and their profiles

Interviewee #	Name	Municipality	Region in MT*	DCS** (Ha)	DCS** Experience (years)	Farmer's Age	Cropping Season
1		Feliz Natal	North	450	17	34	2017-18
2		Diamantino	North	860	8	>35	2017-18
3		Nova Mutum	North	1,350	15	>40	2017-18
4		Alto Taquari	South	1,300	10+	>50	2017-18
5		Rondonópolis	South	1,200	21	>50	2017-18
6		Alto Garças	South	4,000	16	>50	2017-18
7		Canarana	East	80	1	>50	2017-18
8		União do Sul	North	850	20+	>40	2017-18
9		Nova Mutum	North	120	18+	>40	2017-18
10		Canarana	East	1,000	10	48	2018-19
11		Canarana	East	200	11	>50	2018-19
12		Sorriso	North	1,250	13	33	2018-19
13		Alto Taquari	South	1,100	12	54	2018-19
14		Santa Rita do Trivelato	North	120	6+	59	2018-19
15		Jaciara	South	1,300	20	29	2018-19
16		Tapurah	North	1,300	15	48	2018-19

*MT: Mato Grosso State (Brazil); **DCS: Double-cropping System.

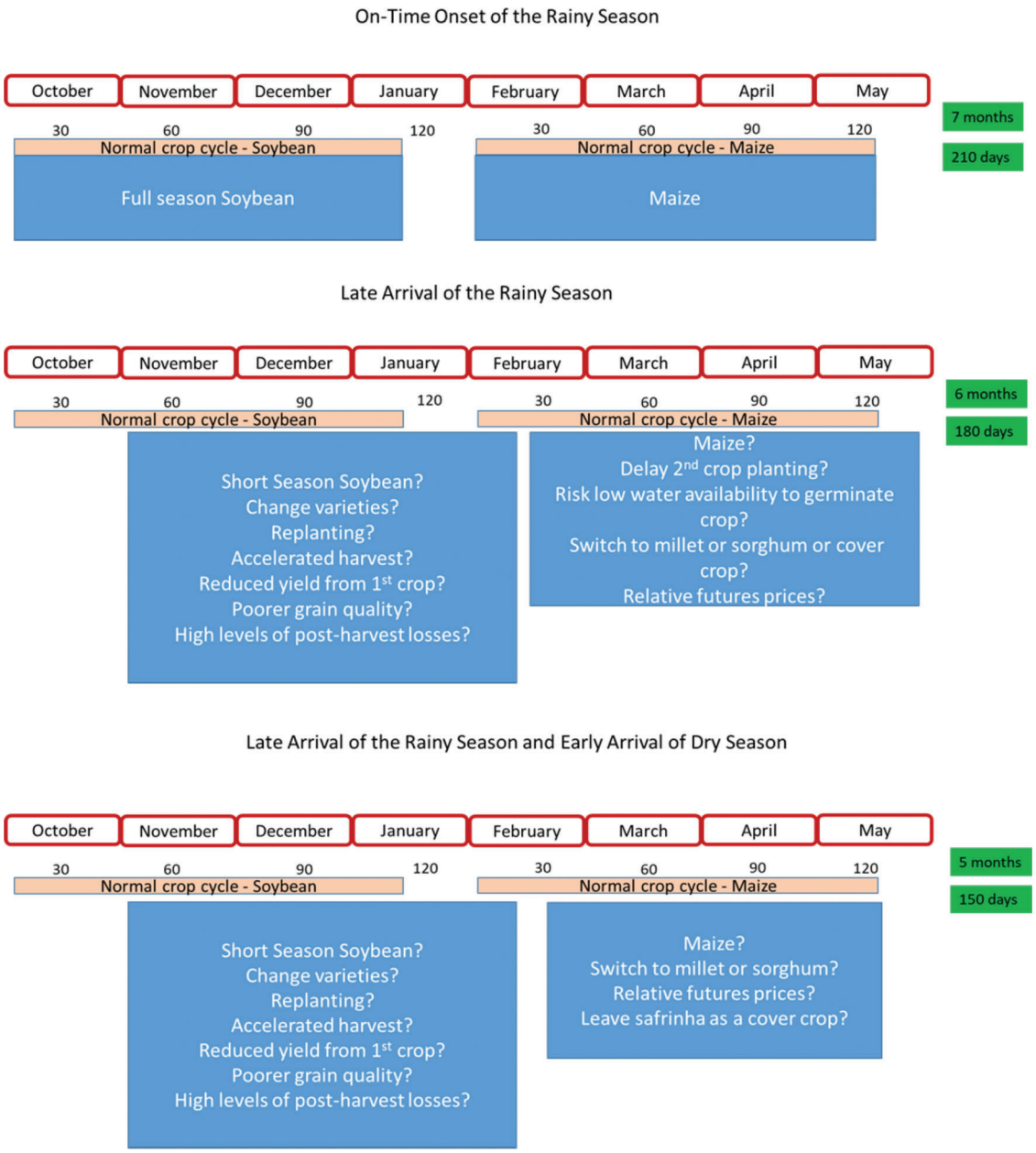

Figure 1: The Complex Decisonmaking Environment Facing DCS Managers

researchers added contextual translation to support respondent's answers.

I. What is the essential element that allows you to engage in the DCS?

> *Basically it's climate only. Because it depends on the soybean harvest to generate the area to plant maize. Sometimes there is a shortage of rain, right? [**Farmer 12**]*
>
> *It's always the weather, right? [We need to consider the weather.] to avoid the risk of planting and losing the crops, then, [the second factor affecting DCS] it is pest management. [**Farmer 10**]*
>
> *The main one is the weather. We depend on the weather. If soybeans are planted early, you can increase the crop area slightly. But if the weather isn't favorable, the rainy season takes a long time to start, and it is delayed; then, the planting window of the "safrinha" is shorter. So, we reduce the area a little. [**Farmer 8**]*

The weather category, fifth out of the six categories in terms of frequency, accounted for 13% or 252 of the 1,978 categorized words. The top three weather related words, totaling 40% of the weather utterances, were not surprisingly, rain, climate, and climatic period (época).

Responses are consistent with previous research (see Shapiro, 1992) that present the long rainy season in certain regions of the tropics as the key enabling condition for the DCS. Soybean maturity ranges from 90-120 days, while time to tasseling in maize is about 75-80 days, thus a 165-200 day rainy season would theoretically allow two full crops. The north central city of Sorriso, Mato Grosso, in the heart of the soybean belt, receives an average total of 1,883 mm of rain per year, with 94% (1,761) occurring in seven months, October – April (Climate-Data.org, 2020).

II. What would be a second, or next most important element for you when thinking to engage the DCS?

*If you cannot do the planting of maize [which would be the preferable crop], we enter with millet to prevent the soil to be uncovered, right? Planting millet, planting sorghum, something like that, right? Because everything you plant will cost. So, I try to establish a crop that has the lowest possible cost, to avoid leaving the soil without anything, right? [**Farmer 9**]*

*I seek to improve the soil. So, if the maize income and expenses are even, if I can put the extra nutrients that the maize needs, avoiding the maize to extract the nutrients already in the soil, and leave a coverage, it's okay for me. [**Farmer 1**]*

The discussion of crop choice, third out the six categories in terms of frequency, occurred 339 times, or 17% of the time during the interviews. The farmers mentioned seven different crops in total, but as expected soybean (47%) and maize (40%) led with 87% of all words spoken within the crops category. The other mentioned crops were, cotton (6%), sorghum (3%), millet (2%), sunflower (1%), and black bean (1%).

Second crop choice becomes the second key element for farmers engaged in the DCS. Second crop brings a key agronomic element, protecting the soils from water erosion, essential when harvesting a first crop mid-rainy season. The thin tropical soils covering the rolling farmland of Mato Grosso present significant erosion risk if exposed post-harvest to an additional 3.5 months of precipitation.

Farmers highlight that the second crop also improves soil organic matter, and breaks pest and weed cycle, and elevates yields of both crops, much like annual maize-soybean rotations in temperate and sub-tropical climates. As a system, the DCS economics and agronomics are interrelated in terms of second crop choice and rainfall timing. While maize is the most profitable and preferred, delays in the beginning of the rainy season and difficulty in first crop establishment then pushes the second crop closer to the dry season window. So crops that can handle dryer conditions or a shorter growing season, like millet and sorghum, become options when rains are slow to come during first crop establishment.

III. What are additional benefits of engaging in the DCS?

*[My first objective regarding DCS] is increasing the income, right? And you also end up with more weed control, because you can use some products that you won't use in the soybean season. [**Farmer 4**]*

*In addition to the financial part [of adopting the DCS], [which is] to have an extra income, is to take advantage of the farm machinery and labor. [**Farmer 12**]*

Economics, fifth out of six categories in terms of frequency, comprises 14% or 282 of the 1,978 relevant words spoken during the interviews. The dominant words comprising 36% of all words within the economics category are prices (20%), markets (10%), and costs (6%).

The second crop really is a secondary crop, hence the name safrinha, as a follow on crop to the primary crop soybean. However, the second crop choice is an economic choice. Farmers for example leverage the second crop to utilize excess inputs in inventory, such as glyphosate, which is a herbicide for both broadleaf and grass weeds, thus has value in both safrinha crops (soybean and maize). The safrinha system also improves operational efficiency by utilizing equipment, infrastructure, and labor over a second crop. Such a practice lowers fixed costs per unit of grain produced or hectare of land.

IV. How do planning for the first and second crop differ?

*Yes, yes [we may speed up operations in the first crop], as long as it doesn't harm the first crop [primary crop]. [If possible] we try to streamline it to benefit second crop as well. But we have the focus that the first crop comes first, and that must be guaranteed. It's no use losing too much on it [first crop] trying to recover in the second crop. [**Farmer 5**]*

*I wait for the right time to harvest soybean, which is the first crop [primary crop], and then I start planting the second crop. So, I don't speed up, I always harvest [primary crop] at the right time. [**Farmer 2**]*

*In fact, I prioritize the first crop [primary crop] right? The second [secondary crop] if it works, it's okay. If it doesn't work, it's okay, too. You may have to delay the harvest of the first crop, and then delay the planting of the second crop. So, I invest less [in the secondary crop]; although, I have already bought the inputs, sometimes I store one fertilizer from one year to the next, [and] change the seed for a cheaper one. [**Farmer 2**]*

*No, never [speed up the first crop]. And it will not happen. Perhaps only if you plant cotton [if cotton is the primary crop], and maize is the "safrinha" in the case [secondary crop]. However, if you plant a soybean crop and then a cotton crop, I think that in fact cotton would have priority [primary crop], which is what happened to farmers who have not yet planted in some fields around here [this season], [because] it has not rained enough. In the soybean fields where seeds didn't germinate very well, farmers are now desiccating, grading, leveling [the field] and they will not even grow soybeans anymore. It is better to plant straight the cotton crop [primary crop]. [**Farmer 3**]*

*It is always very difficult to advance [the operations in the primary first crop]. I always harvest it at the right time [**Farmer 11**]*

*It doesn't happen because soybeans need to close its cycle. (…) Yeah, you can apply desiccant a little bit in advance, but you can't complete the cycle a lot more than a week in advance. [**Farmer 4**]*

As expected, discussion of safrinha management occupied the largest set of text units among the six categories with 548 or 28% of the text units. System (14%), inputs (4%), and availability (3%) comprise the top three most commonly used words within the category.

Soybean really is the first or primary focus for farmers in the tropical DCS. Maximizing system profitability entails not accelerating or reducing managerial focus on that first crop. These comments appear contrary to

Martins *et al.* (2014) that posit an integrated set of production decisions during the critical 1st crop harvest- 2nd crop planting window, who suggest that moderate levels of post-harvest soybean losses result from accelerating harvest to permit 75 days for the maize crop to flower. System optimality involves focusing management on that first crop, and then being flexible with the second crop, whether that be in terms of planting date, input usage, cost management, or crop choice (maize, millet, or sorghum). However, the respondents describe a second DC model where the early crop is the ''safrinha'' allowing cotton to benefit from the more ideal weather during the latter part of the rainy season when conditions begin to dry out.

V. What role does the previous cropping season play in planning for the current year?

*(…) it all depends on the weather [decision about the second crop]. If it's a little late it's going to be cotton, if it's late it's going to be maize, and if it's very late, it's just straw for organic matter. [**Farmer 6**]*

*[We decide on the second crop] depending on the year, on the price, and on the demand. We analyze the market and use other [than maize] crops as well. [**Farmer 12**]*

*[The crop combinations in the last season] were soybeans [first crop], maize and sunflower [second crop]. ...[sunflower] because it requires less rain, less water. [**Farmer 12**]*

*I vary [my decision on the second crop] according to [the conditions] of each year. (…) Because, for example, this year, I started planting soybeans on October 20th [which is late]. I was scheduled to plant cotton and I couldn't do it because of the late planting [of the soybeans]. [**Farmer 15**]*

*(…) then I'll have to be aware of the area's rain [to decide on the second crop]. If it dries I make the maize intercropped with brachiaria which produces a little more straw [organic matter]. Or I'll have to either plant a more drought-tolerant soybean variety, or a more drought-tolerant maize. [**Farmer 15**]*

There appear to be two components of the intertemporal decision making. The first being the in-season relationship between the first crop experience affecting management of the second crop. Managers closely monitor the first crop and continually update their planning for the second crop as that first crop nears maturity. Thus, flexibility becomes key, and appropriate cost management become key to maximizing profitability of that second crop. For example, as discussed above, that second crop can be late, thus a critical decision is not to over invest in the second crop because a full crop may not be possible. Additionally, maize prices too change over the season, as first crop maize in southern Brazil and Argentina is harvested first, as well as the US maize crop, which comes in early in the season. All this information feeds back to inform managers as to the level of investment to make in the second crop.

VI. What challenges are there when selecting your DCS crop combination?

*It's always the market, the price and the weather. It comes down to that. And the price of seeds, too. [**Farmer 10**]*

*Thus, one of the biggest challenge is the production costs. That's why we order and buy inputs in advance, to get better prices. The other challenge is really the climate, which defines which maize [second crop] to use and which technology to use, as well. [**Farmer 16**]*

*[**Interviewer**]: In addition to what you said, which is rain affecting the planting of soybean, would there be any more challenges that you face? [**Farmer** 9]: Yes, several. Costs matter, this influences a lot, [and]. the [product] future price, right?*

***[Farmer 2]:** Not, not at all. I always choose maize or sorghum [as the second crop, having soybean as the primary first crop].*

***[Interviewer]:** (…) and what were the DCS combinations you used over the last three years?*

***[Farmer 6]:** Soybean [primary first crop] and maize [secondary second crop]*

***[Interviewer]:** Is it rare to change this combination?*

***[Farmer 6]:** It is very rare!*

***[Interviewer]:** Do you already have the DCS combination decided for each year or it may vary?*

***[Farmer 7]:** No, it is always maize, right? [as secondary second crop and soybean as the primary first crop]*

***[Interviewer]:** what were the DCS combinations you used over the last three years?*

***[Farmer 8]: (** …) It has always been maize [secondary second crop]. After soybean [primary first crop] I plant maize.*

The second inter-temporal decision involves the annual pattern where experiences in one year carryover to inform planning for the following year, similar to management decision making in temperate and subtropical systems. Farmers rely on past experiences and well known efficient DCS combinations for their farm context and regions. Thus, they follow the same DCS combination year after year. By doing that, they seem to expect that in the long run, their annual decision will result in an efficient and economic DCS combination choice. In the context of the DCS overall dynamics and drivers, both the economic and technical experiences from previous cropping seasons influence on farmers' decision regarding DCS for the next season.

VII. Are there particular challenges to first crop management, specifically soybean, when thinking about the second crop?

*More or less, we have the history of the area - rainfall and such. But, in my case, I wait a little for the definition of soybean planting [first primary crop] to know what my window of the ''safrinha'' [second crop] will be. So, for example, we do not do soybean planting just because the date has come to allow the window of the ''safrinha'' [time window to plan the second crop]. We wait for the rain to do the soybean planting, and once the window of the ''safrinha'' is set, I decide the technology package that I will use [in the second crop]. So this normally occurs in early November. [**Farmer 5**]*

By the time we already have the soybean crop planted [first crop], then, we have to decide on the second crop. We already set plans for the second crop [preliminary plans for the second crop]. But, since the "safrinha" [second crop] is kind of risky for us here, because of the rain issues, right, we wait at least start planting [the soybean] to plan the planting of maize [second crop] (…) ***[Farmer 9]***

(…) from the time I plant the first crop is that I know when I will harvest [and decide about the second crop]. ***[Farmer 4]***

Interestingly, farmers wait well into the season before making a decision. Thus farmers face significant uncertainty and must remain nimble as the rain patterns reveal themselves early in the season. Managers form initial plans and make decisions in the off season with respect to some input purchases. Final decision making, even as to crop choice, is not made until first crop establishment.

VIII. Are there particular challenges to second crop management, specifically maize?

[Due to] the productivity issue of last years' maize, this year I planted only 250 hectares [less area than last season] to invest in a more productive material, with better performance, correcting with limestone. I'll be [planting] only half the area [comparing to last year]. ***[Farmer 1]***

Yes (…) This is also a problem [the climate risk]. It is a very big risk, we even made larger investments in the second crop of the DCS [in the past]. This year we reduced our investment in maize seed. We planted cheaper varieties that were producing the same as the most expensive ones. So, it does not justify using the most expensive. So, under the weather conditions, sometimes the crop goes well, then it lacks a little moisture [water from rain]. It is also a fact that disturbs and worries us a lot. ***[Farmer 13]***

Last year, what influenced a lot was the price issue [price of the second crop] which dropped a lot. So, this year I will invest less than I invested last year [in the second crop]. ***[Farmer 2]***

The DCS not only presents farmers with two crops over which to maximize annual profitability, but also two distinct production activities, both that present significant risk and uncertainty. Much like temperate and sub-tropical farmers who struggle to plant crops when rains are excessive or fail to come, respectively, the tropical DCS farmer worries about the arrival of rain to plant the first crop, and then an early end of the rainy season that can negatively affect yields for the second crop. Then there is the substantial price risk facing DCS farmers. Maize prices can be variable, especially in Mato Grosso, where due to its distance from ports, and harvest timing relative to southern Brazil and the US, the basis can be very weak.

IX. Under the DCS system you harvest the first crop in the middle of the rainy season. Are there challenges maintaining grain quality?

I don't know if you know Mato Grosso at harvesting [time], but here you shouldn't underestimate the rain. It's dry, soon comes rain and you lose your crop because of water ***[Farmer 1]***

(Y)es, because the quality of the grain is an important point at the time of delivery. So, if its wetter, or it's more broken, right? If we get a good grain quality, sometimes we can negotiate better [with buyers]. So we perform this control too. ***[Farmer 5]***

Yes, I do, because when you are going to unload the grain in the elevators [buyers], you have to be careful all the time, right? ***[Farmer 3]***

Yes, because they all go to the warehouse. In fact, if [you (interviewer) mean] the quality in terms of protein and oil content, then I don't know. I know the quality of the warehouse, if it is warehouse standard [grading system standards]. ***[Farmer 2]***

Also, this [grading system quality] is all analyzed, but it is not a problem that will cause a delay or an increase in my planning [DCS planning]. ***[Farmer 9]***

Well (…) You have to see what the weather is like [to harvest first crop]. If it's raining too much, if the crop is starting to be lost, if it's not [raining], its okay! [However] If it's raining too much [in a specific period of days], [if] the grain is swollen and won't come back; [even] If it's raining [at a specific time of a day], sometimes you have to come in and harvest to avoid losses, right? This is it. ***[Farmer 3]***

Farmers sparingly discussed grain quality with only 2% of the text units involving quality. The word quality led the category, while farmers mentioned (grain) moisture only twice among the 1,978 key words. This is surprising given the attention managers pay to weather, rain, and timing. Farmers failed to mention other key quality-related grain terms such as foreign matter, mold, or cracks.

Two unique characteristics arise that make harvest especially challenging and relate to grain quality. The first results from a first crop harvest during the rainy season (January and February), where harvested grain; sits out in combines waiting for fields to dry in between rain events, travels long distances moving from field to storage, originates from green plants desiccated to advance the planting of the second crop, does not properly dry down during the demands of a frenetic harvest period.

The second presents the opposite challenge of excessively dry grain that results from a quick dry down if the dry season ends early or abruptly. Overly dry second crop maize then becomes vulnerable to cracks and breaks during harvest and across the numerous transfer steps as the grain moves from the field to customer or distant ports.

X. Describe the unique risks when you adopt the DCS.

Actually, I think [DCS] increases the risk, right? The advantage is that we get the straw [organic matter], if we do not harvest the "safrinha", if the maize is not good, the straw is for the next year ***[Farmer 2]***

*In fact, we increased the risk [when adopting DCS]. Because "safrinha" [second crop] has a much riskier planting and there may be a lack of water at the end. Over time we are adapting. (…) We would divide soybean planting better in stages when we didn't have a [second] crop. In that sense, I had enough material [varieties] for 100 days, 120 days, 140 days. Today [with DCS], we plant all the materials of 110, 120 days; so, as we shortened the harvest time [of the first crop], we put it all at the same time, increasing our risk of losing [the first crop] in rainy weather. [**Farmer 5**]*

*There is also the concentration of efforts in the harvest. It has to have greater agility, more efficient machinery, well-trained employees to take every minute of opportunity within the harvesting time [of the first crop], right? [**Farmer 16**].*

*(…) so, of course, in the year with a better price forecast for maize [second crop] and longer rain period, of course, this influences; so, we accelerate, we work 24 hours [to plant the first crop]. This increases the risk at harvest, because it concentrates more the planting [of the first crop], so it is a risk that we have to calculate to see if it is worth it. We're having a good result with maize [as second crop], but it increases the risks. [**Farmer 16**].*

There are clearly economic gains from planting two crops both from increased revenue and better utilization of the farm's assets. However, the DCS adds significant risk and uncertainty to the enterprise compared to when farmers plant only one crop per year. Heightened levels of management become essential from crop and input planning ahead of planting, synchronizing operations across wide geographies and tight weather windows during the growing season and at harvest, and training and optimizing the deployment of field and maintenance employees throughout the year.

5. Conclusions

The central objective of this research was to understand the context of the DCS decision making process. Interviews with operators provide insights into the unique management environment of the DCS. The findings, while set in Mato Grosso, Brazil, will prove helpful to both researchers, investors, and policymakers exploring the potential for DCS's productivity gains in other tropical settings.

Specifically, the DCS involves a very tight relationship between the dynamics of the weather and the practice of adaptive management. As the weather changes at planting, say due to delayed rains, then the farmer needs to replant, possibly multiple times, adjust varietal selection for maturity, and change up the second crop choice accordingly. Such dynamics play out throughout the crop year. For example, late planting, or an early end to the rainy season too can mean farmers make the difficult choice to harvest second crop grain or simply plow the crop in to maximize organic matter as a second best outcome.

DCS requires a sophisticated planning process, and the analysis reveals two types of management profiles. The first profile, refers to management intensive farmers that closely monitor the weather and market conditions and prepare themselves to adjust plans in case of any unexpected event from planting through to harvest during the first crop. Management intensive farmers maintain appropriate levels of physical and human capital to take advantage of tight weather windows so they can expedite cropping activities across broad geographies and maintain grain quality. They monitor the market, invest in technology and equipment, and set different DCS plans and possible combinations each year.

Alternatively, there are also more rule based managers, such as corporate farms, where planning needs to be more routine and less adaptive as farming operations are extensive. Smaller farms being less well capitalized behave similarly but for different reasons. They invest less in their management systems and, like the corporate farms, rely on a DCS combination that has, in general shown success over time, such as, a soybean-maize succession system that uses standard varieties and hybrids, respectively.

Another interesting finding from the interviews is that land allocation between the first and second crop often do not align, so rotations are not always complete. First crop planting for example is not a singular event, but plays out over weeks as some fields establish due to adequate moisture, while others do not and require replanting. Similarly, at 1st crop harvest, rains can delay field activities, which also then also disrupt the second crop planting plan. Some fields may receive the intended crop, while others, an alternative grain, while still others simply a cover crop. The lack of a complete alignment then carries over to complicate the following year's plans and implementation as individual fields with different cropping histories require altered fertilizer, liming, or chemical regimes.

The farmers inform us as to a nuanced understanding of the terms "primary" and "secondary" crops. There is the traditional model, where the first crop is the primary crop, often soybean, and it receives the greatest focus, investment, and management within a two crop system when maximizing profitability across the crop year. The manager adapts the second crop, often maize, depending on outcomes from the first crop. S/he may delay planting, switch out the maize for an alternative crop, or even plow under an immature crop.

DCS farmers though, depending on relative prices, costs, and yields, may opt to make the second crop the primary crop, such as cotton, to take advantage of the drier periods later in the growing season. In such cases the farmer may employ an early maturing soybean so that harvest takes place as early as Christmas, which allows a lengthy growing period before the dry season arrives in May.

In either case, managers recognize the importance of the quality of the grain or cotton from the primary crop, in addition to yield, compared with yield and quality from the secondary crop. It is important to note that first handlers in Mato Grosso grade the grain they buy, and provide that information, including discounts, to farmers on the weigh slip. As a result farmer are both informed and incentivized to prioritize quality appropriately.

Lastly, farmers self-report that adopting the DCS creates more stress in the workplace for them and their employees, compared to a single crop system common in temperate and sub-tropical settings. This makes sense as

the weather is so variable, tropical soils have poor water holding capacity, and disease and pest pressure is significant, so risk and uncertainty are high. Managerial decision making becomes a continuous activity, thus there may be more pressure compared with single crop systems. Managers must closely monitor and adapt from pre-season planning through the harvest and sale of the second crop because of the multiple dynamic features of the DCS.

Formally comparing double and single cropping systems as to their level of management required, both qualitatively and quantitatively, as well as the level of risk, becomes a logical next step for researchers investigating farm management in tropical settings. Anecdotal evidence shows single crop managers from the US or Argentina struggle when operating investor owned (large) farm enterprises in Mato Grosso. Martins *et al*. (2014) may shed some light as they discuss the challenge of hierarchical management structures, which present a principal (owner) – agent (operator) problem, when operating in the management intensive environment of Mato Grosso. Though the authors focus on post-harvest loss management, they raise the important point that adaptive management or nimbleness in decision making may suffer when managerial bureaucracies associated with investor-owned farms operate within dynamic environments. In this way the DCS may challenge the investor model as they look to expand professional farming systems into other tropical regions, such as Africa, while being better matched when owners directly operate the farm.

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Appendix

Interview Outlines

FIRST PART: Personal Information:

- Name:
- Age:
- Farm location:
- Cropping area (last cropping season)
- Double-cropping area (last cropping season)

SECOND PART: Challenges and Characteristics of the Double-cropping System (DCS) Decision Making Process

1. How long have you been practicing ''safrinha'' (DCS)?
2. What are the main reasons for adopting the DCS?
3. In which part of the year do you make decisions regarding DCS ? Why?
4. What are the main challenges regarding the DCS planning? Why?
   - Reminders for the interviewer:
     - Crop choices;
     - Price and market information and forecast;
     - Weather information;
     - Credit;
     - Input purchase;
     - Crop conduction; etc.
5. What happens after you decide the DCS combination?
6. During the first crop management and afterwards, in the management of the second crop, what are the main challenges you face? Why?
   - **6.1**- What is the dynamics of the first crop harvest and the sowing of the second crop?
     - **6.1.1-** What are the main challenges at this time? Why?
     - **6.1.2-** How do you decide the best time to harvest the first crop and sow the second crop?
     - **6.1.3-** Which factors can bring problems or lead to changes in the date of the first crop harvest and the sowing of the second crop? How can this happen?
     - **6.1.4**- Which are the procedures to be adopted in case of harvesting earlier the first crop?
       - **6.1.4.1-** What are the consequences of speeding up the machinery during the harvest of the first crop?
     - **6.1.5-** Is it common to change the amount of area from the first to the second crop? If so, why?
7. What is the common combination of crops used in the DCS of the last three cropping seasons? Why?
8. Do you keep records that allow you to know:
   - The first crop expenses and income;
   - The second crop expenses and income;
   - The overall expenses and income from the DCS;
   - The grain quality of the first crop harvest (and why).
9. Which factors happened in the last cropping season and affected your decision making process regarding the DCS of the current cropping season? Why?

REFEREED ARTICLE

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The Impact of Wine Grape Harvester on Labour in Western Cape Province of South Africa

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ABSTRACT

Mechanization and technology in agriculture are becoming more and more evident, not only in developed countries, but also in African countries, and more specifically South Africa. The objectives of the study were to identify the factors that impact labourers when wine grape harvesters are used on farms in the Western Cape Province of South Africa by answering the research question of "Which factors affect labour usage on farms that use mechanical harvesters for harvesting grapes?" The study utilized a survey, secondary data, and a binomial logistic regression model. The study shows that increasing hectares used for the production of wine grapes, farmer's age, machine output and average labour output has a significant impact on the reduction of seasonal labour as well as permanent labour on the farms. The study recommends that the government should intervene or introduce legislation to mitigate the effect of mechanical harvesting of grapes on labour. The government should encourage producers to keep farm workers, given technological advances, which discourage the retrenchment of farmers who apply technology advancement, but retain labourers. The government can also provide incentives to producers who apply technological advancement, but retain labourers.

KEYWORDS: Labour; Wine grape harvester; Production; Seasonal labourers; Permanent labour; South Africa

1. Introduction

The substitution of labour and the introduction of machinery on agricultural operations is a general occurrence, which releases labour for employment in other sectors of the economy. Mechanization leads to higher productivity of land and labour, prepares larger areas of land in less time in comparison to manual labour and brings about a larger output. There is also a push for labourers to move to urban areas for job opportunities, because of economic growth and higher wages. Some implements and labour-saving technologies might positively affect the productivity levels of crops if adopted (Hazarika, 2015).

The cost of manual labour has created a need for specialized vineyard equipment where more activities are performed using machinery. A completely mechanized system is likely in the future for all operational activities in any given season. Mechanical operations should not affect the fruit or wine quality negatively. Mechanized vineyard operations include summer pruning and harvesting, dormant pruning as well as fruit thinning. Mechanical harvesters and other mechanical operations have been in use for some time, but there are no appropriate machines for the 12 major trellising systems (Morris, 2000).

The effect of mechanization could impact on labour on wine producing farms in the Stellenbosch and Worcester district municipalities of South Africa. According to Singh (2006), mechanization technologies keep changing with socio-economic advancement and industrial growth within a country. The non-availability of the agricultural labour for field operations and declining interest in agriculture are some of the socio-economic issues in industrialized nations that promote mechanization. In developing countries, labour productivity with dignity and increasing land use drive mechanization in agriculture. Mechanized technological advances are therefore, dynamic and location-specific. Land and labour productivity as well as the quality of inputs of mechanization may differ considerably[4].

Vivarelli (2012, 2013) discussed the compensation and displacement brought about by mechanization at work. Vivarelli (2013) points out that deskilling and the labour-saving effects of capital-intensive technological advances have been a worry since the Luddite movement of the early nineteenth century. However, the author also

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calls into consideration a range of compensatory instruments that may ease such concerns. Labour-saving effects of technology can be advantageous through: (i) higher demand for goods/services; (ii) larger income emanating from redistribution; (iii) additional employment from creating new machines; (iv) additional investments; (v) decrease in wages from price adjustments and (vi) new products created using new technologies.

Busa and Nandi (2014), and Hazarika (2015) mention both the positive and negative effects in employing mechanization on farms. The positive effects refer to the improvement of productivity and that labour can get more output. While mechanization can reduce time and production costs, farmers can have enough time for other operations on the farm. However, the negative impact of mechanization is that it can substitute manual labour (BFAP, 2012). Saayman and Middelberg (2014) assert that it can be costly to implement mechanization, as not all sectors are capable of structural changes. Studies have different perspectives on what mechanization can bring and whether it is to the advantage or disadvantage of farmers.

Wine grape producers are continuously faced with internal and external farming factors such as increasing production costs, rising labour cost, political instability, economic constraints and technological advances, which impact their decision-making and profitability given the competitive international markets. Regions and different district municipalities where wine grapes are produced depend on the topography of the land. Hills, mountains, rivers, lakes, cities, dams, valleys, and production systems determines a farmer's production techniques. This could influence the financial position of a business and the labour needed. A technique like mechanized harvesting of wine grapes could impact significantly on the viability of a farm and labour usage.

Existing studies such as Adu-Baffour et al. (2019), Busa and Nandi (2014), Reddy et al. (2014), Rotz et al. (2019), and Ugur and Mitra (2017) focus on the impact of promoting mechanization; examine the effective and efficient use of labour; assess indices of labour productivity; and how agricultural technology is shaping labour and rural communities. The studies do not determine the factors and the impact that wine grape harvesters have on labour. Therefore, the objectives of the study were to determine the factors that affect labourers when mechanical wine grape harvesters are used on farms of Western Cape Province of South Africa. This study will aid decision-makers and government to develop policies and make efficient modifications to existing policies on the mechanical harvesting of grapes and labour. The findings will also be useful for extension officers, policymakers, and government to understand the context of mechanization within the wine industry to make recommendations or emphasise sustainable production in provinces, but aligned with labour-related issues.

2. Materials and Methods

2.1. Study area

The Western Cape Province of South Africa has five district municipalities, which include Eden, Overberg, Cape Winelands, West Coast, and Central Karoo. The research was carried out in Cape Winelands, the largest wine-producing region in the Western Cape and South Africa. Many of the wine producers, wine cellars, and producer cellars are found in the Cape Wineland district municipality. About 74% of all private wine cellars are situated in the Cape Wineland district, which made it ideal for this research. The Cape Winelands consist of five local municipalities, namely Stellenbosch, Breede Valley, Witzenberg, Drakenstein, and Langeberg (Cape Winelands District Municipality, 2017).

2.2. Sampling technique

A multi-stage sampling technique was used in this study. The first stage was a purposive selection of the Cape Winelands district municipality. The second stage was utilzed purposive sampling to select the three local municipalities' within Cape Wineland's district municipality, namely, Stellenbosch, Drakenstein and Breedevalley local municipalities. The third stage was the selection of specific farms in these local municipalities. The study area was selected, because the largest number of wine grape producers resided in the three local municipalities, as seen in Table 1. The farms were selected randomly in order to represent the three local municipalities (Table 1). As many farmers as possible were interviewed per municipality to get a strong delineation. The population sample illustrated in Table 1 include private cellars, where the sample size was identified from each of the respective towns and surrounding wine grape producing areas. Private cellars produced on average less than 500 tons of grapes per year with their own vineyards and cellars and produce premium quality wine. Producer cellars produced on average more than a 1000 tons of grapes per year, operated as a wine co-operative, had shareholders who produced wine grapes, and processed bulk wine, which was usually of a lower quality than premium wine of private cellars. In this study producer cellars not included. The number of cellars were obtained from the South African Wine Industry Information and Systems (SAWIS) (SAWIS, 2016).

A sample of 91 farmers was chosen from 348 private wine grape producers across the three local municipalities within the Cape Winelands, who were willing to participate in the study. A survey was conducted by the researcher from October 2018 to February 2019 to assess the effect of wine grape harvesters on labour in the Western Cape Province of South Africa. The survey included output per hour per hectare, the cost per hour per hectare for a wine grape harvester, and the cost of labour use per hour per hectare. Data included, but were not limited to, farm size, age, gender, production systems, labour use, the method for harvesting grapes, degree of mechanization, credit, advisory services, and farming income. Income generated from using labour

Table 1: Number of private wine cellars for the Cape Winelands region

Local Municipality	Number of private wine cellars	Number of farmers sampled
Stellenbosch	172	39
Drakenstein	120	30
Breede Valley	56	22
Total	348	91

Source: Author's compilation from SAWIS (2016).

Table 2: Description of variables for impact on seasonal and permanent labour used in the binomial logistic regression model

Variable	Description
Dependent variable:	
Seasonal labour (LLs) & Permanent labour (LLp) - separately	0 decrease labour and 1 increase labour
Explanatory variables:	
Age (FA)	Age in years
Hectares for production (NHecp)	Hectares under wine production
Seasonal labourers (NSL)	Number of seasonal working during harvest season
Type of harvesting (MethH)	1 if Mechanical harvester, 2 if Labourers, 3 if Both
Type of harvester (TypH)	1 if Self-propelled, 2 if Tractor-drawn and 3 if Both
Length of the harvest season in weeks (DuraH)	Length of the season (weeks)
Machine output in tons per hour (Mchout)	1 if 4 tons/hour or less, 2 if 5 tons/hour, 3 if 6 tons/hour, 4 if 7 tons/hour, 5 if 7 tons/hour, 6 if 9 tons/hour, 7 if 10 tons/hour and 8 if 11 tons/hour or more
Labour output in tons per hour (ALOh)	1 if 4 tons/hour or less, 2 if 5 tons/hour, 3 if 6 tons/hour, 4 if 7 tons/hour, 5 if 7 tons/hour, 6 if 9 tons/hour, 7 if 10 tons/hour and 8 if 11 tons/hour or more
Labourers for 1 ton (LaHar)	How many labourers can harvest 1 ton
Cost of machine harvesting per hour (CostHarM)	1 if R 75.00 per hour or less, 2 if R 120.00 per hour, 3 if R 165.00 per hour and 4 if R 210 per hour or more
Cost of labour harvesting per hour (CostHarH)	1 if R 138.51 or less per hour, 2 if R 169.30, per hour 3 if R 200.08 per hour and 4 if R 230.86 or more per hour
Man-hours per ton (Manhec)	1 if 6 hours per ton or less, 2 if 7 hours per ton, 3 if 8 hours per ton, 4 if 8 hours per ton, 5 if 10 hours per ton and 6 if 11 hours or more per ton
Average machine duration per hour (AvgharMac)	Duration of the machine per hour
Average labour land ratio (Lalahec)	1 if 3 workers:1 ha or less, 2 if 4 workers:1 ha, 3 if 5 workers:1 ha, 4 if 6 workers:1 ha, 5 if 6 workers:1 ha, 6 if 7 workers:1 ha, 7 if 9 workers:1 ha, 8 if 10 workers:1 ha and 9 if 11 workers:1 ha or more

Source: Author Compilation (2019).

and a harvester per hectare was obtained from secondary data sources (man-hours compared to use of a harvester per hectare per hour). The land–labour ratio was also determined per hectare. The collected data were captured in an Excel spreadsheet, cleaned and re-arranged. Jeffreys's Amazing Statistics Program (JASP) and Statistical Package for Social Science (SPSS) were used for the statistical analysis of the data.

In determining the factors that impact labourers as a result of the use of a wine grape harvester, a binomial logistic regression model was used. The binomial logistic regression model was used, because the dependent variables dealt with a binary response variable, multiple explanatory variables and supported categorizing data into discrete classes. The model did not make assumptions about class distribution in featured spaces. Additionally, the output of the binomial logistic regression model was more informative and more significant than other realted models such as probit model. Hence, the dichotomous form of the dependent variable made it possible to determine the significance and influence of selected factors unambiguously. Following the work of Owombo et al. (2012), the logistic regression model is expressed as (Equation 1):

$$LLp/LLs = B0 + B1FA + B2NSL + B3NHecp + B4MethH + B5TypH + B6DuraH + B7Mchout + B8ALOh + B9LaHar + B10CostHarM + B11CostHarH + B12Manhec + B13AvgharMac + B14Lalahec + e \quad (1)$$

Table 2 summarizes the outcome and independent variables of the binomial logistic regression model.

3. Result and Discussion

3.1. Socio-economic characteristic of respondents

Table 3 presents the socio-economic characteristics of wine grape producers. The results showed that 98.9%[5] of the producers are men, where only 1.1% are women. This indicates that wine grape production farms are dominated by men. The results of the research are in line with that of Mariano et al. (2012), where 89% of farmers who adapted to technology such as certified seed technology were men. This implies that male farmers are much more adaptive to new technological advances than female farmers, which will subsequently impact labour use.

Approximately 93.3%[6] of the farmers are married and 6.7% are single, which implies a level of commitment and dedication. A study by Paul et al. (2017) also revealed that marital status is a major factor in technology adoption, which impacts on labour. The respondents are well educated where 19.5% have a secondary education, 5.7% had a higher certificate, 32.2% a diploma and 37.9% held a degree. A total of 4.6% of respondents had a postgraduate qualification (post grade 12 qualifications), which implies the importance of a qualification to manage a farm.

[5] Indicated male producers. Only one, either male or female producers, whether married or not are regarded as farming the land and thus the manager of the farm. It is purely from the perspective of the farmer as an individual and not as partners or shareholders. There is a clear distinction between gender and marital status for quantification and it should not be confused.

[6] Indicated male producers. Only one, either male or female producers, whether married or not is regarded as farming the land and thus the manager of the farm. It is purely from the perspective of the farmer as an individual and not as partners or shareholders. There is a clear distinction between gender and marital status for quantification and it should not confused.

Table 3: Socio-economic characteristics of respondents

Variables	Description	Frequency	%
Gender	Male	90	98.9
	Female	1	1.1
Marital Status	Single	6	6.7
	Married	83	93.3
	Widow	-	
Qualification	Secondary	17	19.5
	Higher certificate	5	5.7
	Diploma	28	32.2
	Degree	33	37.9
	Postgraduate	4	4.6
Source/s of income	Wine	22	25.0
	Wine grapes	17	19.3
	Wine and wine grapes	12	13.6
	Wine and other sources	8	9.1
	Wine grapes and other sources	25	28.4
	Other sources	1	1.1
	Wine, wine grapes and other	3	3.4
Access to credit	Yes, have access	74	89.2
	No, have no access	9	10.8

Source: Author's estimation (2019).

Table 4: Results of mechanical harvest impact on seasonal labour

	Estimate	Standard error	Standardized	Odds ratio	z	p
Hectares for production (NHecp)	0.459	0.181	42.620	1.583	2.544	0.011***
Age (FA)	0.164	0.087	1.895	1.178	1.887	0.059***
Seasonal labourers (NSL)	-0.408	0.157	-11.808	0.665	-2.598	0.009****
Labour output tons per hour (ALOh)	-0.497	0.373	-1.236	0.608	-1.332	0.183**
Type of harvesting (MethH)	-2.583	2.497	-1.295	0.076	-1.034	0.301
Type of harvester (TypH)	-10.017	6.272	-4.774	4.463	-1.597	0.110
Length of the harvest season in weeks (DuraH)	-8.065	6.030	-24.686	3.143	-1.337	0.181
Machine output tons per hour (Mchout)	-0.739	0.750	-1.295	0.478	-0.984	0.325
Labourers for 1 ton (LaHar)	0.156	0.135	1.286	1.169	1.155	0.248
Cost of machine harvesting per hour (CostHarM)	-239.860	15050.990	-145.894	6.763	-0.016	0.987
Cost of labour per hour harvesting (CostHarH)	1.810	1.664	1.704	6.113	1.088	0.277
Man-hours per ton (Manhec)	-1.883	1.333	-3.115	0.152	-1.412	0.158
Average machine duration per hour (AvgharMac)	-3.003	2.853	-2.562	0.050	-1.053	0.293
Average labour land ratio (Lalahec)	3.830	4.326	0.738	46.060	0.885	0.376

***Significant at the 1% level; **significant at the 5% level
Source: Author's estimation (2019).

A quarter (25%) of the respondents had only wine as a source of income. About 19.3% had wine grapes and 13.6% had wine and wine grapes as sources of income. Most of the respondents (28.4%) had wine grapes coupled with other sources of income as income streams. Abbas et al. (2017) found that income raises the probability of acceptance, indicating that incentives for earning income need to be developed. Thus in this research, it is evident that income from the primary production and other income sources within the farming business is significant for technology adaption. It can be noted that most respondents in this study apply a relative level of diversification, which is critical to sustaining a farming business in the long run.

Around 89% of respondents had access to credit. The results of this study are consistent with a study by Mariano et al. (2012) where credit was significant for the adoption of technology. Further, the authors highlighted that sufficient credit is needed for major mechanical investments within agribusinesses. Therefore, most of the respondents maintain a fair amount of viability within their industry and are capable of investing in the mechanical harvesting of grapes.

3.2. Wine grape harvester impact on seasonal labour

Table 4 indicates the impact of a wine grape harvester on seasonal labour. An increase in the number of hectares (NHecp) and farmers' age (FA) significantly affects the impact on seasonal labour. The increase in the number of hectares (NHecp) and the farmer's age (FA) was significant at 1% and positively correlated to an increase in seasonal labour. The results suggested that with an

Table 5: The effect of mechanical harvesting on permanent labour

	Estimate	Standard error	Standardized	Odds ratio	z	p
Hectares for production (NHecp)	0.218	0.065	20.202****	1.243****	3.362	0.001***
Machine output tons per hour (MHout)	-0.954	0.319	-1.672	0.385	-2.987	0.003***
Type of harvesting (MethH)	-4.580	1.991	-4.580	0.010	-2.301	0.021
Length of the harvest season in weeks (DuraH)	0.063	0.158	0.193	1.065	0.398	0.691
Machine output tons per hour (Mchout)	-0.739	0.750	-1.295	0.478	-0.984	0.325
Labourers for 1 ton (LaHar)	-0.009	0.058	-0.077	0.991	-0.159	0.873
Cost of machine harvesting per hour (CostHarM)	-2.747	1.281	-1.671	0.064	-2.145	0.032
Cost of labour harvesting per hour (CostHarH)	0.758	0.689	0.713	2.133	1.100	0.271
Man-hours per ton (Manhec)	0.467	0.316	0.773	1.595	1.480	0.139
Average machine duration (AvgharMac)	-0.118	1.051	-0.100	0.889	-0.112	0.911
Average labour land ratio (Lalahec)	-6.141	4.899	-1.184	0.002	-1.254	0.210

***Significant at the 1% level
Source: Author's estimation (2019).

increase in the number of hectares (NHecp) and increase in farmer's age (FA) means that seasonal labour will increase. The findings correspond with that of Domingues and Del Aguila (2016), where the cost per hectare of grape mechanical harvesting is lower than the cost per hectare of manual harvesting. Mechanical harvesting is therefore justified when vineyard areas exceed 41.92 ha, and will justify the use of a mechanical collection system of grapes. This is particularly true for wine grape farms exceeding 42 ha. The finding in this study correlates is not supported by similar studies of Reddy et al. (2014) and Adu-Baffour et al. (2019), where they showed the mechanization would increase seasonal labour.

3.3. Wine grape harvester impact on permanent labour

Table 5 shows the results of the effect of mechanical harvesting on permanent labour. The variable hectares for production (NHecp) of wine grapes has a standardized coefficient of 20.202 and an odds ratio of 1.243, which is greater than 1 and suggests a positive relationship with a significance at 1%. The NHecp is a positive predictor of a farm being able to employ fewer permanent labours, which probably indicates the economy of scale in production. This means that the farmer will employ fewer permanent labourers. The finding is consistent with that of Reddy et al. (2014), where there is a positive association between farm mechanization, displacement of family labour, and increased casualization of labour across many crops. Thus, as the number of hectares (NHecp) increases, farmers are more likely to make use of mechanical harvesting, and therefore less permanent labour is used.

The variable machine output tons per hour (MHout) for harvesting grapes has a standardized coefficient of -1.672 and an odds ratio of 0.385, which is negatively correlated and significant at 1%. Type of harvesting (MethH) is also a negative predictor with a standardized coefficient of -4.580 and an odds ratio of 0.010, which is significant at 1%. This may simply reflect that mechanical harvesting is becoming more prevalent and that there might be a change in labour shedding in the responding farms. The finding is consistent with the study of Busa and Nandi (2014) who showed that the use of machinery in agricultural production plays an important role in increasing productivity and reducing the unit cost of production resulting in profitability and making agriculture viable. The finding of the study is also in line with that of Ugur and Mitra (2017) where the impact of technology on jobs is more likely to be favourable where data is linked to skilled-labour employment and product innovation.

4. Summary, Conclusion, and Recommendations

The study revealed that increasing hectares used for the production of wine grapes, farmer's age, machine output, and average labour output has a significant impact on seasonal labourers. The application of mechanized harvesting of grapes enhances the number of hectares for production and fewer permanent labourers will be employed. This implies that there will be a reduction of permanent labourers on the farm. However, it will not reduce the number of seasonal labourers used for harvesting grapes on farms.

The Western Cape and in particular the Cape Winelands is a wine grape production intensive region within South Africa, which has the potential to mechanize and improve technology on farms without impacting the employment within the sector. Hence, the study recommends that the government should intervene or introduce legislation to mitigate the effect on labour because of the mechanical harvesting of grapes. Further, government should encourage producers to keep farm workers on the farm given technological advances, by including policies that discourage the retrenchment of farmers who apply technology advancement, but keep labourers. The government should also formulate a policy that motivates the integration of modern agricultural systems with that of current conventional systems. This will inform about the benefits for both the producers and labourers. The result will ensure profitability, productivity, enhance and maintain employment within the agricultural sector.

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Encouraging farmer participation in agricultural education and training: A Northern Ireland perspective

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ABSTRACT

Farmers are increasingly encountering complex challenges which require them to acquire in-depth knowledge of new technologies and best practices to bring about productive and sustainable farming systems. There is a need to update and improve knowledge and skills, particularly for those who have no or low levels of agricultural training. This study focuses on identifying existing and future skills gaps at farm-level and investigates how knowledge provision and training should be developed and delivered to meet industry needs. This research obtained the views of key stakeholders and farmers around agricultural education provision and future training needs. The methodology combined semi-structured interviews and a farm-level survey. The results identified an immediate need to develop a programme of continuous professional development. The key barriers to training were time, cost and the relevance of training to a farmer's particular farming system. Attitudes to training impact on the level of engagement with new practices and technologies; therefore the benefits of life-long learning within the sector need to be promoted. Agricultural education providers should develop stronger collaborations with other education providers and key stakeholders to ensure the sector needs are met.

KEYWORDS: Agricultural education, training, continuous professional development

1. Introduction

Farmers have always had to adapt their behaviour in response to changing market and policy environments. However, they are increasingly encountering more complex challenges which require the adoption of advanced technologies alongside developing sustainable farming systems to improve productivity, in response to world-wide population growth and climate change (Coomes *et al*., 2019). Farmers will require more in-depth knowledge of their production systems and related ecosystems; for example, soil management, land ecology, animal health and welfare and carbon sequestration (Schulte *et al*., 2014; Accatino *et al*., 2019). As highlighted by Lindblom *et al*. (2017), more sustainable agricultural systems are closely linked to a farmer's ability to interpret and make decisions around information and data which will necessitate a paradigm shift in production and management practices at farm-level. The industry's capacity to respond to these challenges will be dependent upon farmers' abilities to improve their skills base and to adopt farm-level innovations, improvements and best practice.

Northern Ireland (NI) is a small and largely rural region of the United Kingdom (UK), with a diverse farming structure. The average farm size in 2017 was 41.1ha with only eight percent of farmers farming 100ha or more (DAERA, 2018). The majority of NI farms are classified as cattle and sheep farms (80 percent), 10 percent are classified as dairy farms and the rest consists mainly of cropping (3 percent) and pig and poultry (3 percent) farms (DAERA, 2017). Ninety-six percent of farmers are male with 55 percent farming full-time (DAERA, 2018). As in other parts of Europe, over the past three decades the NI farming population has become older (Zagata and Sutherland 2015). The median age of farmers in NI in 2016 was 58 years; only six percent were under 35 years old, and there has been a limited flow of younger farmers into the sector, resulting in the number of farmer falling by some 12 percent between 2002 and 2017 to 25,000 (DAERA 2017; DARD, 2008; DAERA, 2018). This diverse farmer profile has contributed to an emerging skills gap in the NI farming sector with a higher percentage of farmers having no agricultural education (75 percent), compared to the UK as a whole (68 percent), and the EU average (68 percent) (Eurostat, 2016).

In Northern Ireland agriculture education falls under the remit of the Department of Agriculture, Environment and Rural Affairs (DAERA) and is delivered by

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The College of Agriculture, Food and Rural Enterprise (CAFRE). CAFRE comprises of three campuses which provide training in agriculture, horticulture, food and equine. In agriculture CAFRE is responsible for the formal education programmes, including further education, higher education and short courses, and knowledge transfer.

Previous studies examining farmers' educational attainment have frequently highlighted low levels of uptake and completion of formal agricultural training, alongside limited participation in engaging in extension programmes around lifelong learning (Gasson, 1998; Huffman and Orazem, 2004; Sewell *et al*., 2014). This is despite research evidence indicating that the relationship between education and farm efficiency is positive (Lockheed, Jamison and Lau, 1980; Huffman, 2001; McDonald *et al*., 2016; O'Donoghue and Heanue, 2018). Furthermore, Kilpatrick and Johns (2003) identified that increased levels of educational attainment support farm-level decision-making through increasing a farmer's awareness of new practices and assisting farmers in their selection of and allocation of inputs between competing uses. Wallace and Jack (2011) and Heanue and O'Donoghue (2014) have shown positive returns to investing in education and training (beyond the minimum school leaving age) for farmers working both on and off-farm. The perceived barriers to training and skills development amongst farmers have been shown to be not country specific, but rather they are comparable between countries (Kilpatrick and Johns, 2003; Seymour and Barr, 2014). In addition, farmers are a heterogeneous group exhibiting a range of learning styles and different attitudes and approaches to implementing learning and new technology adoption (Black, 2000; Seymour and Barr, 2014; McKillop, Heanue and Kinsella *et al*., 2018). Furthermore, as identified by Sewell *et al*. (2017), learning in agriculture is moving away from people directed learning to a more independent approach particularly to encourage the adoption of new innovations at farm level.

Lifelong learning and continuous professional development (CPD) is about gaining new skills and competences, extending knowledge and obtaining qualifications. Other industries, such as veterinarians, have introduced the idea of lifelong learning and CPD which suggests that there is potential to apply the concepts to the agriculture industry. However, the unique circumstances and ingrained attitudes and behaviours to education and lifelong learning in farmers must be acknowledged as major challenges (Caskie, 2018). Learning, adoption and practice change is increasingly being viewed as a social process, influenced by a combination of personal, environmental and social factors (Hall, Turner and Kilpatrick, 2019). Previous studies have suggested these include individual characteristics such as education, social networks, farm business characteristics, and nature of the activity and learning environment (Fulton *et al*., 2003). For education to lead to adoption of practices the providers require a greater understanding of how farmers make decisions, and what factors influence their choice to engage with education. This understanding will allow education providers to encourage engagement and communicate more effectively to achieve greater improvements in farming practices (Turner, Wilkinson and Kilpatrick, 2017). Furthermore, it is understood that this is not a one off event and ongoing continued engagement with supported learning should result in farmers being more likely to develop the knowledge and skills required to undertake practice change (Turner and Irvine, 2017; Hall, Turner and Kilpatrick, 2019).

While there has been considerable research undertaken in the area of agriculture education and how farmers can improve their skills, there have been limited studies focusing on a regional area with a large but diverse farming population characterised by very low levels of agricultural educational attainment. This study aims to examine the current and future skills requirements in the primary agriculture sector in NI and how knowledge provision should be adapted to best meet farmer's lifelong learning needs into the future. A conceptual framework for this study is shown in Figure 1.

2. Methodology

The research focused on obtaining the views of two specific groups, namely key stakeholders within the farming sector; and a cohort of farmers who had previously undertaken some form of agricultural training. A mixed methods research design was used with a combination of qualitative and quantitative approaches. Stakeholder interviews took place between March and June 2016. The interviews were semi-structured containing mainly open ended questions, designed to elicit the opinions of those interviewees. Each interview lasted between sixty to ninety minutes and focused on skills and training under three key themes:

1. The level/ type of training and skills needed in the industry overall
2. The level/type of training needed by individual farmers
3. Future development of training and delivery

Five main groups of stakeholders were identified namely:

1. Farming organisations/farmer representative groups (FO).
2. Senior representatives from agri-food processing companies (AP).
3. Main agricultural education provider - The main provider of agriculture training in NI (MP).
4. Professional services (PS) - individuals/organisations that provide professional services to farmers, they included banks, solicitors and accountants.
5. Learning, training and skills stakeholder (LTS) - other private sector organisations involved in providing agricultural training in NI.

Key stakeholders were selected on the basis of their profile and experience of working in, or their involvement with the NI farming and agri-food sector and their professional contribution to it. Overall twenty four individuals from a range of fifteen organisations were interviewed.

Two researchers attended each interview, taking detailed notes on the responses to each question. Once the interview was complete, the interview notes were written up and compared with the original notes to ensure accuracy and consistency in the documenting of the interview. When all the interviews had been completed and scripted, one researcher evaluated the data

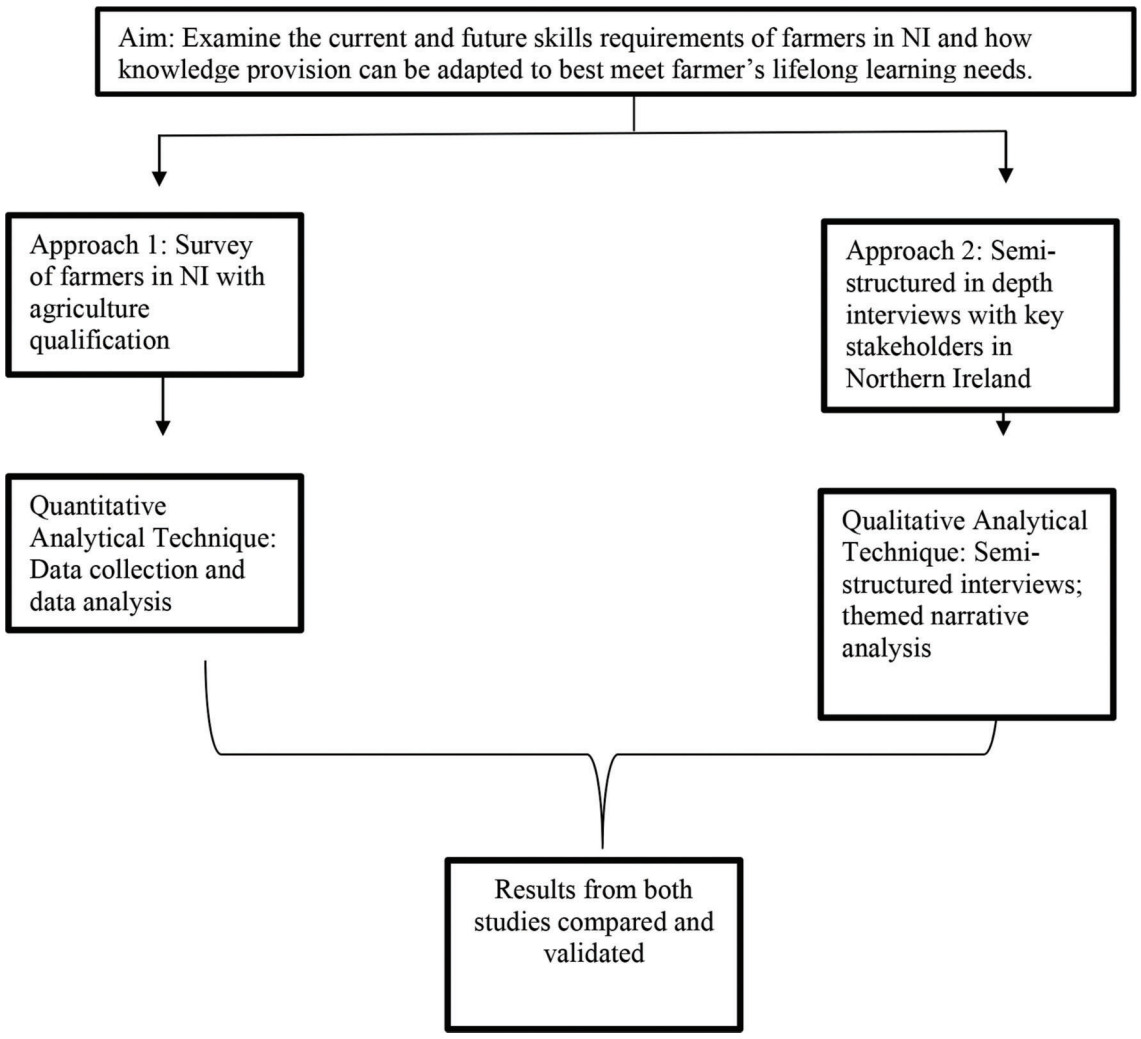

Figure 1: Study conceptual framework

thematically, a foundational method for qualitative analysis, (Holloway and Todres 2003), defined as 'a tool for identifying, analysing, and reporting patterns or themes within qualitative data' (Braun and Clarke 2006). Themes arising in the data were coded. Codes helped to index the themes providing a way to store and retrieve the data easily. Once the codes had been generated a second researcher read through the transcripts and codes to ensure it was accurate. Through discussions between the researchers a subsequent level of sub-coding was generated, which allowed the researchers to identify patterns in the scripting (Punch 2005). In reporting the results and key findings, respondents' answers have been combined and summarised.

Following on from the stakeholder consultation a survey of farmers who had previously undertaken agricultural training at a NI further education college or university was undertaken. This was an online survey, the link to which was emailed directly to farmers by farmers unions and education providers using there contact lists; it was also advertised in the local farming press. The themes around which the questionnaire was designed reflected the themes of the key stakeholder consultation and in addition included questions on the respondents own education level and their current farming activities. A range of Likert scale, ranking and open ended questions were used. The survey was administered online in August 2017 and in total there were 94 responses.

The mixed methods approach employed combines quantitative analysis from the farm based survey with qualitative analysis from the stakeholder interviews. The approach provides a balanced analysis and the responses from the two separate groups helps improve our understanding around agriculture education and training. The mixed methods approach is fast gaining popularity in the literature as it provides a deeper analytical base for responses drawing on personal, social and psychological variables. Examples of studies that have applied similar approaches include Gittins, McElewee and Tipi (2020) in which they combined both interviews with farmers and a Discrete Event Simulation (DES) model to illustrates the benefits and challenges associated with farm technology and software adoption in Yorkshire, England. Similarly, Jack, Adenuga, Ashfield *et al.* (2020) employed the mixed method approach to examine and analyse the drivers of farmers' decisions in relation to joining and participating in a new approach to farm extension, learning and advisory service provision in Northern Ireland.

Seventy-seven percent of the respondents were male and 33 percent were female and the average age of

respondents was 44 years old. Forty-nine percent of respondents had employment outside of farming. Of those who had employment outside of farming, 74 percent worked full time (more than 30 hours per week), 22 percent worked part time (up to 30 hours per week) and four percent had seasonal/casual employment. Thirty-seven percent of the respondents indicated that they worked 30 hours or less per week and 38 percent of the respondents indicated that they worked 60 hours or more per week on the farm. The main enterprises of those surveyed (main enterprise being defined as the one which contributes most to farm business income) were beef cow herd (33 percent), dairying (30 percent), sheep (11 percent), arable (10 percent), beef finishing (8 percent), Poultry (3 percent), pigs (2 percent) and other (3 percent).

3. Results

Main Areas of Training

A need for higher levels of technical and business management skills were the main areas of training identified within the stakeholder consultation. Further training areas included business succession planning and Information Technology skills (IT); specifically how IT can be used to reduce workload and manage information. A recurrent theme from the stakeholder consultation exercise was the need for farmers to develop good information handling and analytical skills.

> "*Technical efficiency, business management and sustainability*". *(MP)*

> "*How to collect (proper) data and how to manage and interpret it, especially on beef and sheep farms*". *(AP)*

The main emphasis among the stakeholder responses was towards getting farmers to 'take ownership' of data aimed at improving key farm performance indicators. For example, undertaking their own analysis of costs of production and setting targets to improve profit margin per unit of output or per hectare of land.

> "*Training in collecting data and understanding performance indicators and costs on the farm; benchmarking against other similar farms and then using this data to make decisions*". *(AP)*

When asked to respond to the question, 'Over the next five to ten years, what areas do you consider should be a priority for training and skills development for the industry at farm-level', there was a common consensus across all the stakeholders that training should aim to improve farm technical efficiency and business management skills.

> "*Training gives the farmer the potential to make broader decisions around the farm business*". *(FO)*

Those who responded as part of the farmer survey identified management and business skills as the priority area, followed by technical agriculture and subsequently animal and plant health and welfare (Figure 2).

When asked, what an up-skilled agricultural sector would look like stakeholders indicated that,

> "*Farmers, from whatever farm size or system, would be more empowered to make broader decisions around the farm business, which may involve looking at off-farm opportunities, new markets, new innovations around the resources that they have and diversification opportunities*". *(LTS)*

> "*Farmers could speak from a position of knowledge rather than perception*". *(MP)*

Furthermore, focusing on the farm as a whole resource and identifying ways of maximising resource use was an important aspect of farming for the stakeholders; with a greater emphasis needed on developing skills which allow farmers to develop new opportunities through innovation and diversification.

> "*There needs to be an emphasis on innovation and exploring how farms can develop other income streams through diversification and innovation*". *(PS)*

Mandatory training

The majority of stakeholders indicated that training should be mandatory in areas such as first aid, manual handling, use of pesticides and medicines, basic IT, health and safety. However, some stakeholders were resistant to the idea of training being viewed as a "*licence to farm*" i.e. farmers must have a minimum level of agriculture education to farm. There was a general consensus that training should be incentivised, for example, completion of training could provide access to additional funding and subsidies.

> "*Not sure in legal sense, but conditional on receiving certain types of investment and support*". *(AP)*

> "*See the need for training, but want people to do it for themselves. It should be a carrot not a stick approach*". *(FO)*

Main methods of Training

The stakeholder consultation concluded that the main training methods for farmers should be practically orientated, allowing them to see the benefits of newly emerging techniques and best practice in an applied way. It was judged that this would be best achieved through a mixture of learning methods; from 'on the job' learning to farm visits aimed at showcasing new innovations and best practice. Stakeholders acknowledged that individual farmers do respond differently to different ways of learning hence a need to include a range of different training methods in lifelong learning for the agriculture sector.

> "*Practical vocational training not in a classroom*". *(AP)*

> "*Host farm visits - seeing from the experience of others*". *(MP)*

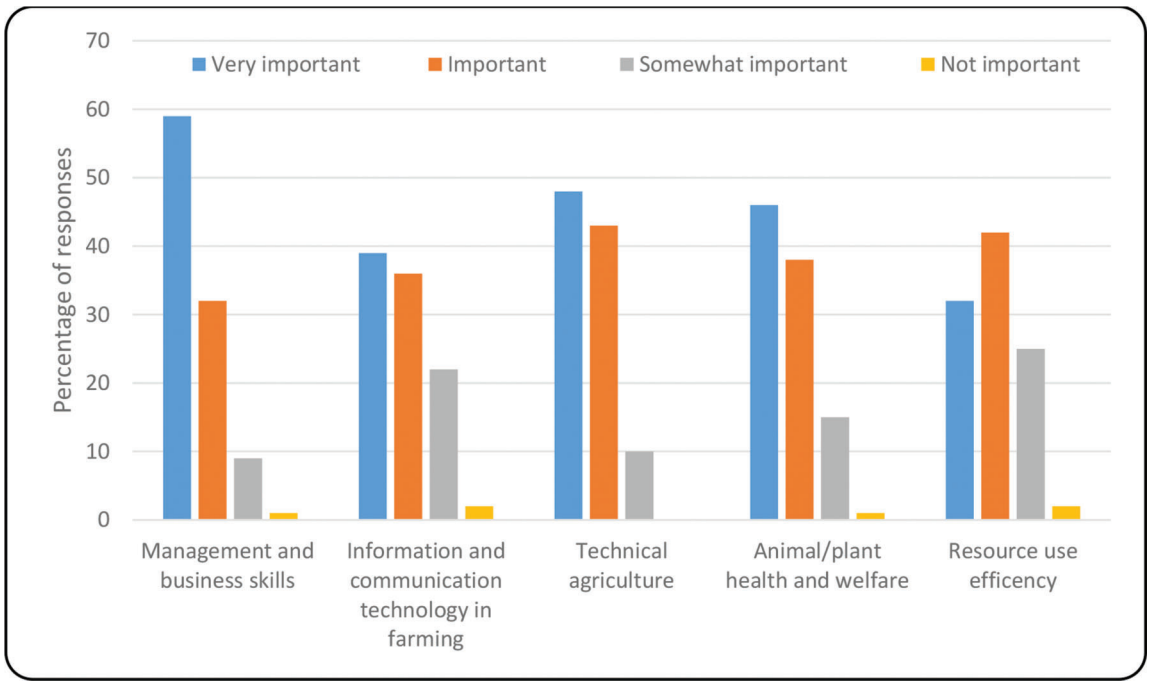

Figure 2: Percentage distribution of survey respondents by priority training areas over the next 5 years

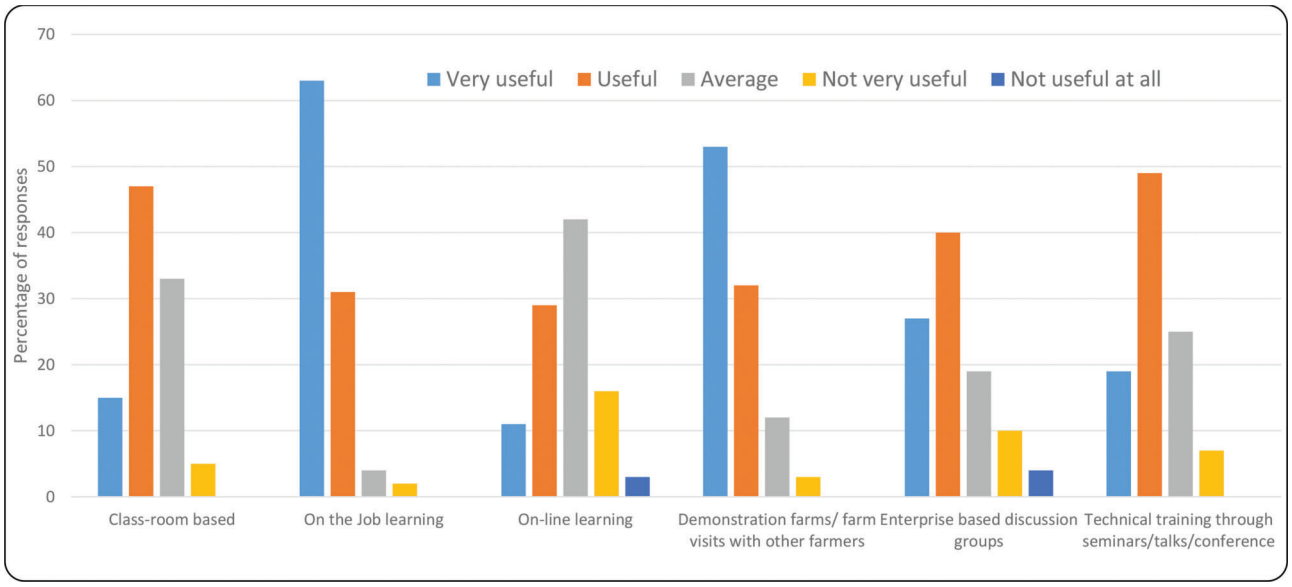

Figure 3: Percentage distribution of survey respondents rating of different training methods

The farmers responding to the survey also expressed an overall preference for non-formal training methods, such as on the job learning alongside demonstration farms and farm visits focused around specific technologies and practices (Figure 3). Stakeholders emphasised that colleges and universities needed to develop students' business management skills (understanding and interpreting business figures and data), their proficiency in IT skills and develop their problem solving and critical thinking skills by employing more problem-based leaning techniques and 'real-life' case study approaches. These should not be limited to decisions around farm production but should also explore medium term strategic management decisions. For example around decisions to introduce a new farm enterprise, on-farm diversification and succession planning.

> "*Need training through practical case studies as it is a better way of learning, not just desk bound learning*". *(PS)*

> "*Agriculture should be as innovative as any other sector - farmers have a wide range of resources and possible other incomes that can come from it*". *(LTS)*

Overall, farm discussion groups, a relatively new approach to advisory extension services in NI focused around peer to peer learning, were viewed as a positive mechanism in developing and delivering knowledge

transfer at farm-level. Discussion groups were deemed to provide a suitable forum for demonstrating new and improved technologies and best practice techniques, providing an opportunity for farmers to learn from each other and discuss business issues and relate this back to their own farming situation.

> *"They (discussion groups) are good because farmers pick up information more from other farmers, farmers like to see others doing it and if they see it working on another farm then it makes it easier for them to adopt new technologies". (FO)*

Furthermore the value and benefits of discussion groups beyond their aims around improved farm performance and knowledge transfer were also identified:

> *"They may help reduce the level of isolation that farmers can experience and allow social interaction; that is they could be seen as a mechanism for peer-to-peer support, which is important in times of financial pressures". (PS)*

Barriers to training

This study identified that the main barriers to training were cost, time, location (must be local), the availability of someone to look after the farm to allow participation, the relevance of courses offered; and the age and attitude of farmers themselves.

> *"Time – farms are busy places (releasing time to invest is a problem)". (AP)*

> *"Cost, time and accessibility". (LTS)*

Both the stakeholder consultation and the farmer survey indicated that for part-time farmers, who have off-farm jobs, finding the time to attend courses during the day can be difficult highlighting a need to explore other training delivery mechanisms and times.

> *"A lot of part time farmers have other commitments". (MP)*

A number of stakeholders expressed concern that a negative learning experience can impact on a farmer's future engagement in learning. That is, if farmers undertake courses which are too wide-ranging and lacking relevance to their farming situation this may result in them deciding not to participate in training in the future.

> *"Courses need to be relevant and have up to date information". (FO)*

> *"Relevance of training is important to get farmers to attend training". (PS)*

Farmers ranked improving farm business performance as the most important reason for them to participate in training (Figure 4) and the most important factor affecting their decision to undertake training was the perceived relevance of the training to their business (Figure 5). In general, a more 'business focused approach to farming' was identified as one of the biggest challenges facing the sector.

> *"There is a need to move away from the idea of farming as a "way of life" and doing it the way it has always been done to a more business focused attitude". (AP)*

The majority of farmers surveyed recognised the need to improve their farming knowledge and indicated that they would need more training in the future in order to achieve this. Whilst acknowledging farmers' openness to training, the stakeholder consultation respondents perceived a greater need for farmers to engage in lifelong

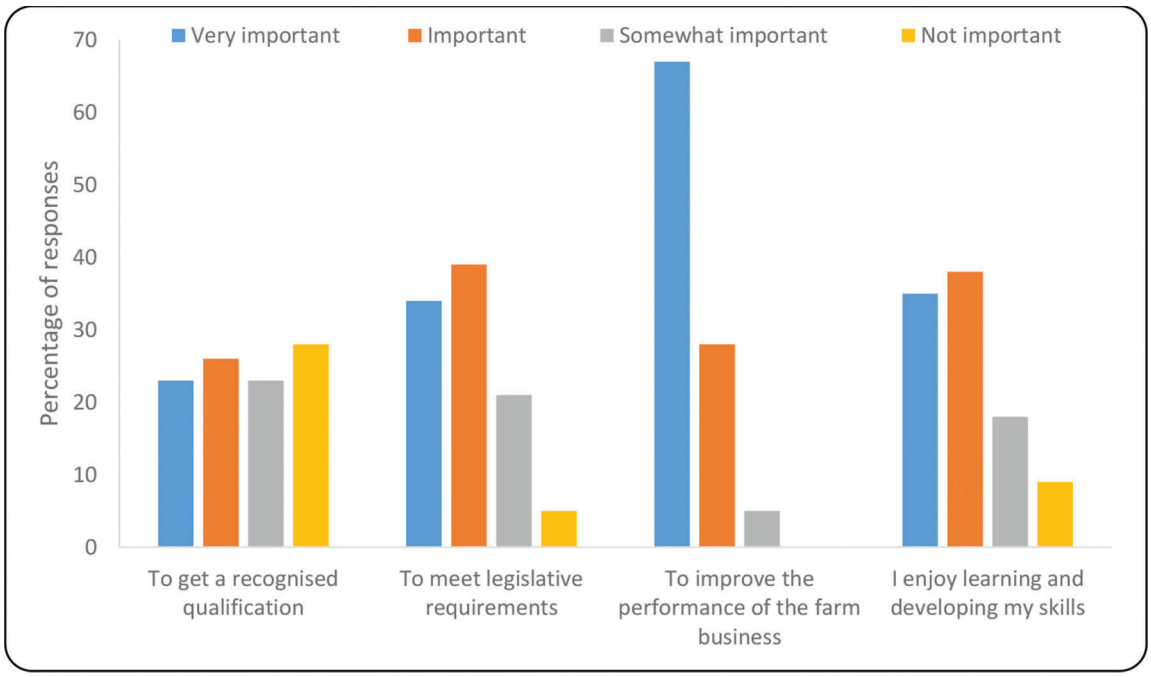

Figure 4: Percentage distribution of survey respondents rating of their reason to undertake training

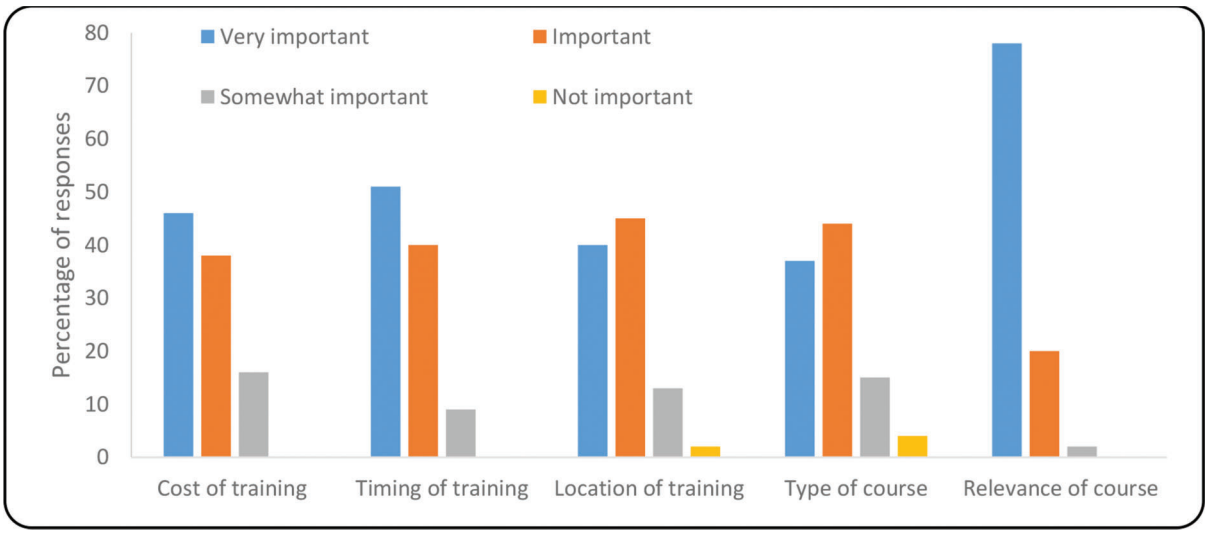

Figure 5: Percentage distribution of survey respondents rating of factors affecting their decision to undertake training

learning to bring about change and innovation in the sector and develop skills which would allow them to be more responsive and adaptable to markets, new technology and innovations, and wider policy changes.

> "*Need to change farmer's attitude and behaviour so they themselves want to seek out the further training they need*". *(LTS)*

Perceived Skills Gaps

The general conclusion emerging from all stakeholders was that there is considerable variation in the level of skills amongst farmers. A few stakeholders indicated that there was a perception that NI farmers' skills levels are lower than farmers in other parts of the UK and Ireland. In addition, it was perceived that skill levels differed between sectors, with the more intensive sectors (pigs and poultry), viewed as having a higher skills base, this was considered to be partly due to the supply chain within these sectors having a more vertically integrated structure.

> "*Most farmers are able to do most things, just not all at a high level*". *(MP)*

> "*Large gap on financial skills side, very low knowledge base*". *(PS)*

The stakeholders believed beef and sheep farmers had the lowest level of skills and training. However, it was acknowledged that this was probably reflective of the diversity within the sector, in terms of farm size, systems and structures and whether farms were operating on a part-time or full-time basis. Age was also identified by the stakeholders as a factor influencing skill levels, with the younger cohorts of farmers perceived as being more willing and prepared to engage in training and developing skills.

> "*Big gap especially in older generation*". *(FO)*

> "*Younger farmers have more of the necessary skills than older farmers because they have been taught them*". *(LTS)*

The pace of change within the sector, driven by increased globalisation, was seen as a factor that would have a significant impact in the future; not just on farmers but also on the wider agri-business supply chain and all the key actors involved within it. Stakeholders expressed a need for increased skills levels within the sector as the approach of '*It's been done that way before and it is how it will continue*' will not be sufficient to deliver improved performance and sustainability into the future.

4. Discussion and Policy Implications

Throughout European agriculture there is an increased awareness of the need to develop more efficient farming systems that are economically and environmentally sustainable (Coomes *et al*., 2019). Furthermore, UK farmers are facing potential challenges and opportunities from the impact of Brexit which has the potential to change the trajectory of many farming businesses (Davis *et al*., 2017). The post Brexit UK policy environment is orientating towards developing a whole farm approach which integrates efficient food production alongside incorporating more environmentally sustainable farming practices, (DEFRA, 2018; NFU, 2019). This will place new demands on farmers in terms of their need to adapt their production and management practices at farm-level. This inevitably will require farmers to improve their knowledge and skills base and to adopt farm-level innovations, improvements and best practice.

This will present particular challenges for the NI farming population as, in general, it is characterised by a low level of engagement and attainment of agricultural training compared to other regions, despite research highlighting that investment in skills and training provides positive returns (Jack and Wallace, 2011). The findings emerging from this mixed method approach of both the stakeholder consultation and the farmer survey identified a need to advance lifelong learning amongst farmers through a programme of continuous professional development. The study identified that such programmes need to provide for two distinct and discrete groups namely; those young people coming into farming with a view to becoming farm managers/work in the

industry in the future and a relatively older cohort of farmers with substantial farming experience.

Both the stakeholder consultation and farmer survey acknowledged that the pace of change within the sector, whether it be market, policy and/or legislative change, was an important factor in creating learning and skills gaps. This is supported by research undertaken in the US over the past 20 years looking at the educational and training needs of farmers, which has shown that the educational needs of farmers are continually evolving over time (Carter & Batte, 1993; Joerger, 2003; Eberspacher and Jose, 2005; Suvedi, Jeong and Coombs, 2010).

A strategy for delivering a programme of continuous professional development in agriculture should have a strong emphasis on training as an investment and the benefits that engaging in lifelong learning programmes can bring to the farm business. When making a capital investment on farm, whether it be a new piece of machinery or upgrading farm buildings, farmers recognise the benefits that the investment will bring to the farm business. In a similar way, the research results identified an increased need for this to be communicated to farmers in order to develop their understanding of why investing in their own development can lead to positive returns within a farm business. An important finding of the research was the need for increased collaboration among the key stakeholders within the agricultural skills development sector, i.e. industry, educators, researchers and government, to encourage cultural change that will develop a more positive attitude towards lifelong learning within the farming industry. Furthermore, the research identified the need for post qualification engagement between training providers and students, in order to help embed and encourage participation in lifelong learning throughout their farming career, which supports the research by Turner and Irvine, (2017) and Hall, Turner and Kilpatrick (2019).

This study identified that wider consideration needs to be given by agricultural education and training providers to the level of existing knowledge and the age profile of their student cohort groups. In general, younger farmers have higher levels of formal educational achievement compared to older farmers (Eurostat, 2013), and different age groups will prefer different methods of delivery. Failure to take account of this would impact on farmers' engagement and uptake within a professional development programme. This is further emphasised by a previous study conducted by Ota *et al.* (2006) who highlighted that in order to deliver effective lifelong learning a combination of teaching strategies (lectures, problem based learning, case studies, and role play) have the greatest impact. Furthermore, Kilpatrick (1996), Hansen (2015) and Hall, Turner, Irvine *et al.* (2017) have found that a farmer's level of formal educational attainment can influence their perceived motivation to participate in learning. Those who have low levels of formal learning find it more difficult to engage in further lifelong learning while those farmers with higher levels of formal education are more likely to seek further opportunities for learning. The results from this study have shown that farm and research demonstration visits aimed at showcasing new techniques and best practice are the most popular. For those farmers coming from a less formal educational background these methods make training and learning more accessible. The challenge from an educational delivery perspective is to ensure that, improvements in knowledge, skills and competencies are achieved through a range of formal and in-formal techniques which provides for a range of individual preferences and requirements.

Survey respondents expressed an overall preference for non-formal training methods which are short in duration and relevant to farm business needs. This supports the findings of Hall, Turner and Kilpatrick (2019) who found that farmers were more likely to attend non formal training on a topic that was relevant to their farm. The research identified a range of barriers that contributed to farmers nonparticipation in training, these were similar to those widely identified in the international literature (Kilpatrick and Johns, 2003; Seymour and Barr, 2014). From the current study the convenience of both location and timing of training is important but added to this in terms of encouraging engagement is the relevance to a farmer's particular farming system. The overall design and implementation of agricultural training and skills provision, needs to ensure that progression along a 'learning and skills pathway' is visible and accessible, as non-formal training and skills programmes were seen as a gateway for younger farmers to move into a more formal qualification.

The survey and stakeholder feedback identified the important role that technically capable advisors bring to the farming sector which supports the findings of Hall, Turner and Kilpatrick (2019). An important aspect of that relationship is their ability to build trust and employ their professional knowledge in assisting the farmer to identify what training would be relevant to their farm business. There is a role for the advisors to identify with farmers what skills they need and assist them to navigate their training needs. However, in the context of a more complex farming environment which is becoming more technology and data driven (Wolfert *et al.*, 2017) there is an increased need for advisors to be provided with the time and resources to engage in their own continuous professional development and keep their specialist knowledge up to date and aligned with best practice.

A recurrent theme from the stakeholder consultation was the need for farmers to develop business-oriented skills and strategies. Developing analytical skills was seen as relatively more important in the current farming environment compared to the past. An increased emphasis is needed in getting farmers to 'take ownership' of data in order to improve the key performance indicators of their own farm business. It was also highlighted that there was a need for farmers to recognise that in order to be sustainably competitive they must engage with those innovations and technologies which will improve their business performance alongside developing technical and business management skills. These findings concur and support evidence from a recent study undertaken in the Republic of Ireland examining training for dairy farm managers (Deming *et al.*, 2019).

The implementation of an upskilling programme which emphasises developing business orientated skills and best practice adoption will provide challenges as it represents a major change for all those involved in the industry; farmers, agri-food processors, educators, researchers and government. Due to the pace of change that the industry is facing, technological advancements

and wider societal demands, there is a greater need for the main agriculture educational providers to engage more with other education providers (universities and research institutes), farmers and agri-food processors in order to keep pace with changes in the sector and to ensure that the resulting programmes and curricula are meeting industry requirements. This engagement could take the form of establishing a wider industry consultative body to oversee the strategic development of an agriculture and land based training and skills development programme.

A limitation of this study was the small number of farmers who responded to the survey. There was no database of farmers with agricultural qualifications available, therefore, the authors went to considerable effort to ensure the survey was advertised widely through the farming press, knowledge transfer newsletters and by the farming unions. The authors have come to the conclusion that the limited response reflects a certain level of disengagement in formal agricultural training amongst the farming sector in NI. This in itself provides a basis for undertaking further research in this area to gain a better understanding of why there is a low level of participation in formal agricultural training.

5. Conclusion

This research focused on examining the current and future skills requirements within the primary agriculture sector in NI and how knowledge provision should be adapted to best meet farmer and industry needs. A mixed methods approach, combining structured interviews of key stakeholders and a survey of farmers was employed. The results from this study have offered a number of recommendations around the future provision of agricultural training which are considered relevant to NI and other regions, with similar farming structures, both nationally and internationally.

Embedding key professional skills, both business and technical, into the more practical aspects of farming through a programme of Continuous Professional Development (CPD) should be a priority. Delivery will require improved collaboration between education providers and the wider industry as this study has identified a 'mixed methods approach' as the most appropriate way of securing farmers' engagement and adoption of new practices. The main training providers should explore the possibility of widening delivery of courses, in conjunction with local Further Education Colleges, particularly with a view to facilitating access to provision for part-time farmers. Teaching and advisory staff should be provided with the time and resources to engage in their own CPD, keeping their specialist knowledge up-to-date and increasing their knowledge of new technologies together with new approaches to learning, as they arise.

In general, the study identified that there was a need to encourage a more positive attitude towards qualifications, training and lifelong learning in the primary agriculture sector. The wider industry needs to lead on promoting a positive image of farming as a career, focusing on the technological and scientific nature of modern agriculture and the role of farmers in managing sustainable rural businesses. Moreover, the findings indicate a requirement for greater partnership among the key players; researchers, extension services and educators due to the pace of change in relation to new innovations, technologies and practices within the sector. This would allow for a more timely transfer of new science and innovations to be translated into farmer learning and innovation, resulting in behavioural and practice changes at farm level.

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Competitive Strategy Analysis of NZ Pastoral Dairy Farming Systems

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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 is the same for all systems, cost leadership, 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.

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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:

$$\text{RoA} = \text{OPM} \times \text{ATR} \quad (1)$$

Where OPM = operating profit / gross farm revenue
ATR = 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.

RoA and RoE calculations used by DairyBase and for this analysis are as follows:

$$\text{Return on Assets (RoA)} = (\text{operating profit} - \text{rent})/\text{opening assets} \quad (2)$$

$$\text{Return on Equity (RoE)} = (\text{operating profit} - (\text{interest rent}))/\text{opening equity} \quad (3)$$

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

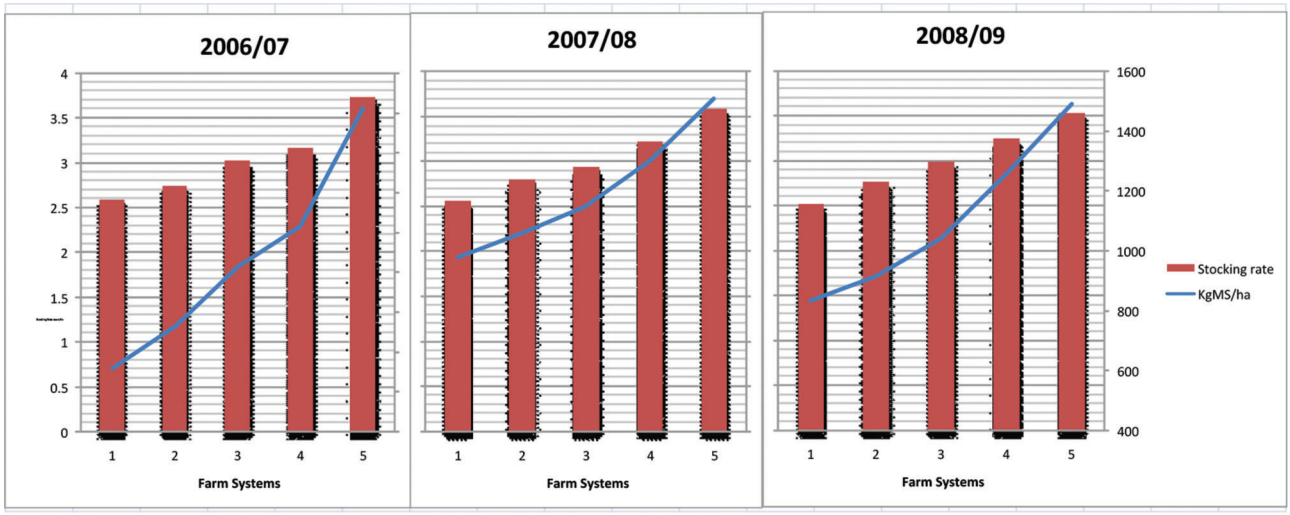

Figure 1: Stocking rate (cows/ha) and production (kilograms milksolids (MS)/ha) for the three years of 06/07, 07/08 and 08/09 by farming system

The RoA, RoE, OPM and ATR all feature as recommended ratios by the FFSC (1995) and Barry *et al*. (1995) 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.

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

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.

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[3] 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

[3] All financial expressions are in New Zealand dollars. In mid-January 2012 one $NZ was worth approximately $US 0.80, £0.52 and €0.62.

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. 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, did not deliver an equal, not a greater return on equity. There was also no significant difference over 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 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).

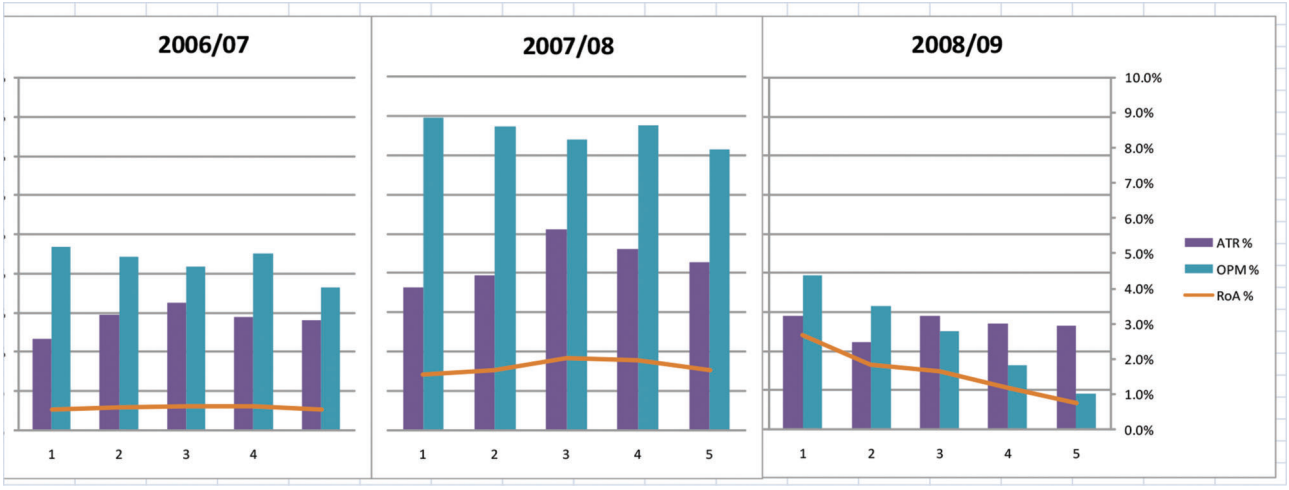

Figure 2: Return on Assets (RoA), AssetTurnover (ATR) and Operating Profit Margin (OPM) for the three years of 06/07, 07/08 and 08/09 by farming systems (1,2,3,4+)

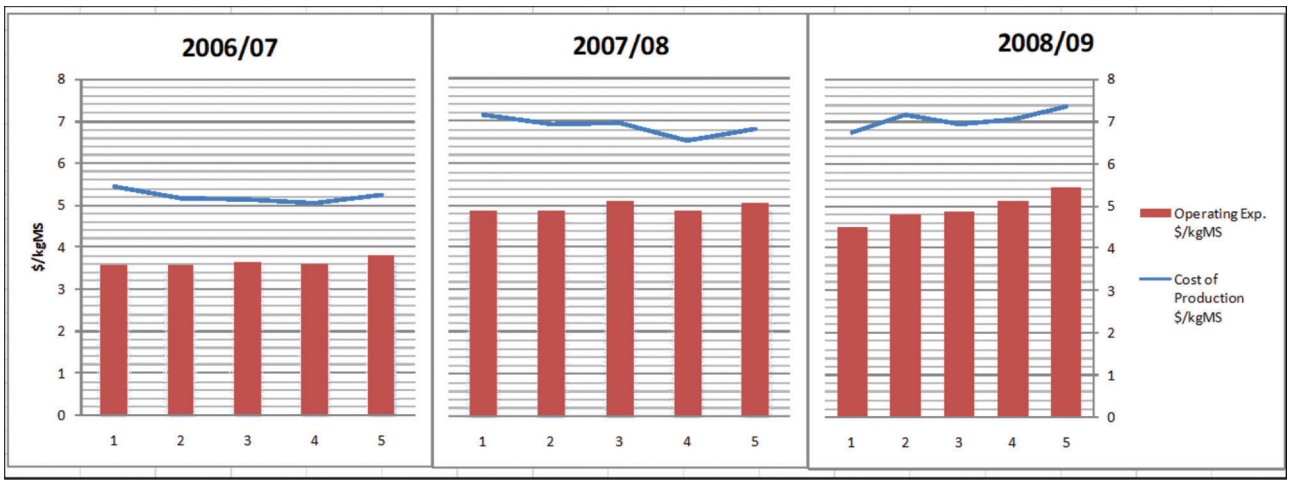

Figure 3: Operating Expenses and Cost of Production ($/kgMS) for the three years of 06/07, 07/08 and 08/09 by farming systems (1,2,3,4,5)

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

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 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.

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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 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%

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

IVY DRAFOR[3]

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'

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inability to cope with the systems, which were developed with limited community involvement.

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. Cash books 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. Care is to be taken in intercropping situations. 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

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REFEREED ARTICLE[1]

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An economic analysis of the Irish milk quota exchange scheme

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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 eminent 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 on 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 move after the abolition of quota. Further, the

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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 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:

$$\underset{Q_i}{Max} \prod i = \sum_{t=0}^{T} \frac{1}{(1+r_i)^t} [\pi(M_{it}) - P_t Q_{it} - C(Q_{it})] \quad (1)$$

where $\prod_i$ 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[5]. 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 Qit 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.

[5] 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.

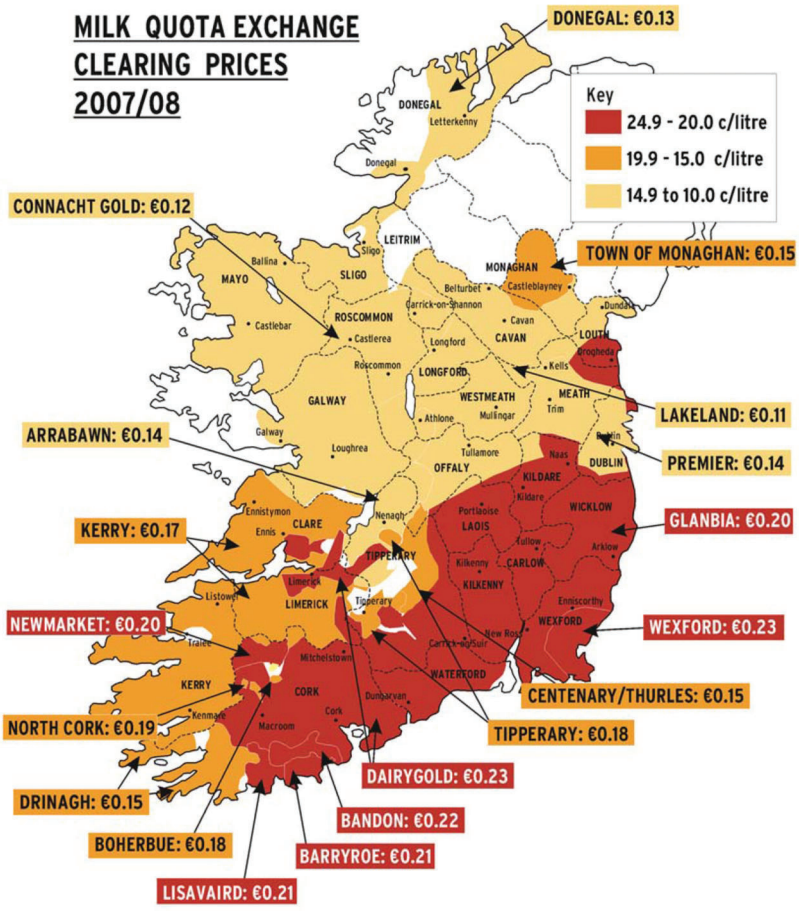

Figure 1: Milk Quota Exchange Clearing Prices. *Source: Irish Farmers' Journal (2007)*

Since it is assumed that milk deliveries M_{it} are equal to the farm's milk quota in period t, then:

$$M_{it} = M_{it-1} + Q_{it}. \tag{2}$$

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:

$$L_i = \sum_{t=0}^{T} \frac{1}{(1+r_i)^t}[\pi(M_{it}) - P_t \cdot Q_{it} - C(Q_{it})] + \sum_{t=0}^{T} \lambda_{it}(M_{it-1} + Q_{it} - M_{it}). \tag{3}$$

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[6].

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 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

[6] 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.

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[7] 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[8]. 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.

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.

[7] 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.

[8] 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.

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[9]. 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 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 of 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 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[10].

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.

[9] In late February 2012 €1 was approximately equivalent to £0.85 or U$1.35 (www.xe.com)

[10] The three months average milk price preceding the quota exchange scheme is used.

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)

Table 2: Milk Quota Exchange Clearing Prices for Selected Co-operatives

	2007/08		2008/09		2009/10		2010/11
Exchange	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**
Closing date for bids	10/06	01/07	10/07	01/08	10/08	01/09	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*

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

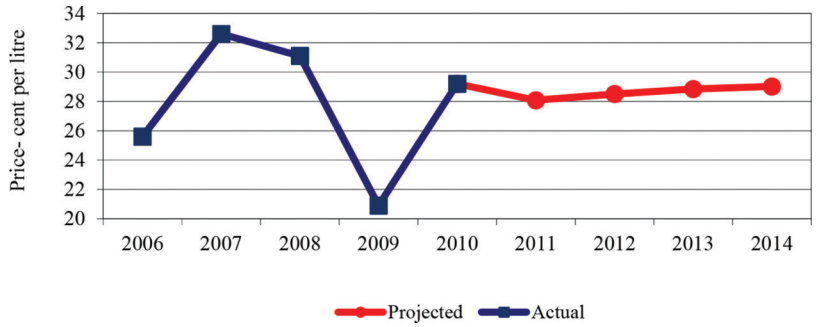

Figure 2: FAPRI-Ireland Farm-Level Milk Price Projections for Ireland. *Source: Binfield et al. (2008)*

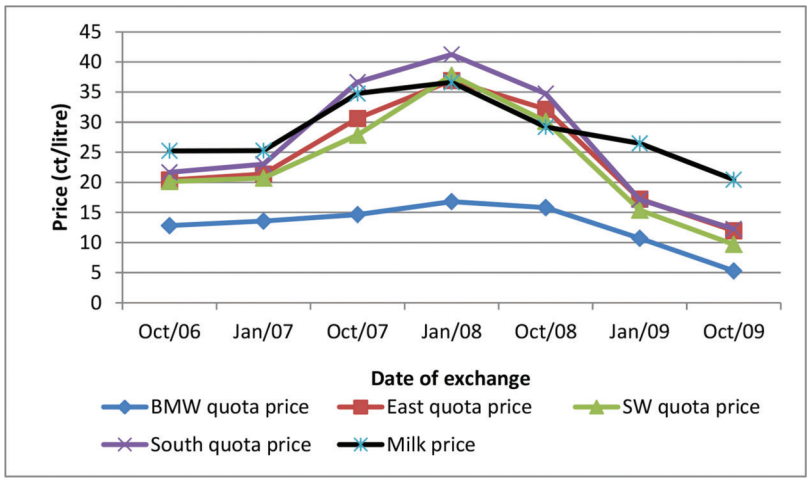

Figure 3: Development of Prices by Region

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.

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 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, 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 with 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

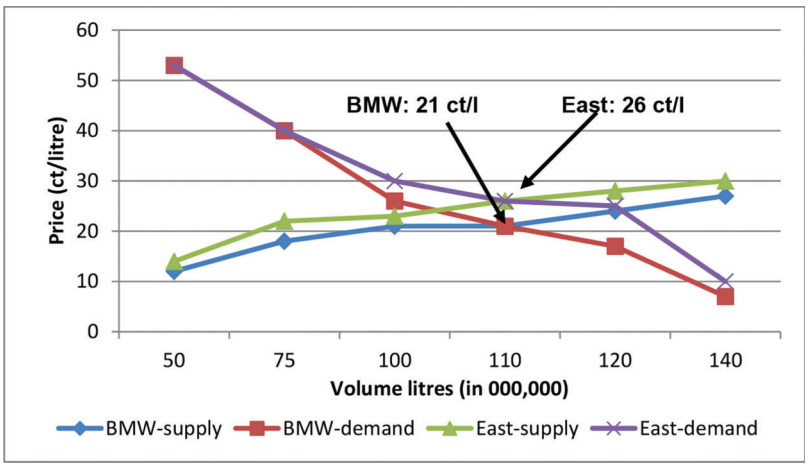

Figure 4a: Regional Milk Quota Market – BMW and East Region

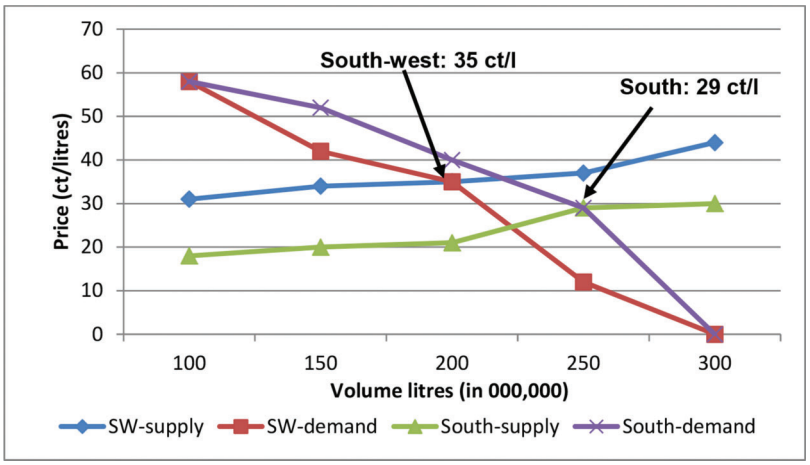

Figure 4b: Regional Milk Quota Market – South-west and South Region

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.

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 estimations 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 results allow suggestions 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 of 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.

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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[11]. 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:

$$C_{ix} = \frac{23(Wage_t) + (0.1 + IntFac_t)}{(Yield_{it})} \frac{(InfraX) + NDprof_{it}(1 + RP_i)}{} \quad (5)$$

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:

$$C_{iy} = \frac{\left(Rent/_{SR_i}\right) + 35(Wage_t) + (0.1 + IntFac_t)}{(Yield_{it})} \frac{(InfraY) + (1 + Int_t)(CowCost)}{} . \quad (6)$$

[11] 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.

REFEREED ARTICLE

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Eliciting Farmers' Willingness to Pay for Innovative Fertilizer Against Soil Salinity: Comparison of Two Methods in a Field Survey

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ABSTRACT

Salt stress noxiously shocks agricultural yield all over the world affecting production whether it is for subsistence or economic outcomes. Although agribusinesses are constantly seeking new technologies or inputs with novel attributes, they are not able to properly price these products and usually are based on the cost of production adding the percentage of profit they are seeking on that market. In order to uncover farmers' preferences for an anti-salinity product as well as, the determinants of farmers' willingness to pay for it, primary data were collected from 150 farmers in the regions of southwest Greece. Our estimates revealed that farmers would be willing to pay almost 22.91 €/lt for an innovative fertilizer against salinity. The results suggested that farmers' willingness to pay for the specific anti-salinity product is influenced by a host of factors. Especially the empirical results showed that the size of cultivated land, the level of education, the knowledge scale about salinity, and the package of liquid fertilizer that farmers usually buy have a positive effect on willingness to pay. The implication is that taking these factors into account while large companies are looking for new and profitable products by investing in research and development enables companies' managers to come up with projects that win acceptance from the farmers.

KEYWORDS: Salinity; Willingness to Pay; Contingent Valuation; Inferred Valuation; Dichotomous Choice

JEL CODE: C10 C29 C83 D12 M31 Q16

1. Introduction

Most plants are exposed to a lot of stresses throughout their life cycle. Abiotic stresses, such as salinity, drought, chemical toxicity, extreme temperatures, and oxidative stress are major threats to agriculture, leading to the downgrading of the environment. Salinity is among one of the most challenging environmental constraints to crop productivity worldwide. Salt stress has a serious impact on agricultural yield all over the world affecting production whether it is for subsistence or economic outcomes. According to Ghassemi *et al.* (1995), more than 12 billion US $ per year losses in agricultural production systems are estimated from salinity and the cost is expected to increase as soils will be further affected.

The term ''salinity'' refers to the presence of dissolved salts in soil and water in high concentrations that are detrimental to the soil. The composition of salts in large amounts mostly are calcium, sodium, magnesium, chloride, and sulfate ions and in relatively small amounts are potassium, carbonates, bicarbonates, borate, and lithium salts (Zhu, 2001). Approximately 17% of the world's cropland is under irrigation, but irrigated agriculture contributes much more than 30% of the total agricultural production (Hillel, 2000). Therefore, secondary salinization of irrigated lands is crucial for global food production (Machado and Serralheiro, 2017). High salt levels cause various effects on plant physiology such as ion toxicity, changes in plant growth, elementary nutrient deficiencies, decreased photosynthetic capacity, nutritional disorders, hyperosmotic stress and ion disequilibrium, leaf burn, necrosis, and defoliation (Shrivastava and Kumar, 2015). These effects vary among species and especially among varieties of a given crop. In fact, it is difficult to accurately determine the level of salt concentration in which the crops are more resistant, due to the fact that plant sensitivity depends on different and mutually interacting factors such as climate (temperature and potential evaporation),

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soil fertility (availability of nutrients), soil physical conditions (porosity, aeration, water regime), genotype and plant age. In addition to the salinity resistance mechanisms developed by the plant itself (salt inclusion, salt exclusion), several techniques have been also developed in order to reduce the phenomenon. Farmers facing several problems with their crops that are affected by salinity and it is of crucial importance for them to be aware of the ways in which plants respond to high levels of salinity, the relative tolerances of different crops, their sensitivity at different rates of growth as well as to find the right products or methods to ameliorate the production of their crops. Resultantly, we could assume that there is a high demand for ''anti-salinity'' products.

For the above reasons, producers and agribusinesses are constantly seeking new technologies or inputs with novel attributes that may help them to reduce production costs and at the same time increase their revenue. However, the novel nature of these products does not imply that prospective suppliers have data from actual markets to estimate the potential demand for these new products or inputs (Zapata and Carpio, 2014). Even if they roughly estimate the demand for new technologies or inputs, they are not able to properly price these products and usually are based on the cost of production plus the percentage of profit they are seeking on that market.

Contingent valuation, a survey-based methodology, was initially developed to elicit the value (i.e. Willingness to Pay) that people place on nonmarket goods and services. The majority of the theoretical and empirical studies have been focused on the consumer side, rather than on the producer side. These studies are focused on consumers' Willingness to Pay (WTP) for novel products, food quality enhancements or specific attributes. However, little conceptual or empirical work has been conducted to understand the monetary value that producers place on the new technologies or novel products that will reduce their cost production (Lichtenberg and Zimmerman 1999; Qaim and Janvry 2002; Danso *et al*. 2006; Bakopoulou *et al*. 2010; Ulimwengu and Sanyal 2011; Abaidoo *et al*. 2014; Uddin *et al*. 2016; Etim and Benson 2016; Bozorg-Haddad *et al*. 2016; Adnan *et al.* 2017) compared to the numerous studies have been conducted for consumers' perceptions. It is worthwhile to mention that most of these studies have been mainly conducted in developing countries while a very small number of studies including information about farmer acceptability and WTP are not widely reported in Greece. There is a statement that the studies conducted in developing countries could result in lower external validity for the agriculture sector in developed countries where the figures in terms of wages and access to resources (e.g., improved technology, people employed in agriculture, farm size and production) are completely different. There are several challenges of conducting field experiments with farmers especially when there are no economic incentives for them to participate in a survey and this may be a significant reason for the small number of studies that had been conducted with farmers. This may also justify the small number of farmers participating in surveys involving producers, which is evident in most published studies we have already mentioned above. Limited research suggests that farmers are more likely to respond when promised monetary incentives (Weigel *et al*., 2020), too. The present study has a sufficient number of participants and it is worth noting that their recruitment was quite difficult as we targeted specific types of crops where the good under valuation can be applied.

For a farmer (producer), it is significant to maximize his/her profit-making decisions according to budget limitations, input, and product combinations. In the same way, companies define their production according to their technological equipment, cost constraints, and the inputs' plurality of combinations in order to produce outputs. Through the willingness to pay (WTP), it is possible to formulate the demand curve for a new entrant product in the marketplace. As a result, the average value could be considered as an estimation of the price that farmers could pay for a desired amount of input. To the best of our knowledge, farmers' preferences, and willingness to pay for fertilizers against soil salinity have not been investigated. Furthermore, additional research into this area demonstrates a number of non-financial variables affecting the decision of farmers on the adoption of new technologies and policies, such as farmer and household characteristics (e.g., age, education, gender), type and size of the farm, grower's social milieu (e.g., local culture, social attitude, fellow farmers, policy environment) and the characteristics of the innovation to be adopted (Murphy, 2012).

The objective of this study is to elicit and evaluate producers' WTP for the adoption of a novel fertilizer against salinity and define the major factors affecting the payment decision amongst greek farmers, employing traditional stated preferences methods augmented with recent methodological advances designed to identify and weed out potential biases. This is important for agrochemical companies or agricultural research organizations promoting new products and technology (i.e. fertilizer, seeds, varieties, etc).

2. A Theoretical Review

The theoretical model which employed in this article, was developed by Zapata and Caprio (2014), within the context of neoclassical theories of utility and profit maximization. It allows the analysis of producers' WTP for a change in quality of any factor of production such as a novel fertilizer against the salinity. More specifically, the variation function, or producers' WTP, for novel inputs or technologies is derived using an individual indirect utility function in combination with the firm's profit function. This theoretical model is developed in a context where the production function $f(\boldsymbol{X},\boldsymbol{q})$ has, as arguments, a vector of input quantities $\boldsymbol{X}$ and a vector of input quality levels $\boldsymbol{q}$. The level of $\boldsymbol{q}$ is fixed exogenously; thus, the profit and cost functions are also conditional on $\boldsymbol{q}$. The analysis considers an improvement on a particular input quality level, qi.

The theoretical results imply that the maximum amount of money that a producer is WTP for a new production factor is equal to the difference between the *ex post* and *ex ante* firm's profit levels. Moreover, the producers' WTP is a function of output and input prices and input *ex ante* and *ex post* quality levels.

To elicit valuations for an innovative fertilizer against salinity, we employed the Contingent Valuation Method

(CVM) which belongs to stated preference methods[3]. The CVM has become one of the most widely used methods to measure WTP values for private and public goods, services, or amenities. In simple terms, CV is a survey-based technique regularly used for placing monetary values on environmental goods and services not bought and sold in the marketplace. CVM is simple and has great flexibility, as well as allowing estimation of a total economic value, rather than just components of that total value[4]. This is not possible with many of its alternative non-valuation techniques.

The CVM was initially proposed by Ciriacy-Wantrup (1947) only at a theoretical level. However, the first empirical CV survey started with Davis (1963) who tried to estimate the benefits of goose hunting through a survey among the goose hunters[5]. Its application in other areas in economics such as health economics (e.g., Johannesson *et al*., 1991; Johannesson *et al*., 1993; Liu *et al.,* 2000), transportation safety (e.g., Persson *et al*., 2001) and cultural economics (e.g., Santagata and Signorello, 2000) was being increasingly developed. Except for these areas, it has made significant progress in the valuation of food safety and food products in the last decades (e.g., Gil *et al*., 2000). It is called ''contingent'' valuation since as people are asked to state their WTP, it depends on a specific hypothetical scenario and description of the environmental service.

It is common that CVM can be applied to goods that are and are not traded in regular marketplaces. In particular, a hypothetical valuation scenario is created in which respondents are asked to state their maximum WTP for the product undervaluation. An important aspect of CV surveys is the choice of payment vehicle that is being selected for the valuation question. Besides the fact that a number of payment vehicles give incentives to participants to answer strategically, the Organization for Economic Cooperation and Development suggests that the comparison of mean WTP with different payment vehicles (OECD, 1989) could contribute to the choice of the appropriate payment vehicle in a variety of surveys.

There are many different question modes that can be used such as open-ended (OE), bidding games, payment card, choice experiments, single-bonded and double bounded methods. Nevertheless, CVM is subject to severe criticism as economists have raised several types of objections. A large number of studies have shown that results from the CVM may seriously be sensitive to social desirability bias (hereinafter SDB) (e.g., Phillips and Clancy, 1970, 1972). In fact, SDB is considered to be one of the most common sources of bias affecting the validity of experimental and survey research findings (Peltier and Wash, 1990; Paulhus, 1991) and refers to the tendency of participants to give socially desirable responses instead of selecting responses that reflect their true feelings, placing the speaker in a favorable light (Grimm, 2010). Among the methods that have been developed to restrict social desirability bias is the Inferred Valuation Method (IVM) which addresses SDB by asking participants to state their views concerning the average consumers'/producers' valuation for a good (Drichoutis *et al*., 2017). Lusk and Norwood (2009), noted that the IVM creates valuations that are less likely to suffer from biases such as SDB. Also, they found that responses based on IVM predicted consumers' actual shopping behavior much better than CVM did. The authors proved that when social desirability appeared, the IVM generated less hypothetical bias and that goods with normative dimensions are more acceptable to SDB. Consequently, the IVM is more effective to fill the gap between the laboratory and field evaluations (Drichoutis *et al*., 2017).

The Dichotomous Choice (DC) format (also known as ''take-it-or-leave-it'', closed-ended or referendum) was initially used by Bishop and Heberlein (1979), while Hanemann (1984) developed the conceptual and theoretical arguments in order to use this method to estimate welfare benefits (Ryan *et al*., 2004). Since the panel of National Oceanographic and Atmospheric Administration (NOOA) criticized the open-ended method as causing unstable and biased answers (Arrow *et al.,* 1993), the DC approach gained remarkable acceptance due to its substantial simplicity of use in data collection and Incentive Compatibility (IC). Strategies that are used by respondents have been criticized as problematic in public economic studies. In particular, Samuelson (1954) argued ''*It is in the selfish interest of each person to give false signals, to pretend to have less interest in a given collective activity than he really has*''. Incentive Compatibility can only be proposed for goods in cases that the binary choice exists between two different forms of the undervaluation good.

Hanemann and Carson (1985) proposed to add a follow-up discrete choice question in order to improve the efficiency of discrete choice questionnaires. Hanemann *et al*. (1991) indicate that the double bounded method is more preferred than the single one as they proved that adding a follow-up bid to a conventional, dichotomous choice CV survey significantly ameliorated the statistical information provided by the data. It is believed by many economists that the double-bonded model gives more information on the WTP of the respondents. However, the double-bonded dichotomous choice CV format is believed to produce more precise welfare estimates. However, there are questions about its validity as there are studies (Herriges and Shogren 1996; Alberini*et al*., 1997; Burton *et al*., 2003; Whitehead 2004; Bateman *et al*., 2008) which cast doubt on the double-bounded method indicating that this model can be inadequate and give inconsistent results. In this study, we use the single-bonded elicitation method because the double-bonded method presents a number of drawbacks. More specifically, there are concerns for the existence of starting point bias which occurs in cases where the survey tool provides a prearranged range of choices for answering their values (Ahmed and Gotoh, 2006). For a number of reasons, in CV surveys that include follow-up questions, participants tend to ''anchor'' the value they place on a good on the bid amounts presented to them in the initial and/or subsequent payment questions (Veronesi *et al*., 2011). The presence of starting point (''anchoring'') bias may control individuals' responses in a way that affects the underlying WTP directly if bid information is used by the participants to update their

[3] Techniques for measuring the WTP are categorized in those including revealed preferences (RP) and those including stated preferences (SP). The SP method asks directly individuals about their preferences. On the other hand, the RP method notices individuals' behavior in markets. The advantage of SP method is that it estimates use and non-use values while the RP method estimates the use value of a product or service.

[4] Ecosystem Valuation (Found at: http://www.ecosystemvaluation.org/).

[5] For more details see: Mitchell and Carson, 1989.

true WTP, and/or through the comparison between WTP and the bid (Veronesi *et al*., 2011). Under the double-bonded format answers to the second round are anchored on the value of the first bid (Chien *et al*., 2005; Flachaire and Hollard, 2006). There is also a possibility that responses to the follow-up questions may yield a lower WTP (Cameron and Quiggin, 1994). It is hard for researchers to apply alternative models in order to detect and fix the ''anchoring effect'' which may result in biased estimates of mean WTP, something that is obvious in the outcomes of the study of Veronesi *et al.* (2011) where biases are more severe the stronger the anchoring is, and the severity of the biases varies with the bid design used. The single double-bounded format is easier to implement and has been widely used in surveys for the valuation of water quality (Altaf *et al*., 1993), health (Cropper *et al*., 2004), and forestry (Köhlin, 2001).

There is strong evidence proving that the CV technique frequently overstates real economic value. Much of the literature compares hypothetical and actual values from several CV studies. Hypothetical bias refers to a significant difference between responses to real and hypothetical valuation questions. This situation has motivated research in order to develop methods that either eliminate or adjust the hypothetical bias. The ''cheap talk method'' was initially recommended by Cummings and Taylor (1999). They tried to decrease the hypothetical bias by completely describing and discussing the tendency of participants to exaggerate stated WTP. The use of cheap talk proved to be potentially effective as well as decreasing the mean WTP in several studies (e.g., Cummings and Taylor, 1999; List, 2001; List *et al*., 2006; Aadland and Caplan, 2003; Bulte *et al*. 2005; Landry and List, 2007). Its simplicity makes it an appealing approach in lowering hypothetical bias (Murphy *et al*., 2005). Nevertheless, in other studies this mechanism was not effective (e.g., Brummett *et al*., 2007; Loureiro *et al*., 2009). Empirical findings revealed that participants in CV surveys give answers which are inconsistent with the tenets of rational choice as well as they might underestimate or overestimate their paying ability for a variety of reasons. Carson and Groves (2007) argued that a hypothetical survey might bring in more than hypothetical responses in case the survey is perceived by respondents to be consequential. In consequentiality scripts, survey participants are clearly told that their responses to preference questions will influence competent authorities' decisions regarding the public good undervaluation. Therefore, the respondents' answers represent revealed economic behavior. In their study, Drichoutis *et al*. (2017) found that their consequentiality and cheap talk script had not any effect in mitigating hypothetical bias. External validation of the CV technique continues to be a serious issue. One way to avoid these difficulties, in part, is to design experiments in which an artificial capability is created to pay for private or public goods. Hence, it is recommended the results of a CV estimation of WTP to be compared with the ''real'' behavioral WTP for goods (in a sample or an analogous sample) that can be actually bought and sold (Arrow *et al*., 1993).

3. Survey Design

The design survey of the product undervaluation is focused on treating the symptoms of salinity. Its application is mainly proposed in crops with particular sensitivity to salinity. It is a special molecule (metabolite) of natural origin that has the potential to increase the resistance of the cultures to salinity by avoiding the process of protein denaturation when subjected to high salinity water or soil conditions. Its use at low concentrations in the plant promotes the synthesis of biologically active metabolites, which give the plant systemic acquired resistance against the stress of salinity. After the plant is ingested, the inducing agents promote a so-called ''plant-immune response'', leading to greater tolerance of abiotics. What differentiates it from other salinity management methods is that it 'treats' the plant rather than water or soil, promoting its self-defense that results in greater resistance to salinity. It is worth noting that its function is comparable to vaccination (pre-immunization) in mammals and humans. Therefore, all subjects were first informed about the new product against salinity providing a script with relevant information about the product undervaluation. In addition to the empirical objective related to the fertilizer against salinity, we also explore several methodological issues that are relevant to non-market valuation, such as social desirability bias, hypothetical bias, consequentiality of the survey, and certainty of respondents.

To answer the methodological issues, we adopt a design with elements within, as well as between-subjects, design. In order to elicit valuations for the fertilizer against salinity, we examined two packs of 1lt and 5lt capacity respectively. The specific packs were preferred as after a brief survey conducted in three Greek online and physical agricultural stores, it was observed that the packages of liquid fertilizers available on the market are mainly those of 1lt and 5 lt and less often 2.5 lt. Hence, it would be helpful for the company that produces the under evaluation fertilizer to gain knowledge about the offered prices for the capacities that are most preferable by the farmers.

At this point, it should be stressed that the price for the fertilizer undervaluation has not yet been established, since the specific salinity product is in the final experimental stage. Therefore, the ten bid amounts used for the Discrete Choice format (10 € vs. 12 € vs. 15 € vs. 17€ vs. 20 € for the package of 1lt and 37€ vs. 45€ vs. 56€ vs. 63€ vs. 75€ for the package of 5tl) were indicated by the competent company based on prices of other similar products.

For the between-subjects design, each questionnaire examined the WTP for both packages of fertilizer. The order of each package had been considered. So, half of the participants were asked to answer the WTP question for the 1lt package first and then for the 5lt package. Conversely, the rest of the sample had to answer the WTP question for the 5lt package first and then for the 1lt package. We followed this technique in order to avoid any order effects and sequential bias. Table 1 summarizes the survey's experimental design.

Moreover, a salinity knowledge index was constructed via ten ''True / False'' sentences related to salinity issues. The higher the number of correct answers, the higher the knowledge that producers have of the problems associated with soil salinity.

Table 1: Survey's experimental design

Packages 1lt – 5lt				
a. 10 – 37 10 – 45 10 – 56 10 – 63 10 – 75	b. 12 - 37 12 - 45 12 - 56 12 - 63 12 - 75	c. 15 - 37 15 - 45 15 - 56 15 - 63 15 - 75	d. 17 - 37 17 - 45 17 - 56 17 - 63 17 - 75	e. 20 - 37 20 - 45 20 - 56 20 - 63 20 - 75

Afterward, the cheap talk script was compiled from several studies (e.g., Drichoutis *et al*. 2017; Bulte *et al*., 2005) and reads as follows:

> *"In a minute you will be asked whether you are willing to pay a certain amount for the specific fertilizer.*
>
> *This question will be hypothetical, that is, you will not actually have to pay. In general, people experience difficulties in answering hypothetical questions. They often state they are willing to pay an amount larger than the amount they are willing to pay in reality.*
>
> *One reason why this happens is that when the time comes to actually make the payment, they also consider that this money won't be available for other purchases. Therefore, when the question is hypothetical, their response exaggerates.*
>
> *Before answering the willingness to pay question, try to think whether you are really willing to pay this amount for the fertilizer and that this amount will no longer be available for other purchases."*

The consequentiality script was adopted by Vossler and Watson (2013) and Vossler and Evans (2009) and read as follows:

> *"We would like to inform you that the survey results will become available to producers, traders, and retailers of agricultural supplies as well as to the wider general public of consumers. This means that this survey could affect the decision of producers, traders, and retailers to adopt practices for the production of innovative agricultural products and as a result of the average price of the fertilizer."*

After the above scripts were read, the valuation questions followed. We used a dichotomous choice question as recommended by the NOOA (Arrow *et al*., 1993). Farmers were asked to the following yes/no questions:

> *"Would you be willing to pay ___€ (including VAT) to buy 1lt bottle of the specific liquid fertilizer?"*
>
> *"Would you be willing to pay ___€ (including VAT) to buy 5lt of the specific liquid fertilizer?"*

According to the literature on certainty scales (Champ *et al*., 1997), every CV discrete choice question was followed by a question asking the participants to state how certain they were about their answer on a 10-point scale characterized by the labels "Not certain at all" and "Very certain".

Following the spirit of CV questions, IV questions were formatted to elicit the WTP for each package of the fertilizer.

> *"Do you think that an average producer would be willing to pay ___€ (including VAT) to buy 1lt bottle of the specific liquid fertilizer?"*
>
> *"Do you think that an average producer would be willing to pay ___€ (including VAT) to buy 5lt bottle of the specific liquid fertilizer?"*

A consequentiality question (Vossler *et al*., 2012; Vossler and Watson 2013) was included to allow us to test for differences between participants with different consequentiality perceptions of the survey. Respondents had to point out the indirect consequences of the survey on a 5-point Likert scale characterized by the labels "not at all" and "very much". The question read as follows:

> *"To what extent do you believe that your answers in this survey will be considered by producers, traders, and retailers?"*

According to Drichoutis *et al*. (2017), the questionnaire, in order to elicit respondents' beliefs about the likelihood of hypothetical bias and social desirability bias, employed the Social Desirability Scale of Stöber (2001). A set of demographic questions on age, gender, education level, income level, source of information, his/her experience as a farmer, his/her main suppliers of agricultural inputs, and his/her knowledge regarding salinity as well as farm characteristics related to the type of crop and on size of the farm was also asked.

4. Data Collection Methods

A pilot questionnaire was pre-tested in Messinian regions in a small sample of subjects. Through this process, some "strengths and weaknesses" could be estimated in the structure of the questionnaire. Furthermore, it was helpful for us to know where problems might arise during the interview. Thus, it was found that some of the existing questions needed redesign in order to be clearer and some others removed. The full-scale survey was then launched on May 14, 2017, and questionnaires were filled in until August 21, 2017.

The study was conducted in 3 regional units in south Greece, named Messenia, Argolida, and Corinthia. These regional units were selected after an evaluation of their availability and the type of crops that are cultivated. The main categories of crops selected were those of vegetables (tomatoes, potatoes, cucumbers, lettuce), citrus fruit (orange, lemon, mandarin), peaches, apricots, almonds, cherries, vines, and pomegranates

that are more sensitive to salinity. Also, most of the chosen areas face salinity problems due to reasons that have been referred to above. The meetings with the farmers were arranged after a telephone communication. During the telephone conversation with the farmers, we introduced ourselves and the aim of this study, before asking them if they were willing to participate. The personal interviews took place on their farms. In all, 189 subjects were asked to participate in the survey and 150 agreed to take part resulting in a cooperation rate of 79.36%. The questionnaire took participants around 15 minutes to complete. Nevertheless, a small number of the participants refused to respond to certain questions which further reduced the available sample for statistical analysis. Data were subjected to analysis using the software STATA v14.0.

5. Descriptive Data Analysis

All the basic descriptive statistics for a set of demographic variables are presented in Table 2. The ages of the subjects ranged between 23 and 92 years and averaged 49 years. The vast majority of respondents were males (94%) while females were 6 %. Also, farmers' educational level was measured at five levels: up to primary school, primary school, secondary school, college graduate, a university graduate. Other variables measured were farmers' experience in agriculture, the household income, and the application of a new method. According to the educational background, the results revealed that most farmers (48.67%) had secondary school education. The vast majority of the sample (74.67%) stated that they do not apply a ''new method'' in their cultivation technique. Furthermore, 57.33% of the participants claimed that they face salinity problems in their crops. Of those whose crops suffer from salinization about 72.58% have used a product to face this problem and the majority was ''Little/Medium'' satisfied with its effectiveness. Finally, 33.33% of the sample usually buys packages of liquid fertilizer with a capacity of more than 10 lt. This implies that the producers prefer mainly larger packages.

Table 3 presents the farmers' opinions regarding which factors they consider are responsible for their choice of fertilizer. So, it is revealed that 33.33% of the farmers affirmed that ''price'' is a ''Very important'' factor for their choice of fertilizer. This was followed by 68.67% and 30.67% of the participants who stated that the ''quality-composition'' and the existence of ''innovation-patent'', respectively, are ''Very important'' reasons for choosing a fertilizer. It is worthwhile the fact that 37.33% of farmers claimed that ''packaging quality characteristics'' is ''Not important at all'' reason for their choice of fertilizer. Furthermore, 24% agreed that ''brand name'' is ''Important'' for their decision to buy fertilizer. Finally, the majority of the respondents (about 79.33%) said that ''rapid action'' is a ''Very important'' factor behind their choice of fertilizer.

Concerning the farmers' WTP for the package of 1lt (Figure 1), it seems that as the proposed bids increase,

Table 2: Summary of descriptive statistics

Definition of Variables (Variables)	Variable levels	Frequency	Mean
Age (age)			48.94
Farm experience (years)			25.77
Gender (gender)	Male	141	94.00%
	Female	9	6.00%
Education (edu)	Up to primary school	11	7.33%
	Primary school	36	24.00%
	Secondary school	73	48.67%
	College graduate	11	7.33%
	University graduate	19	12.67%
Income (income)	Very bad	2	1.33%
	Bad	7	4.67%
	Below average	19	12.67%
	Average	58	38.67%
	Above average	30	20.00%
	Good	26	17.33%
	Very good	8	5.33%
Application of a ''new method'' (innov)	Yes	38	25.33%
	No	112	74.67%
Salinity problem (salpr)	Yes	86	57.33%
	No	26	25.33%
	I don't know	38	17.33%
Product against salinity (proion)	Yes	90	72.58%
	No	34	27.42%
Satisfaction (satisf)	Very little	1	2.95%
	Little	12	35.30%
	Medium	13	38.23%
	Very	4	11.76%
	Very much	4	11.76%
Package of fertilizer that farmers usually buy (susk)	Unpacked	0	0.00%
	1 lt	22	14.67%
	2,5 lt	8	5.33%
	5 lt	31	20.67%
	Do not buy liquid fertilizer	39	26.00%
	Package > 10 lt	50	33.33%

Table 3: Factors responsible for farmer's choice of fertilizer

	Not important at all				Very important
Price	8 (5.33%)	27 (18.00%)	21 (14.00%)	44 (29.33%)	50 (33.33%)
Quality-composition	1 (0.67%)	0 (0.00%)	9 (6.00%)	37 (24.67%)	103 (68.67%)
Packaging quality characteristics	56 (37.33%)	37 (24.67%)	30 (20.00%)	13 (8.67%)	14 (9.33%)
Brand name	31 (20.67%)	20 (13.33%)	36 (24.00%)	28 (18.67%)	35 (23.33%)
Ease of application	17 (11.33%)	26 (17.33%)	33 (22.00%)	36 (24.00%)	38 (25.33%)
Rapid action	0 (0.00%)	0 (0.00%)	2 (1.33%)	29 (19.33%)	119 (79.33%)
Innovation-Patent	18 (12%)	17 (11.33%)	26 (17.33%)	43 (28.67%)	46 (30.67%)

Note: Figures in brackets represent percentages, while others are frequencies.

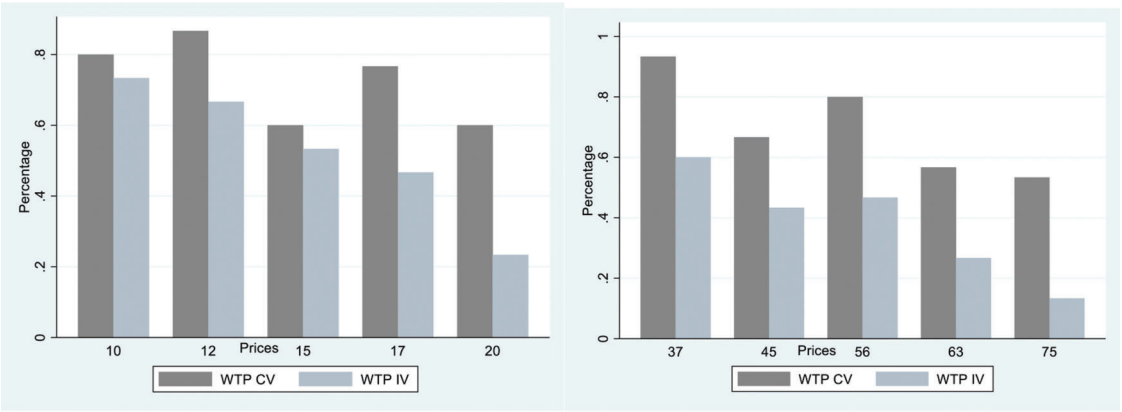

Figure 1: Percentage of WTP for the 1lt package (left) and 5lt package (right) with CV and IV methods

the percentage of farmers' WTP for the good is reduced. Also, WTP based on IVM is lower than CVM. The same trend is observed for the 5lt package.

According to CVM, the vast majority of the sample (86.7%) is willing to pay the amount of 12 € for the 1lt package and about 73.3% is willing to pay 10 € for the 5lt package with the IVM.

As we can see from Figure 1 about 93.3% of the farmers would offer the amount of 37 € for the 5lt package and finally with the IV method the majority of the respondents would also pay 37 € for the 5lt package.

Explanatory variables considered in the econometric model are presented in Table 4. Observations with missing variables were left out from the econometric analysis. Accordingly, the sample for the WTP model consists of 145 subjects.

7. Empirical Results

In this paper, we choose to estimate the model using the Interval Regression Model. In the interval regression, the upper and lower limits are set to the price if the answer is a "No" and "Yes", respectively. As explained in Hanemann and Kanninen (2001), procedures such as the delta method, Monte Carlo simulation, or bootstrapping (Poe *et al.*, 1994, falls in this category) are used to calculate the variance of WTP estimates that are constructed using functions (e.g. ratios) of maximum likelihood estimators, because the distribution of these functions is not asymptotically normal (even when the original estimators are). So, we have used interval regression which is completely equivalent to a probit model with price as one of the independent variables but with the likelihood function re-parameterized in terms of WTP (Cameron and James, 1987; Cameron, 1988). Due to this re-parametrization, it provides a direct estimate of WTP via the appropriate element of the inverse of the information matrix (Hanemann and Kanninen, 2001). One of the advantages of the interval regression model is that the estimated parameters can be interpreted analogously to the results from OLS regression. Therefore, while the parameters from other models (e.g. probit) require some transformation for interpretation in the WTP space (Cameron, 1991), our estimated coefficients can directly be interpreted as WTP values. Thus, the corresponding ***p-values*** of the estimated coefficients from the output of the interval regression model are exactly what we are interested in. According to the above, the econometric model takes the following form:

$$\mathbf{WTPi} = b_0 + b_1 CVIV_2 + b_2 order + b_3 conseq_3 + b_4 conseq_4 + b_5 hbias_2 + b_6 hbias_3 + b_7 hbiasot_3 + b_8 hbiasot_4 + b_9 sunesp + b_{10} sunpur + b_{11} kt + b_{12} ku + b_{13} sunloi + b_{14} sunel + b_{15} know\_new_3 + b_{16} know\_new_4 + b_{17} know\_new_5 + b_{18} age_2 + b_{19} age_3 + b_{20} years + b_{21} edu_2 + b_{22} edu_3 + b_{23} edu_4 + b_{24} income_4 + b_{25} income_5 + b_{26} income_6 + b_{27} susk_3 + b_{28} susk_4 + b_{29} susk_5 + b_{30} susk_6 + b_{31} innov + b_{32} salpr_2 + b_{33} salpr_3 + u + b_{34} bottle + ui$$

The empirical results are presented in Table 5. Count R^2 is the number of correctly predicted observations using the model divided by the total number of observations. It measures how well the model predicts the correct value of the dependent variable, using known values. For our model Count R^2=0.707. Our hypothesis is that the IV method would better manage to mitigate social desirability by generating less exaggerated valuations. The estimated coefficient of variable ***CVIV*** which is associated with the method of willingness to pay is -4.332 and is statistically significant at a 5% significance

Table 4: List of Explanatory variables

		Definition of variables
Dummies	CVIV*	Contingent Valuation=1, 0 otherwise
	$CVIV_2$	Inferred Valuation=1, 0 otherwise
	order	The order of the package in the WTP question, where 0=5lt is the display of 5lt first and where 1=1lt is the display of 1lt first
	$bottle_1$*	Package of 1lt=1, or 0
	$bottle_5$	Package of 5lt=1,or 0
	$Conseq_1$*	1 if producer believes that his answers will be taken ''Not at all/Low'' into account, 0 otherwise
	$Conseq_2$	1 if producer believes that his answers will be taken ''Moderate'' into account, 0 otherwise
	$Conseq_3$	1 if producer believes that his answers will be taken ''Very/Very much'' into account, 0 otherwise
	$hbias_1$*	1 if producer believes that it is ''Not likely at all'' to exaggerate his answers, 0 otherwise
	$hbias_2$	1 if producer believes that it is ''Unlikely'' to exaggerate his answers, 0 otherwise
	$hbias_3$	1 if producer believes that it is ''Neither likely, nor unlikely/Likely/Very likely'' to exaggerate his answers,0 otherwise
	$Hbiasot_1$*	1 if producer believes that it is ''Not likely at all/Unlikely'' for the other participants to exaggerate their answers, 0 otherwise
	$Hbiasot_2$	1 if producer believes that it is ''Neither likely, nor unlikely'' for the other participants to exaggerate their answers, 0 otherwise
	$Hbiasot_3$	1 if producer believes that it is ''Likely/Very likely'' for the other participants to exaggerate their answers, 0 otherwise
	$know\_new_1$*	1 if producer has scored ''Minimum/Low'' knowledge, 0 otherwise
	$know\_new_2$	1 if producer has scored ''Good'' knowledge, 0 otherwise
	$know\_new_3$	1 if producer has scored ''Very good'' knowledge, 0 otherwise
	$know\_new_4$	1 if producer has scored ''Excellent'' knowledge, 0 otherwise
	age_1*	1 if age category $<$ 40 years, 0 otherwise
	age_2	1 if age category 41 – 60 years, 0 otherwise
	age_3	1 if age category $>$60 years=1, 0 otherwise
	edu_1*	1 if education level ''Up to primary school'', 0 otherwise
	edu_2	1 if education level ''Primary school'', 0 otherwise
	edu_3	1 if education level ''Secondary school'', 0 otherwise
	edu_4	1 if education level ''University/College graduate'', 0 otherwise
	$Income_1$*	1 if income characterized ''Very bad/Bad/Below average'', 0 otherwise
	$Income_2$	1 if income characterized ''Average'', 0 otherwise
	$Income_3$	1 if income characterized ''Above average'', 0 otherwise
	$Income_4$	1 if income characterized ''Good/Very good'', 0 otherwise
	$susk_1$	Purchase of bulk package=1, or 0
	$susk_2$*	Package purchase of 1lt=1, or 0
	$susk_3$	Package purchase of 2,5lt=1, or 0
	$susk_4$	Package purchase of 5lt=1, or 0
	$susk_5$	1 if producers do not buy liquid fertilizer, 0 otherwise
	$susk_6$	1 if Package purchase $>$10lt, 0 otherwise
	innov	Are you applying a new method to your cultivation technique? where 1=Yes and 0=No
	$Salpr_1$*	1 if farmer faces with salinity problems in his crops, 0 otherwise
	$Salpr_2$	1 if farmer doesn't face with salinity problems in his crops, 0 otherwise
	$Salpr_3$	1 if farmer doesn't know if his crops suffer from salinity, 0 otherwise
Continuous	Sunesp	Total area (in acres) of citrus fruit.
	Sunpur	Total area (in acres) of nuts.
	Kt	Total area (in acres) of greenhouse horticulture.
	ku	Total area (in acres) of horticultural under cover.
	Sunloi	Total area (acres) of other crops.
	Sunel	Total area (in acres) of olive trees.
	Years	Producer's working years with agriculture

Notes: Variables with an * were not included in the econometric model in order to avoid the problem of Perfect Multicollinearity. The dummy **susk1** was not included to the econometric model, as it had zero observations.

level. Overall, this implies that the average difference between the CV and IV methods for both packages is 4.33 €/lt. In particular, the farmers' willingness to pay per liter of packaging is 4.33 € lower with the IV method than the CV method. This indicates that subjects under the IV method elicited lower the product, which is a likely clue that this method successfully mitigates social desirability and hypothetical bias as it was stressed above. This is in accordance with the results that Lusk and Norwood (2009) found in their study where the responses to the IV method better predicted actual shopping behavior than did those from a CV method. This simple twist in the wording of the valuation question generated (inferred) valuations that were close to real valuations (as compared to an experiment) and lower than hypothetical valuations (Stachtiaris *et al.*, 2012). Also, another study used both the CV and IV methods and proved that CV yields higher WTP (Drichoutis *et al.*, 2017). Hence, it seems interesting to examine both stated and inferred WTP evaluations and be able to see the differences between these two methods. There is no other study in the agricultural sector that uses both the above elicitation methods and this indicates the uniqueness of our study.

Also, there is significant evidence of ***order*** effects. When the 1lt package of fertilizer was asked first, farmers tended to pay 3.86 €/lt more than the others who were first asked for the 5lt package of fertilizer. This could be

due to the fact that answering the 1lt package question first, made the subjects think that it would be better for them to begin testing the product on a smaller field of crops in order to control its effectiveness before they decide to pay more for the bigger package. Additionally, the coefficient of the variable ***bottle*** indicates that farmers on average are willing to pay 9,95 €/lit more for 5lt packages than for 1lt packages.

As far as the consequentiality (***conseq***) is concerned, it appears that farmers who stated that they believed their answers will be considered by producers, traders, and perceptions on a "Moderate" and "Very/Very much" response were willing to pay 3.86 €/lt more than the others who believed that their responses of "Not at all/ Low" will be taken into account. Also, participants who noted that it is "Likely/Very likely" for their colleagues to exaggerate in their answers (***hbiasot***) were willing to pay 5.72 €/lt less, compared to those who stated "Not likely at all/Unlikely".

Moreover, the empirical results suggest that the type of farming affects farmers' WTP. Specifically, for an extra acre of greenhouse crops (***kt***) and the crops of vine and pomegranate (***sunloi***) farmers were willing to pay 12 cents/lt and 19 cents/lt more respectively. Regarding the level of education, farmers who have acquired a "Secondary school" education and the "University/ College graduate" were willing to pay 5.85 €/lt and 6.16 €/lt more respectively compared to those who declared an "Up to primary school" level. This element supports the hypothesis that human capital plays a positive role in the adoption and evaluation of new ideas (Etim and Edet, 2013; Etim and Benson, 2016). Also, farmers who have "Very good" knowledge were willing to pay 4.82 €/lt more than those who have "Minimum/ Low" knowledge while farmers who usually buy liquid fertilizer in a 2,5 lt package were willing to pay 13.2 €/lt more than the others who bought the 1 lt package. It is notable that the age of farmers, their income, the years being a farmer and the salinity problems that they might face (***salpr***) do not influence farmers' willingness to pay.

Figure 2 presents the graph of the aggregate demand curve from the common regression of CVM and IVM for the novel product under examination. For graphing the aggregate demand curve, we used predicted valuations from the estimated model. The inclusion of the demographic variables and farm characteristics provide more variation in the predicted values between subjects and avoids graphing a step function. We then sort the

Table 5: Interval regression estimates

Variables	Coef. (SE)	Variables	Coef. (SE)
$CVIV_2$*	-4.332*	$know\_new_5$	0.747
	(1.099)		(2.329)
order*	3.867*	age_2	-1.449
	(1.166)		(1.696)
$bottle_5$*	9.947*	age_3	-2.661
	(2.069)		(2.859)
$conseq_3$*	3.861*	years	0.076
	(1.405)		(0.056)
$conseq_4$*	3.864*	edu_2	3.511
	(1.537)		(2.682)
$hbias_2$	1.514	edu_3*	5.852*
	(1.503)		(2.809)
$hbias_3$	3.260**	edu_4*	6.166*
	(1.904)		(3.065)
$hbiasot_3$	-2.725**	$income_4$	-1.068
	(1.491)		(1.722)
$hbiasot_4$*	-5.727*	$income_5$	-2.549
	(1.499)		(1.870)
sunesp	-0.028	$income_6$	-1.675
	(0.048)		(1.896)
sunpur	-0.074	$susk_3$*	13.200*
	(0.061)		(4.382)
kt*	0.128*	$susk_4$	-0.988
	(0.059)		(1.849)
ku	-0.014	$susk_5$	-0.441
	(0.011)		(1.904)
sunloi*	0.195*	$susk_6$	-0.783
	(0.086)		(1.798)
sunel	-0.018	innov	-2.102
	(0.016)		(1.411)
$know\_new_3$	2.103	$salpr_2$	-1.958
	(1.858)		(1.945)
$know\_new_4$*	4.822*	$salpr_3$	0.023
	(1.914)		(1.426)

Notes: * and ** represent significance at the 5% and 10%, respectively.

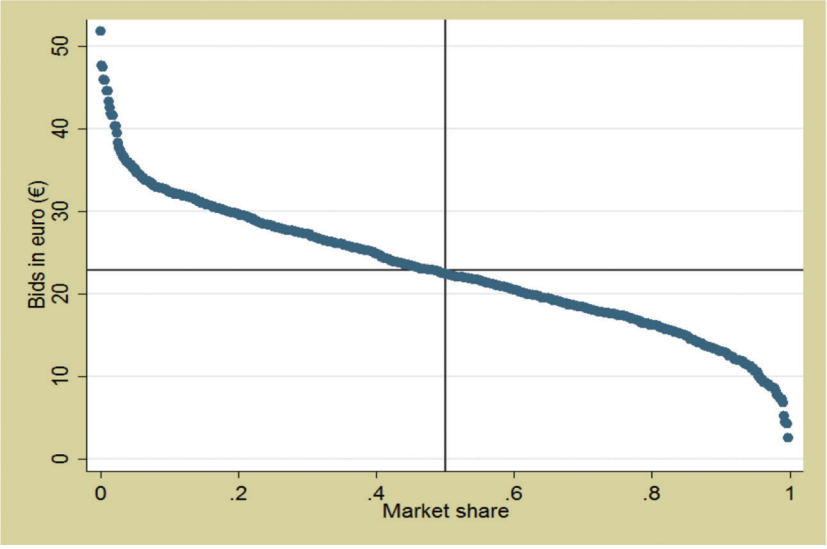

Figure 2: Demand curve from the common regression of the CV and IV elicitation methods

predicted valuations from the lowest positive to the highest positive value. Note that the predictions are not precluded from being negative, which are to be interpreted as cases for which subjects do not value the product offered as of higher quality. The lowest positive predicted valuation can be interpreted as a price point which all subjects with positive valuation would be willing to pay. The highest positive valuation can be interpreted as a price point which none of the subjects would be willing to pay. A similar exercise can be performed for each individual prediction, achieving a one-to-one correspondence between predicted WTPs and the percent of subjects willing to pay that particular price. The points can then be plotted to produce a scatter graph similar to Figure 2. The extraction of the demand curve is based on the acceptance that we refer to buying a unit per product per consumer. Each point of this curve indicates the percentage of respondents that would buy fertilizer at the bids projected on the Y-axis. According to the results, the expected willingness to pay ranges from 2.55 € to 51.87 €. As we clearly see in Figure 2, the average willingness to pay for the under-valuation product is 22.91 €. Also, the average value for each liquid fertilizer package is 17.94 € for the 1lt and 139.4 € (27.88 €/lt) for the 5lt.

8. Conclusions and Discussion

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because most of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil, and the area of land affected by it is increasing day by day. For all-important crops, average yields are only a fraction – somewhere between 20% and 50% of record yields. Unfortunately, large areas in the world including a large proportion of cultivated land in Greece remain unexplored due to salinization. On the other hand, efficient fertilizer can help to overcome salinity stress. Although agrochemicals companies produce anti-salinity fertilizers, they usually price these products based on the cost of production ignoring the farmers' WTP for a novel fertilizer in order to give a radical solution to the problem they face.

This paper attempts to elicit farmers' WTP for a novel anti-salinity product in the agricultural field. To do so, we used a CVM to uncover the underlying preferences of Greek farmers for two packages (1lt and 5lt) of an innovative fertilizer against salinity.

The survey results revealed that 57.33% claimed they face salinity problems in their crops and the vast majority of these farmers (72.58%) have used a product to tackle this problem without great success regarding the effectiveness of the product. On average, farmers would be willing to pay 22.91 €/lt for an innovative fertilizer against salinity. They are willing to pay on average 17.94 € for the package of 1 lt and 27,88 € for the package of 5 lt. A possible explanation for this awkward result is that the undervaluation product that is examined in this study doesn't exist in the real market hence, it is possible that there are systematic differences between farmers' estimation of hypothetical product alternatives and the real options.

Also, the econometric analysis indicates that the most critical determinants which had a positive effect on farmers' willingness to pay for the fertilizer were the level of education, the farm size, and the scale of knowledge about salinity. It also emerges that the liquid fertilizer package usually purchased by farmers and the farmers' perception of the extent to which they believe it will influence their responses are positively influenced farmers' willingness to pay. In contrast, a negative effect on willingness to pay was farmers' perception of the extent to which they believe that the other respondents in the survey will overtake their responses. The findings of this research are encouraging for the industries of agricultural supplies that try to differentiate their products and are wondering if costs associated with product differentiation can be recouped from potential customers.

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CONFERENCE PAPER

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Farmer Managerial Sovereignty: An International Issue Glimpsed in Kenya & the UK

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ABSTRACT

Decision-making is a crucial component of farm management. Farmers may choose to cede decision-making to others inside or outside their businesses (as specialists, contractors or consultants). However, their decision-making may be [or may feel] usurped against their will. This Paper explores Farmer Managerial Sovereignty (FMS). FMS is about the extent to which decision-making is freely and flexibly in the hands of practical farmers and farm managers at farm level rather than with bureaucrats, policymakers, the suppliers of their inputs and/or the buyers of their outputs. This paper explores whether or not FMS has changed over the past two decades, and if so, how? Do farmers/farm managers in Kenya feel more or less change in FMS over these past two decades than those in the UK or vice versa? Two somewhat eclectic samples of 24 contrasting farmers/farm managers from Kenya and 24 from the UK were asked to provide indicative responses: Kenyan farmers felt FMS only lessening somewhat, notably due to increased government bureaucracy and public scrutiny. The UK sample aggregate FMS score indicated a much lessened to lessened overall FMS during the past two decades, especially due to increasing environmental rules, pesticide limitations, increased government bureaucracy and public scrutiny.

KEYWORDS: farmer; managerial; sovereignty; decisions; choices; freedom

Introduction

Good decision-making lies at the heart of farm management. Giles and Stansfield (1980) note with some sympathy that someone has defined farm management as 'the art of making good decisions based on inadequate information.' To some extent the quality of that information depends upon that farm's previous record-keeping! Arguably, digital data input to the farm office is now excessive! However, that farm management is an art is agreed by Press (RSA Businessman of 1980) who defines management as 'the greatest of the arts since its medium is human talent itself.' Earlier, St Benedict (c.530 AD) advised, 'If you act always after hearing the counsel of others, you will avoid the need to repent of your decision afterwards!' This was no doubt based not only on his experience but derived from founding that upon the Bible's Book of Proverbs (11:14): 'Where no counsel is, the people fall; but in the multitude of counsellors there is safety'. Hardaker (1969) advocated the decision-tree approach to systematic farm management decision-making. Thus, the concept of complete autonomy in decision-making as a totally independent dictator is not a worthy aspiration and leads to ruin. However, there is balance, and the ability to make decisions free from unnecessary constraints, and then to take responsibility for them lies at the heart of the concept of Farmer Managerial Sovereignty (FMS). Nevertheless, a wise farmer or farm manager takes account of shrewd advice and informed opinions of team and family members.

Most farm businesses are family businesses and are small by contrast with many other industrial firm structures (Gasson *et al*., 1988). Farming still occupies over 35% of the world's workforce. Indeed, there are some 500 million farming families worldwide of which over 80% farm areas under 2 ha (Lowder *et al*., 2014). Family farmers are reckoned to work a significant proportion of the world's agricultural land:- Africa (62%); America North & Central (83%); America South (18%); Asia (85%); Europe 68%) according to FAO, 2014.

Characteristics of the Family Farm have been summarised by Van der Ploeg (2013):

a. Controls main farm resources
b. Provides most of the farm labour
c. Exists between Family & Farm (=Farm-Household System – FAO, 1989)
d. Provides the farm family with part or all of its food and income

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e. Provides place identity of home
f. Links past, present and future inter-generationally
g. Is a place of accumulated learning + experience (ITK)
h. Is where culture is applied and conserved in agricultural context
i. Aggregates with other Family Farms into the wider rural economy
j. Makes up an intrinsic part of the wider rural landscape.

Decision-making features in all the above characteristics and is culturally influenced and thus variable. For instance, Garforth *et al*. (2004) found significant variation in attitudes and behaviour between farm and farmer types when analysing knowledge transfer among livestock farmers in south-west England. The adventurous entrepreneur may well take bold decisions but, if wise, even then will not do so without proper risk management assessment and due consultation. While the current nominated 'farmer' in a family business may consider himself or herself 'independent' as far as decision-making is concerned, this may be far from the case in practice. The extent to which decisions are shared and determined by consensus varies with individuals, cultures and from family to family.

The Nature of Decision-making at Farm Level

Decision-making is a crucial component of farm management; some may say it is the key factor both in terms of strategic (longer term) and tactical (shorter term) decisions. The skill and judgement required to achieve best practice in farm management are certainly reflected in the quality of decision-making.

There is a sequence in decision-making (after Giles & Stansfield, 1980): identify the problem/challenge → assess its significance → consider alternatives → gather information → evaluate options → make choice(s) → implement the decision → check results → take responsibility for those results. Obviously attitudes vary from farmer to farmer but that of one farmer (Watson, 2018; www.riverford.co.uk) seems to express due ethically-sensitive humility and to encapsulate universally applicable farm management wisdom: ''Decisions that don't use what feels right as a sanity check can be just as dangerous as emotional decisions made without checking the measurable evidence.''

In Nigeria, 70% of smallholder farmers out of 95% that feed the nation are women, according to the Federal Minister of Agriculture and Rural Development, Audu Ogbe (*Daily Trust*, Oct.28th 2018). According to the World Farmers' Organisation (www.wfo-oma.org in 2018) though women in Kenya carry out a similar percentage of farm work at around 70%, they own only some 5% of land; yet empowering women has been shown to increase farm productivity in many countries. The World Bank has made gender equality in the agriculture and food sector an explicit goal. The Bank works to expand women's access to land and rural finance. Providing women with greater access to land, finance, and production inputs is critical to closing the productivity gap between men and women. Closing the gender gap could increase yields on women-run farms by 20-30% (World Bank, 2017). In the UK, though registered female farmers are increasing, they are still well under 10% of all farmers.

The Meaning of Sovereignty

Sovereignty means unrestricted freedom, power and authority to make choices and take responsibility for decisions. At a country level, sovereignty is about the ability of each nation to make its own decisions independently of other nations (though with due regard for their well-being also). Recovery of national sovereignty was a leading motivation for the UK's vote in 2016 for Brexit from the European Union. Regarding food sovereignty, the concerted voice of small farmers sounded the alarm on the need for it (La Via Campesina, 1996). Food sovereignty is about reclaiming decisions about food production policy at national and even regional levels (Windfuhr & Jonsén, 2005). Food sovereignty thus implies individuals', peoples', communities' and countries' authority to define their own agricultural, labour, fishing, food, land and water management policies which are ecologically, socially, economically and culturally appropriate to their unique circumstances (Pimbert, 2009). Agroecology inspires it.

Farmer Managerial Sovereignty

Farmer Managerial Sovereignty (FMS) arises as a focal category within the globally growing food sovereignty movement. FMS is the freedom to make both day-to-day tactical and longer term strategic decisions and choices in a minimally constrained way. Of course, due respect for other people, creatures and the land itself is the assumed foundational context for that freedom. Farmers are constrained as business operators by three principal categories (Cottington, 2018). These are their own cultural and personal aspirations; the regulatory and contractual context in which they operate; and their 'bottom line' financial resilience, which enables the other two. Within the contracts and regulations category will come the environmental requirements of public goods. This is the category which may be most likely to limit FMS depending on how realistic these are and how well communicated to farmers (Fig.1).

Loss of farmers and thus the need for farmer conservation has long been an issue (Wibberley, 1992; Lobley *et al*., 2012). In an era when the 'five freedoms' of livestock in an animal welfare context are accepted (UK Animal Welfare Act, 2006), what about these applied to

Figure 1: Majors Drivers affecting the Farmer as Business Operator (after Cottington)

farmers and farm managers in relation to FMS? The five freedoms recognise the needs of livestock as follows: a suitable environment; a suitable diet; to be able to exhibit normal behaviour patterns; to be housed with, or apart from, other animals; to be protected from pain, suffering, injury and disease. At a time of renewed emphasis on mental health, including that of farmers (Banks & Lloyd, 2013; www.fcn,org.uk) it is surely relevant to consider farmer well-being in regard to FMS. In the UK, anecdotal evidence is regularly gleaned among struggling farmers and farm businesses that bureaucracy coupled with feelings of loss of control to others are increasing stressors (Jones *et al*., 2015). On the other hand, some decisions may be voluntarily, deliberately and even keenly ceded to specialist advisers or contractors such as employed agronomists and dairy consultants by progressive farmers. For instance, while saving the wages of a full-time dairyman, a UK farmer who has installed robotic milking for his 110 cows now employs a dairy consultant costing the equivalent of 25% of a full-time monthly wage and willingly cedes responsibility for key decisions to him. This is also the case with agreed salad and vegetable delivery contracts ex-farm. Hence this enquiry and the sampling of farmers' opinions regarding whether there are increasingly imposed restrictions on FMS in two contrasting contexts, Kenya and the UK.

Methodology

On the basis that to discover rural realities one should 'ask the fellows who cut the hay' (Evans, 1975), and that an axiom of good management is to ask practitioners' opinions, the authors decided to conduct two sample surveys of opinion among 24 farmers in Kenya and 24 farmers in the UK as to how FMS may have changed during the past two decades. Though eclectically selected, there was an attempt in both samples to mirror the reality of average farmer's age and gender in both particular countries. The questionnaire used was similar for both countries (Appendix 1). The data generated are only indicative but it is hoped that they provide at least a discussion starter if not a research prompter for this issue. Thus, by reference to two small and eclectic samples of 24 farmers in each of Kenya and the UK, this paper seeks to explore Farmer Managerial Sovereignty and whether or not it is perceived to be increasing or decreasing in a series of categories inviting responses from farmers and farm managers. Though the samples were eclectically drawn, there was an attempt to represent a spectrum of farmers and to reflect some typical contrasts between Kenya and the UK (Fig.2.).

The Kenya sample was drawn from within Siaya County in south-western Kenya bordering Lake Victoria, while the UK sample was from England north, south, east and west and even included Scotland. Notable contrasts are in farm size (more than 4,000-fold greater in the UK). The percentage female farmers in the Kenya sample at 50% is actually below the Kenya national average, while the UK sample at 12.5% is above the UK average. The age of the farmers sampled in Kenya at 51 is typical while for the UK, the mean age of the sample at 58 is at the often-quoted UK average. While only 36 % of the interviewed farmers in Kenya had not gone beyond primary education (indicating a reasonable level of literacy), all of the UK sample had completed post-secondary (college/university) education, and some had done postgraduate studies. Both groups majored on cereals in arable farms and had useful contributions from milk. The Kenyan farmers derived much more of their remaining output from vegetables and poultry than in the UK sample. By contrast with Kenya, the UK sample derived significant income from beef, and more from non-farming contributions – notably property and EU Single Farm Payment.

Farmer Managerial Sovereignty assessment was based on a Likert scale of 1-5, with 1 representing less freedom of choice and 5 representing more freedom of choice.

n = 24 + 24 Kenya + UK farms = 48	**KENYA mean**	Max.	Min.	**UK mean**	Max.	Min.
AGE OF FARMER	50.6	70	25	58.2	84	33
% FEMALE FARMERS	50.0	-	-	12.5	-	-
AREA FARMED (Hectares)	0.2	1.2	0.1	420	1497	81
% CEREALS	37.0	70.0	0	28.1	100	0
% FIELD VEGETABLES	18.0	63.6	0	2.1	30.0	0
% SALAD CROPS	6.0	30.0	0	0.7	0.7	0
% OTHER CROPS	-	-	-	6.2	40.0	0
% BEEF	2.5	40.0	0	22.4	100.0	0
% SHEEPMEAT	3.2	40.0	0	4.5	50.0	0
% PIGMEAT	2.1	30.0	0	2.5	60.0	0
% POULTRYMEAT	10.0	40.0	0	1.0	35.0	0
% EGGS	5.1	30.0	0	1.0	35	0
% MILK	12.0	75.0	0	19.4	93	0
% OTHER	4.1	40.0	0	12.1	35.0	0

Figure 2: Characteristics of the Kenyan and UK Farmers sampled (n=48)

The responses of Kenyan farmers were ranked according to their degree of perceived freedom of choice as in Fig.3. Then the results for the UK were presented according to the same order of choices as smoothly ranked in Kenya, thus showing diagrammatically their variations by contrast (Fig.4).

Results and Discussion

In the case of Kenya: all the sample of 24 farmers asked their opinions on FMS were in Siaya County which borders Lake Victoria in the south-west of Kenya. Their holdings were typically small and dominated by cropping outputs, especially cereals but also substantially vegetables. The greatest constraints on their choices were deemed to arise from government bureaucracy, the burden of increasing public scrutiny, marketing rules beyond the farm gate, and environmental constraints and rules to determine public good – though only bureaucracy and public scrutiny burden scored below 2.5 on the Likert Scale.

In the case of the UK: the sample of 24 farmers was drawn widely in terms of location, mostly in England but from all points of the compass. The farm sizes typify serious commercial farm businesses of varied types from arable, through mixed farming and dairying to specialist beef and sheep production in the uplands. Poultry was represented by a specialist organic day-old chick raising farm also producing some eggs and meat for sale. The greatest perceived constraints of the UK sample were environmental rules, pesticide limitations, government bureaucracy, increased public scrutiny and restricted herbicide choice – all five issues scoring below the 2.5

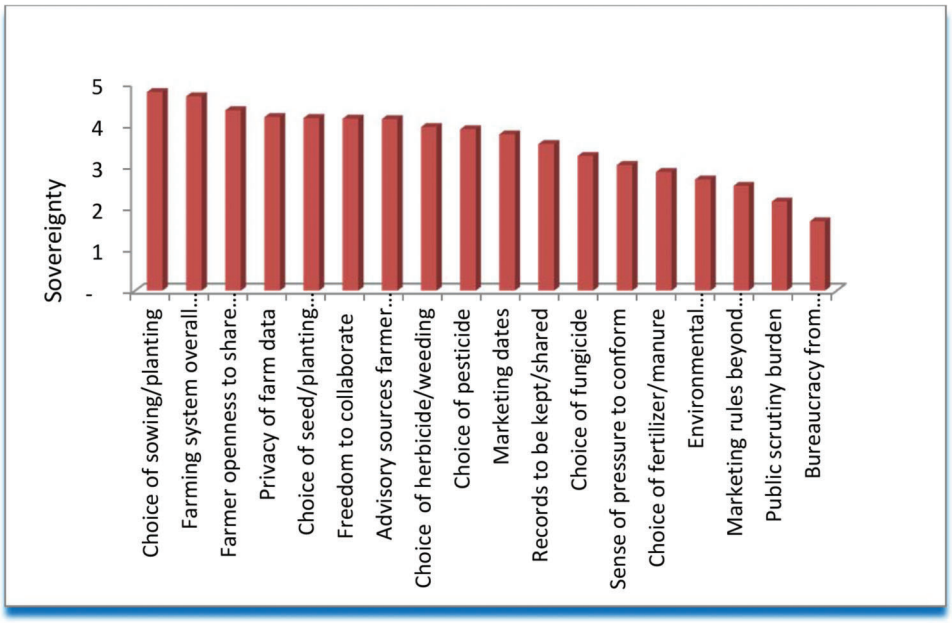

Figure 3: Farmer Managerial Sovereignty across different choice horizons in Kenya

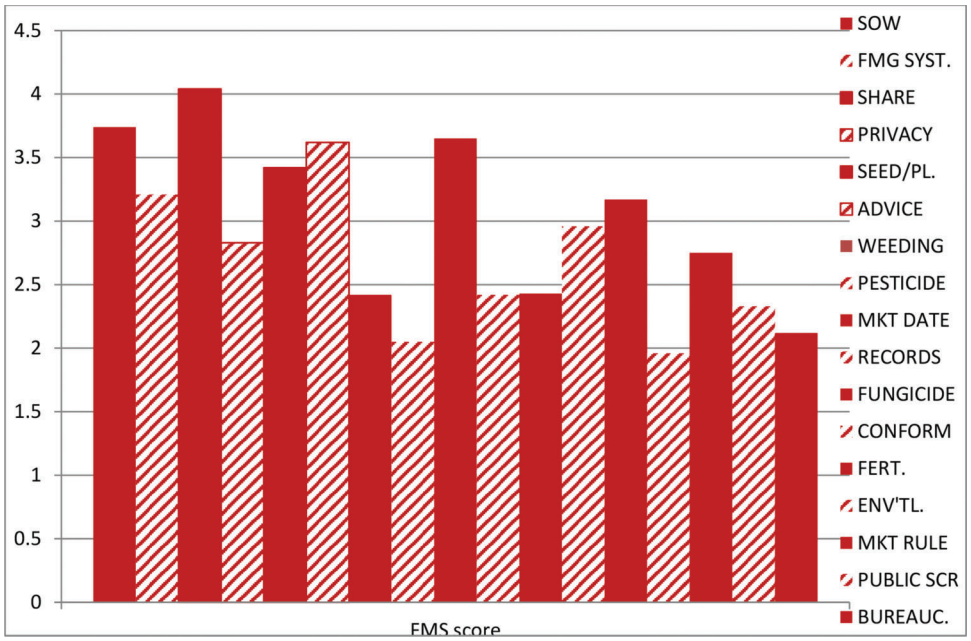

Figure 4: Farmer Managerial Sovereignty across different choice horizons in the UK. (List at RHS corresponds with chart read left to right)

level on the Likert Scale. In the case of herbicide choice, this is not only a matter of restricted options but of exacerbated needs, especially in relation to blackgrass control (*Alopecurus myosuroides*) which is becoming more persistent with farmers' own choices to pursue intensive, early-sown winter cereal sequences, and also with development of some herbicide resistance.

The overall aggregated FMS score for Kenya was 3.61 i.e. indicating FMS only lessening somewhat, whereas the UK sample aggregate score was 2.88 indicating a much lessened to lessened overall FMS during the past two decades.

The wider context in Kenya includes the devolution of policy and encouragements for development to Counties in recent years (County Governments Act, 2012), while in the UK Brexit was voted for in 2016 by many farmers not only on grounds of recovering national sovereignty but based on a feeling that remote bureaucracy and policymakers' rulings were usurping their freedom to make on-farm choices and decisions – such as stocking rates, grazing periods and fieldwork timing. The results of the enquiry reported here indicate the relative strength of feeling among farmers in the two contrasting nations of Kenya and the UK. However, the strength of feeling regarding loss of sovereignty is greatest among the UK sample – although most variable among farmers within that sample with aggregate FMS scores per farmer ranging from 1.91 (FMS very much lessened) to 4.28 (FMS the same). The UK farmers deemed some items better than experienced two decades ago, such as choice of advisory sources and opportunities to collaborate scoring higher on FMS. The Kenyan farmers considered that farming system choices, openness to share among farmers, sources of advice and willingness to collaborate among farmers had all improved in their experience.

One UK farmer in organic production for 18 years, noted that the burden of regulation is slightly less onerous than for conventional farming i.e. less recording of inputs used, exemption from some bureaucratic and restrictive cropping rules, and being less affected by input cost inflation. An upland tenant farmer in the UK noted less choice at farm level regarding decisions, mostly down to having to abide by endless new rules and an ever smaller pool of available tools (particularly spray chemicals). However, he noted that there are some very exciting technologies and ideas becoming available.

On the National Trust Estate in the UK, when land is taken back in hand by the NT and re-let for grazing, it tends to be micro-managed by a Conservation Ranger team with regard to stocking dates and numbers; then fertiliser, lime, sprays and sometimes even sheep may be seen, for the most part, as unacceptable on in-hand land. Thus FMS is reduced for farmers who choose to take the grazing on that land. Furthermore, Brexit in the UK is a very concerning issue if a tenanted farm happens to be coming to the end of an AHA tenancy (Agricultural Holdings Act, 1986), to be replaced with a FBT (Farm Business Tenancy, as per the 1995 Act) – which is shorter term and less secure.

Conclusions and Recommendations

Perceived managerial sovereignty of farmers in the Kenyan sample has improved over the last decade with respect to a number of farm decisions. However, Farmer Managerial Sovereignty is still restricted when it comes to bureaucracy from government, public scrutiny, marketing rules beyond the farm gate and environmental constraints/rules which are considered to determine the public good. In the UK, Brexit is influencing the responses of some farmers although a majority are keen to leave the FMS constraints of the EU. Overall, the UK farmers sampled perceive their FMS to be lessened to a greater extent than is the case in Kenya.

The issue of Farmer Managerial Sovereignty needs to be pursued as a relevant concept, investigated further and researched in other places. Are tomorrow's farmers and farm managers becoming monitors and adjudicators of digital data rather than direct observers and interactors with farm reality? The voices of farmers and farm managers and their mental health and well-being, need to be better registered among policy-makers and those who are most likely to constrain FMS unnecessarily. It must always be realised that FMS is not a concept seeking absolute autocracy and thus is not a threat to responsible land husbandry and management but rather the guarantor of it in the hands of enabled practitioners.

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Appendix 1. Farmer Managerial Sovereignty (FMS)

Sovereignty is about the ability of each nation to make its own decisions independently of other nations (though with due regard for their well-being also). **Food sovereignty** is about reclaiming decisions about food production policy at national and even regional levels. **Farmer Managerial Sovereignty** (**FMS**) is about **the extent to which decision-making is freely and flexibly in the hands of practical farmers and farm managers** rather than with bureaucrats, the suppliers of their inputs and/or the buyers of their outputs. Has **FMS** changed over the past two decades? If so, in which ways? Do farmers/farm managers in the **UK** feel more or less change in **FMS** over these past two decades than those in **Kenya**? Two somewhat eclectic samples of contrasting farmers/farm managers from the UK and Kenya are asked to provide indicative material towards the debate about this legitimate topic on the *loci* of **farm management decision-making**.

Brief Description of your Farming:-
YOUR AGE (years)?____; Male or Female?____Acres?___

YOUR FARM PRODUCTS	TICK THOSE THAT APPLY	WHAT % OF YOUR TOTAL FARM OUTPUT VALUE?
CEREALS		
FIELD VEGETABLES (INCL. POTATOES)		
SALAD CROPS		
OTHER CROPS – WHICH?		
BEEF		
SHEEPMEAT		
PIGMEAT		
POULTRY MEAT		
EGGS		
MILK		
OTHER –PLEASE STATE		

IS **FMS** VERY MUCH LESS (i.e. have farmers lost control), TO SAME, TO MORE? PLEASE *GRADE* THE FOLLOWING ASPECTS BY **TICKING** THE APPROPRIATE COLUMN AGAINST EACH ONE:-

ASPECT	VERY MUCH LESS Free at Farm level	MUCH LESS Free at Farm level	LESS Free at Farm level	SAME at Farm level	MORE Free at Farm level
Choice of Sowing/Planting date					
Choice of Seed/planting material					
Choice of fertilisers/manures					
Choice of herbicides/weeding					
Choice of pesticides					
Choice of fungicides					
Environmental constraints/rules					
Marketing dates					
Marketing rules beyond farm gate					
Advisory sources farmer can use					
Privacy of farm data					
Records to be kept/shared					
Bureaucracy from government					
Public scrutiny burden					
Sense of pressure to conform					
Freedom to collaborate					
Farmer open-ness to share info.					
Farming System overall choice					

Thank You for participating – PN/EJW, 2018

CONFERENCE PAPER

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Integrating Agricultural & Environmental Management Policy: A UK Perspective

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JOHN WIBBERLEY[2]

ABSTRACT

During a period when agricultural management signals and imperatives are being reviewed internationally, this paper explores the balance between production-linked and environmental care aspects. It reviews the case of the UK, especially England with particular reference to Exmoor in the south-west. However, it seeks to elicit some principles that may seem to apply internationally. After a review of policy signals and reactions over the past half-century or so in the UK, it outlines the September 2018 Agriculture Bill, discusses the changes it may herald, and the issues that need to be incorporated in the final Environmental Land Management System (ELMS) being debated in the UK Parliament at the time of writing. These include a global perspective on farming policies, agricultural innovations, energy security and care of the farmed landscape. It is argued that an overarching vision of Ecosystem Security includes people and it is proposed that food production and productivity (measured in terms of the rate of output per unit of input) must be included within the 'envelope' of ecosystem services and in the valuation of natural capital. Both necessary agricultural productivity and responsible environmental management are mutually inclusive and require policies that integrate them as simply as is possible.

KEYWORDS: productivity; environmental management; policies; natural capital; farmers

Introduction

The quest for increasing land productivity (rate of output per unit of input) was underpinned in the UK by the encouragements of the 1947 Agriculture Act. However, productivity came to be measured by tonnes or litres of agricultural product per person employed. Mechanisation improved that ratio no end but did not consider the downward energy-efficiency trends accompanying input-fuelled advancing yields, nor the consequences of disconnecting people from the land. By the 1960s, the success of this was beginning to call into question its environmental stewardship impacts. Rachel Carson's 1963 book *Silent Spring* sounded the alarm internationally over the escalation of agrochemical and biocide usage, while Mellanby (1967) provided some of the increasing evidence for pollution from pesticides. Already, others had sounded the trumpet for more environmentally friendly approaches to agricultural management that recognise the fundamental importance of soil biology from Balfour (1943), to Russell (1957) and Stapledon (1964). In a quest for compromise between the competing – though necessarily ultimately collaborating – aspects of productivity and environmental care, a seminal conference was convened by the Royal Society for the Protection of Birds (Barber, 1970). Attendance at that conference confirmed the present writer's quest for balance - as for instance in Wibberley (1989) where 'husbandry' replaces mere 'production'. Many British farmers have, like this writer, been influenced not only by the sense that God cares for land (Psalm 65:9-13) but also by adages:-

> *'Live as though you will die tomorrow; farm as though you will farm forever'* and the balancing:
>
> Swift's (1726) quote: '*whoever could make two ears of corn or two blades of grass to grow upon a spot of ground where only one grew before, would deserve better of mankind and do more essential service to his country than the whole race of politicians put together.*' This latter imperative has all too often led to production and productivity trumping environmental care.

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In the sphere of economics, seminal steps have occurred in recent decades from Schumacher (1974) who prioritised people, to Pearce *et al*. (1989) who appealed for environmental accounting to monitor the natural resource base for productivity. By the 1990s, the role of transnational corporations in the rising tension between productivity and environmental impacts was registered (Korten, 1995) and in the new millennium, the downsides of globalisation were alerted (Stiglitz, 2002). Rising up the agenda politically in the UK is the state of the natural world (Defra, 2011) and realisation that nature services humanity in unrecognised and undervalued ways (Juniper, 2013) with the concept of natural capital to put economic value on the planet (Helm, 2015). The concept of natural capital should include its overarching context of ecosystem security in which human skills are valued and security of their daily bread included within ecosystem services (Wibberley, 2013). UK Farmers are working together in *LEAF* (linking environment and farming; www.leaf@leafuk.org) and in the nature friendly farming network (www.nffn.org.uk). The National Trust in England, Wales, and Northern Ireland (the world's largest conservation charity with some 5.2M Members) is working hard with its 1800 farming tenants to deliver landscape-scale environmental management alongside profitable farming (www.nationaltrust.org.uk). Meanwhile, on an English estate of some 1400 hectares in West Sussex, bold decisions to pursue wilding were taken in 2000 and outcomes are brilliantly documented (Tree, 2018) flagging up useful debate and practical experience of delivering meat from that landscape alongside much-enriched nature conservation.

In the context of all this, a new Policy from 2019 in the UK from Defra (Department for Environment, Food & Rural Affairs) was initiated in autumn 2018 after wide consultation. Legislation to deliver a cleaner and healthier environment for future generations came after some 45 years under EU rules (Agriculture Bill, UK Parliament, 12th September, 2018). This set out how farmers and land managers would in future be paid for 'public goods', such as better air and water quality, improved soil health, higher animal welfare standards, public access to the countryside and measures to reduce flooding. It replaced the subsidy system of Direct Payments to farmers based on the total amount of land farmed. Those payments have been skewed in favour of the largest landowners but not linked to any specific public benefits. The top 10% of recipients have received almost 50% of total payments, while the bottom 20% received just 2%. Accordingly, the expected reductions are tabulated below:-

Annual Direct Payment	% Payment cut in 2021
Up to £30,000	5%
£30,000-50,000	10%
£50,000-150,000	20%
£150,000 or more	25%

From 2019, via this Environmental Land Management System (ELMS), the UK government has pledged to work together with farmers to design, develop and trial this new approach. Under the new system, farmers and land managers who provide the greatest environmental benefits will secure the largest rewards, laying the foundations for a 'Green Brexit' after the UK leaves the European Union (EU) in March 2019. The Bill will also be underpinned by measures to increase productivity and invest in research and development (R&D). Farmer collaboration will be encouraged towards improved soil health and sustainable livestock farming, combining profitability with reduced environmental 'footprint'. To enable farm business innovation and adjustment to the new scheme while encouraging young entrants, there will be a 7-year transition period away from the EU Common Agricultural Policy (CAP) – which has cost over half the EU budget and is politically unsustainable anyway.

The 2018 UK Agriculture Bill specifies possible financial assistance to farmers when:-

- Managing land or water in a way that protects or improves the environment;
- Supporting public access, enjoyment; understanding of countryside, farmland, woodland;
- Managing land or water to maintain, restore or enhance cultural or natural heritage;
- Mitigating or adapting to climate change;
- Preventing, reducing or protecting from environmental hazards;
- Protecting or improving the health or welfare of livestock;
- Protecting or improving the health of plants.

Both the CLA (UK Country Land & Business Association) and NFU (National Farmers Union) expect the new Environmental Land Management System (ELMS) to open for applications from 2021–2025, depending on how well the trials and pilot testing of the scheme go. Until ELMS is fully up and running, Countryside Stewardship will continue and Higher Level conservation agreements may be extended as required. It is likely that integration of trees into farming systems will be better encouraged than hitherto (Wibberley, 2014). There will be a support scheme to build farm capability to manage risk, improve productivity, support new entrants to get into farming and deliver public goods but this funding will be time-limited (probably to 2021–2027). There will be funding for farmer-led research. A 'higher animal welfare standard' is to be be defined in 2020 but it is unclear what it will cover. Payments will be 'delinked' from the requirement to farm the land, to enable recipients to invest, diversify or retire. There should be an option to take payments as a lump sum. There is no indication of just how the overall support budget for farming will change during the transition period. It is currently around £3.2bn per annum for Direct Payments and rural development spending.

It is unclear on what basis DEFRA would like to set the overall support budget. The most rational basis might be to agree targets for the environmental outcomes desired from the new policy related to public goods and climate change, then work out how much it will cost to deliver those outcomes. The Bill does not mention future policy associated with agricultural workers and trade policy, nor whether UK standards for food production will be maintained, although a pilot overseas workers scheme has been launched and the government has repeatedly said that food standards will not be reduced for both UK production or imported food. Given that

the gist of WTO policy is 'non-discrimination against imports', unfiltered exposure to cheap and substandard agricultural imports would jeopardise not only the September 2018 UK Agriculture Bill's worthy environmental aspirations but also the fabric of UK farming livelihoods to deliver them. It is vital that this fundamental contradiction is recognised and its mitigation made central to negotiations of the UK's final trade deals, and indeed in moderating WTO policy internationally (Wibberley, 2011). The dominance of multinational corporations in the Food Industry means that proper governance is needed internationally to ensure that policies do not crush the very farming communities who produce food and care for the natural capital upon which it depends - which includes skilled rural people.

Meanwhile, before ELMS applies in the UK, it is understood that there have been some 101 Pilot Scheme bids to Defra for support, one of which is *Exmoor*'s Ambition (Deane, 2018). From the treasured 692 km^2 (267 square miles) that has formed the Exmoor National Park since 1954, the need for integration of agriculture and environmental management should be self-evident. The Exmoor Society, founded in 1958, continues to recognise this and to advocate for viable farming not only for landscape care but also for rural livelihoods and to sustain our valued cultural heritage. Exmoor Farming is precarious (Wibberley & Turner, 2009; Dwyer *et al.*, 2015; Howe & Wibberley, 2017). In response to the important emphasis on natural capital (Helm, 2015) and the UK government's espousal of it, The Exmoor Society commissioned work towards a register of Exmoor's natural capital (Deane & Walker, 2018). Among other options, the Exmoor Consultative & Parish Forum provides regular opportunities for community engagement, and the Exmoor Hill Farming Network stands ready to deliver (www.exmoorhillfarmingnetwork.org.uk; Knight & Wibberley, 2017).

The case has to be made to both policymakers and the wider public for policies and practices that favour such integral management with viable farm livelihoods at their heart. As the wise Women's Institute poster of some twenty years back said '*Farming is Everyone*'s business.' Farming is an integral part of sound environmental management. For everyone, that integrated ecosystem in which farming is central must provide a comprehensive ecosystem security which consists of: water security + food security + energy security + livelihood security + geopolitical security. In other words, ecosystem security must take account of all factors relevant to life on earth with agriculture having a crucial role. Thus food production is an essential ecosystem service to be included within that comprehensive portfolio.

Global Perspective

In a world of some 7.7 billion in 2019, still one person in eight is hungry. There are some 500 million farming families worldwide still maintaining the crucial linkage between family and farm that has sustained life on earth for millennia. As the finite nature of unmanaged environmental resources becomes clearer, farming's central role should be more obvious to all. Therefore, these are hopeful times for farming when the UK and each country's agriculture must again become central in:-

- Global ecosystem security policy, with more food sovereignty recovered from the EU & WTO;
- Biodiversity and landscape conservation to care at scale for the countryside, integrating trees;
- Achieving sustainable rural livelihoods within relational, well-connected rural communities.

People are integral to global environmental management and Civil Society needs to be mobilised and led accordingly.

Farming Policies

An enabling, simple and understanding governance framework is needed both within the UK and in taking international leadership with Defra alongside DfID (UK Department for International Development) in raising agriculture's worldwide profile. International issues require concerted leadership notably for climate change mitigation and adaptation, and for soil and ocean care.

Further encouragement of food chain linkages is merited from 'land to mouth' in all countries. Whole systems approaches need analysis and monitoring for environmental impacts – both negative and positive.

Relationships between farmers and the UK government need to be revived more. Better TB control is vital in this, as are initiatives to catalyse farmer networks (Rose Regeneration, 2013) and to strengthen farmer sovereignty in decision-making and voluntary collaboration for resilience using natural capital. Natural capital includes not only the natural physical and biological resources but especially also people and their skills and entrepreneurship (as encouraged by the Exmoor Society's Pinnacle Award). Good practice in environmental management is only deliverable through positive relationships with farmers and local people.

Reintroduction of regional advisory panels or *fora* of farmers and objective rural practitioners would help to harness the pool of experience, professionalism and goodwill for UK agricultural progress. Engaging with over-arching experience and wisdom of rural communities is vital, with specialisms alongside to inform this practical core.

Agricultural Innovations

Farmer-generated innovations have always been crucial to practical agricultural progress. Great caution needs to be exercised regarding GM technology – and indeed all 'silver bullets' backed by any over-ardent vested interests. Worldwide experience suggests that farmers are the best judges of appropriate agricultural innovations. A principal issue with GM is its potential to erode farmers' control over their natural resources, including timely availability of seeds and intergenerational selection from a wide gene pool of crops and livestock breeds. There is such a precious thing as farmer managerial sovereignty: farmers retaining maximum feasible control over their adoption of innovations and decision-making about key matters such as cultivations and sowing of crops (Nyangweso & Wibberley, 2019). Other small businesses may well concur with this sovereignty aspiration. Research on GM needs to be independently and not commercially funded. The widespread USA experience with *Roundup-Ready* soya beans and maize crops has

raised salutary questions of rumen microbiological interference, food chain and ultimately human health issues through over-use of the albeit intrinsically low-mammalian-toxicity glyphosate herbicide. Other improved technologies within agro-ecologically mixed frameworks offer much greater scope for seamless adoption, for example use of gene markers, composite crosses, precision digital aids in both crop and livestock husbandry, low ground-pressure tyres, less oil-dependent farming, conservation agriculture (more adopted globally than in the UK; Kassam, 2020) and encouragement of genuinely pasture-fed livestock systems (www.pastureforlife.org). Existing agro-ecological approaches are sustainable. Technological innovations need objective, precautionary research.

Energy Security

Energy efficiency needs to become the accepted baseline technical criterion for comparing alternative agricultural systems for productivity (measured in terms of the rate of output per unit of input) and in encouraging and evaluating integrated rural development and resilience. Energy efficiency on a planetary scale needs analysis and monitoring, with best practice guidelines. Renewable energy sources – notably micro-hydro and solar panels on farm buildings – need an enabling planning environment. However, it is necessary to beware biofuel crops, intrusively sited wind turbines, and solar-panelled arable fields when reasonably priced food is increasingly important worldwide. Renewable energy that conflicts with priority land uses needs cataloguing, research, strategic appraisal and management.

Farmed Landscape Care

Special schemes for family-worked farms and territorial intergenerational succession should be encouraged, including using revised national planning laws that unduly restrict housing retired farmers on their own farms. Cultural heritage is a vital part of ecosystem services and in maintaining environmental integrity for future generations. Succession planning is a key issue assisted in the UK by FCN (Farming Community Network; www.fcn.org.uk; Jones *et al*., 2015).

Upland support, such as carefully proposed by *Exmoor*'s Ambition needs to be retained, simplified and improved. It is for the public good of future generations that we should conserve family farms and coastal/marine communities retaining those people 'there to care' versus their displacement costs – both financial and social. Modulation using satellite-maps should be explored, based on real land area to take account of the greater costs and difficulties of farming uplands and steep slopes.

Conclusions

The UK needs to assume a clear leadership role both in reform of WTO trading rules and *versus* land grabbing so that genuine, private enterprise of smaller farms and rural micro-businesses is not ruined internationally. Fairer International Agricultural Trading (FIAT) is required to counter adverse environmental and geopolitical impacts of land grabbing and food commoditisation (Wibberley, 2011). Agricultural productivity and responsible environmental management are mutually inclusive and require policies that integrate them as simply as is possible.

The UK needs to lead in improving sustainability of global farming practices and farm livelihoods, rewarding farmers for comprehensive ecosystem security: food, timber plus clean water, carbon capture (soil nitrogen), and other income streams from therapeutic, recreational/touristic and heritage/cultural values of land.

Ecosystem security needs to be embraced to become the template for the over-arching environmental management vision. It is illogical to separate food security and home food production from its legitimate practical place *within* the overall concept of ecosystem security for ultimate public good. England's Exmoor is in a position to provide a constructive lead in these matters, with its Hill Farming Network (EHFN) including its various farmer groups, supportive National Park Authority team and keen advocacy through the Exmoor Society and others.

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BOOK REVIEW

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by John Wibberley[1]

ADVANCES IN CONSERVATION AGRICULTURE: Two Volumes – Kassam, A. – Ed. (2020)

Kassam, A. – Ed. (2020) *Advances in Conservation Agriculture* Vol.1 Systems & Science, 575 pp.; Vol.2 Practice & Benefits, 472 pp. (Burleigh Dodds, Cambridge, UK, Series in Agricultural Science Nos. 61 & 62)

Overview

Conservation Agriculture (CA) represents an expanding and hopeful approach to sustainable agricultural management requiring full appreciation by farm managers internationally. In a total of 26 chapters, these two volumes are very ably edited by Professor Amir Kassam of the University of Reading, UK who is Moderator of the FAO-based Global CA Community of Practice. Each has a foreword, a preface and an index, with the end of each chapter having its own ample references listed. These very important and timely books collate principles that have been field-tested in research and farm practice worldwide. They attribute the foundations of thinking behind CA to three notable books: *Ploughman*'s Folly (Edward Faulkner, 1943); *An Agricultural Testament* (Sir Albert Howard, 1947) and – in Japan, *One Straw Revolution* (Masanobu Fukuoka, 1975). More reference to intercropping research than is here at present might appear in future revisions on CA.

These volumes contrast the intrusive nature of predominant agricultural systems with the agro-ecological approaches enshrined in CA. They outline many CA farming systems and the science underpinning them, together with the benefits attributable to CA, also acknowledging that some CA agronomy is contested. Their scope is global, and they reckon CA adoption so far to be approximately one-third in South America, one-third in North America and one-third in the rest of the world – with huge scope for its wider uptake, especially in Europe and Africa, but also more within China, India and elsewhere.

Within these chapters involving over 120 contributing authors, it is frequently acknowledged that farmers and farmer-to-farmer extension through farmers' groups, and farmers' associations have been keys to CA uptake so far – and are likely to be so in future. Some parts of academia and governments have not been without their resisters! Profits increase under CA systems, otherwise farmers would not adopt CA so readily. Perhaps more documented evidence of the extent of economic benefits of CA would be expected in future editions. Most CA so far is in rain-fed, annual cropping systems as the data show but there is real potential to extend adoption into a wide range of cropping systems where CA has already started in smaller ways – notably within agroforestry. Perhaps centres such as the new Wangari Maathai Agroforestry Research Centre at Nairobi University, Kenya will become key promoters? Linkage could be strengthened of CA integrated crop-livestock systems to movement towards pasture-fed livestock among farmers and consumers.

There is some variability in the use of illustrations – outstandingly good in this respect are:- chapter 3 on Soil health and landscape management; chapter 7 on Management of vegetable CA systems; chapter 9 on Integration of crop-livestock in CA systems – which notes the general disastrous decoupling of crops and livestock in intensive systems; chapter 10 on The status of mechanisation in CA systems; and in Volume 2 – chapter 9 on Biodiversity management practices and benefits in CA systems. It might have been expected that Volume 2 would have lent itself to more photographic and illustrative presentations of evidence than Volume 1. Inclusion of chapters 11 and 12 in Volume 1 on Certification and Policy matters respectively provides fruitful material for application to other issues relevant to agricultural progress, and enriches the wealth of information contained.

Clearly, the production of these two volumes has been a monumental task, and has resulted in seminal reference works of high quality on CA. Of particular value is the systematic way they combine principles and practice and have – via the Global CA Community of Practice – engaged and harnessed farm management involvement from a huge number of farmers in diverse agroecosystems within the range of research recorded.

It is to be hoped that ways can be found to make these key books available more widely in affordable form since the present cover price of £150 per volume is prohibitively high. CA benefit to SDGs and to the poor, as well as to society as a whole is noted in these texts. Among many encouraging glimpses recorded, is the benefit to Great Barrier Reef protection of CA adoption in Queensland Australia.

***Advances in Conservation Agriculture* (CA)** Vol.1 Systems & Science, 575 pp. (Burleigh Dodds, Cambridge, UK)

Noting that *Conservation Agriculture* (CA) has only been defined in internationally agreed terms since 1997[2], this volume charts its spread. Although the three principles[3] put forward in the definition of CA have been encountered within various expressions of cultivations and cropping policy, they are by no means always integrated simultaneously as in proper CA. There is a valiant attempt to chart the adoption and uptake of CA systems globally – a difficult task indeed but the reader is referred to constantly updated websites and sources of information to track changes. With such a number of authors, there is some inevitable repetition of facts

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[2] FAO (2020) defines CA as a farming system that promotes continuous minimum soil disturbance, maintenance of a permanent soil cover and diversification of plant species.

[3] On p.17 of Vol.1, the three integrated principles of CA are described as:- a) Continuous no or minimum mechanical soil disturbance; b) Maintaining a permanent mulch cover on the soil surface; c) Diversification of species in the cropping system.

Chapters in Volume 1. *Advances in Conservation Agriculture* (CA) - Systems & Science

1. The Need for CA
2. Development of CA systems globally
3. CA systems: soils health and landscape management
4. The role of no or minimum mechanical soil disturbance in CA systems
5. The role and management of soil mulch and cover crops in CA systems
6. The role of crop and cropping system management in CA systems
7. Management of vegetable CA systems
8. Managing perennial CA systems: orchards, plantations and agroforestry
9. Integration of crop-livestock in CA systems
10. The status of mechanisation in CA systems
11. Certification schemes for CA systems
12. Institutional and policy support for CA uptake

and data. Each chapter appears designed as almost a 'stand-alone' presentation on its particular title, though evidently and desirably overlapping with others.

Advances in Conservation Agriculture Vol.2. Practices and Benefits, 472 pp. (Burleigh Dodds, Cambridge, UK)

Volume 2 logically covers all aspects of the practical management of CA systems, and concludes with chapters covering benefits to natural resource management for the sake of all. While the weed management chapter does mention that glyphosate over-use has become controversial, and gives a couple of references, there needs to be more recognition of how very widespread is glyphosate dependence within systems currently described as CA, especially in the Americas. This arises from annually repeated use, such that glyphosate accumulation is in soils, crop residues, livestock feeds, interfering with the rumen microbiota of feedlot cattle in such farming systems, and moving on into the human food chain, adversely affecting human health via intestinal problems. More development of the use of cover cropping and knife-rollers within CA rather than using glyphosate is advocated in the text but the CA-CoP might further address this key practical issue in its future work. The need for integrated weed management, and integrated pest management is stressed, along with the need to adopt integrated, pasture-fed, less intensive livestock systems. It is made clear that genuine CA espouses these principles within its three key ones.

Arguably, the chapters in Volume 2 on Carbon might be more logically located in Volume 1 since they report experimental data and principles more than farm practice *per se*. However, that would have created a logistical problem in making Volume 1 relatively too much longer than Volume 2, unless Vol.1 chapter 7 on Management of Vegetables had been put in Vol.2 since it has much emphasis on CA practice, farm-level innovations, and benefits.

Overall, these two volumes provide an exciting collation of the science and practice of CA and its increase across the world. They are hugely valuable resources to stimulate further work for adoption of CA systems using emergent multivariate analysis - possible with digital technologies - of farming systems previously regarded as too complex to analyse. Complex mixed cropping and mixed farming systems, adopted because of their resilience by many farmers, can now be trialled. These books offer an inspiration for CA practitioners, for students of agricultural subjects, for entrepreneurs and all who are concerned for sustainable agricultural management towards Ecosystem Security.

Chapters in Volume 2. *Advances in Conservation Agriculture* (CA) - Practice and Benefits

1. Practice and benefits of CA systems
2. Crops and cropping systems management practices and benefits in CA systems
3. Soil management practices and benefits in CA systems
4. Weed management practices and benefits in CA systems
5. Insect pest and disease management practices and benefits in CA systems
6. Nutrient management practices and benefits in CA systems
7. Carbon management practices and benefits in CA systems: carbon sequestration rates
8. Carbon management practices and benefits in CA systems: soil organic carbon fraction losses and restoration
9. Biodiversity management practices and benefits in CA systems
10. CA: climate change mitigation and adaptation benefits
11. Benefits of CA to farmers and society
12. Social benefits of CA systems
13. Harnessing ecosystem services with CA
14. Rehabilitating degraded and abandoned agricultural lands with CA systems