VIEWPOINT

DOI: 10.5836/ijam/2019-08-01

Observations on *Moving away from Direct Payments* (Defra, 2018a)

JEREMY FRANKS[1]

The Agriculture Bill (2018) was published in September 2018 (House of Commons, 2018). At about the same time Defra published an evidence report *Moving away from Direct Payment: Agriculture Bill: Analysis of the impacts of removing Direct Payments* (Defra 2018a). This viewpoint article argues that this document does not clearly define Farm Business Income (FBI), the measure of income chosen in the analyses, and that this makes it harder for the reader to understand the possible impacts of the withdrawal of Direct Payments on returns to "farmer, spouse and unpaid labour" for their labour and managerial input into the business: an issues of key concern for the future structure of the sector.

The use of Farm Business Income as a measure of "net profit" or "profit"

The Summary section of *Moving away from Direct Payments* (Defra, 2018a) states:

> "Farm Business Income (FBI) is a measure of *net profit*, calculated as Farm Business Outputs (revenue) minus Farm Business Inputs (costs). Between 2014/15 and 2016/17 the average *profit* for all farms was £37,000" (p 5, italics added).

Immediately below this statement is this comment:

> "Across all farm types, over the period 2014/15 to 2016/17, Direct Payments were equivalent to 61% of Farm Business Income (*profit*), but this varies greatly by sector, being most significant for Grazing Livestock and Mixed farms" (p 5, italics added).

Therefore, early in the document, and indeed in the very same paragraph, and on the very same page, FBI is described as a measure of both "net profit" and "profit". This raises the question, what does FBI really measure? Page 19 informs the reader that:

> "FBI equals farm business output less farm business inputs" (p 19).

And that farm business inputs include:

> "feed, materials, labour and machinery, measured in physical or financial terms" (p 19).

Why an input cost might be measured in physical terms is not explained. However, this statement implies that all labour costs are paid, but a further statement on the same page states that:

> "FBI is the amount that a farm business has left after costs to invest, pay taxes and pay salaries" (p 19).

In fact, *Moving away from Direct Payments* does not *explicitly* stated which labour costs are deducted to arrive at FBI and whose salaries need to be paid out of FBI. To answer the question, the reader needs to look elsewhere. For example, Defra (2018b) defines FBI as representing:

> "the financial return to all unpaid labour (farmers and spouses, non-principal partners and their spouses and family workers) and on all their capital invested in the farm business, including land and buildings" (p 11).

This makes it clear that FBI does not represent "profit" in the sense a layperson would understand the term: total revenue less total costs. Defra also defines and uses another measure of farm income, Farm Corporate Income (FCI). FCI subtracts an imputed value for 'farmer, spouse and unpaid family labour' from FBI (Franks, 2009) to give an alternative measure of income, and one that better reflects "profit" as it is more commonly understood. *Moving away from Direct Payments* makes no reference to FCI.

The choice of income measure used to analyse the impacts of the withdrawal of Direct Payments is important because, as Table 1 shows, the difference between FBI and FCI can be large. For example, the average charge made for 'farmer, spouse and unpaid manual labour (excluding unpaid managerial labour)' for farms in England (2015/16) was £28,452, and for hill farms in England (2016/17) £25,726/farm.

This viewpoint presents two examples that shows how the misrepresentation of FBI as "profit" makes the impacts of the withdraw of Direct Payments on farm businesses presented in Defra (2018a) more difficult to understand. This is important because, as argued, it will have a significant influence on the future structure of farm businesses.

Original submitted November 2018; accepted November 2018.
[1]Corresponding author: Jeremy Franks, Ph.D, Newcastle University, Newcastle upon Tyne, UNITED KINGDOM. Email: Jeremy.Franks@newcastle.ac.uk

Table 1: A comparison of the values of FBI and FCI

Sample	England (£)	Hill Farms (£)
Year	(2015/16)	(2016/17)
Farm Business Income (FBI)	31,482	18,972
Adjustment for unpaid "farmer, spouse and unpaid manual labour"*	28,452	25,726
Farm Corporate Income (FCI)	3,030	-6,754

*Note that this imputed value does not make a deduction for managerial input of "farmer, spouse and unpaid family labour". (Source: Rural Business Research (2018) and Harvey and Scott, 2018).

Impacts of the withdrawal of Direct Payments on input prices and farm incomes

Moving away from Direct Payments presents several analyses of the financial challenges farm businesses may face following the withdrawal of Direct Payments. To give one example, it calculates that half of the loss making Less Favoured Area Grazing Livestock farms will need to reduce costs by more than 16% to breakeven without Direct Payments (p 25—27). It is estimates such as this that lead Defra to conclude that withdrawing Direct Payments:

> "may encourage more rapid structural change" (page 9).

As the rate of structural change is typically measured by the rate of change in the number and size of farm businesses it is clearly an issue of interest to the farming population.

Moving away from Direct Payments argues that the size and scope of any adjustments a farmer may need to make following the withdrawal of Direct Payments will, in part, be related to how input prices change. An example provided is farm rents:

> "as Direct Payments have led to an increase in rents, their withdrawal will see the reversal of this impact" (p 15).

This is because:

> "Direct Payment is indirectly paid to the landowner through inflated rent prices" (p 15).

This raises the question, if Defra are confident of the link between Direct Payments and land values, why has it apparently been happy to allow the link to exist when agricultural policy is principally aimed at supporting farmers' incomes? Putting this question to one side, and given that there is a link between Direct Payments and land values, and most economists would agree that there is, what will be important to the adjustments farmers need to make is the rate at which rents fall and the level to which they fall. This will, in part, depend on when rental agreements are due to be renegotiated:[2]

> "rental agreements may not be up for a renewal immediately after the withdrawal of Direct Payments. Rent reviews will vary by type of farm and tenancy." (p 28).

Farm Business Tenancy rents are typically more changeable than other tenancy agreement rents, in part because they tend to be negotiated more frequently, which makes them more responsive to changes in farm profitability. Unfortunately, economic theory is silent on the rate at which input prices in general may change. However, as this example shows, the rate at which prices change generally reflects the contractual terms, and therefore the relative market power of buyer and buyer of their produce. For most inputs, an individual farmer has less market power than a seller. Because of this input prices are likely to be 'sticky', that is, to remain constant or fall more slowly than they had previously increased.

Given sticky input prices, the first "hits" of the loss of the Direct Payment will be the amount available to compensate 'farmer, spouse and unpaid family' for their manual labour and managerial input: because FBI is not clearly defined, this consequence of withdrawing Direct Payments in not transparently clear in *Moving away from Direct Payments*.

The use of depreciation to support "farmer, spouse and unpaid labour"

Moving away from Direct Payments suggests that farmers could use depreciation to support 'farmer, spouse and unpaid family' labour when Direct Payments are withdrawn. It notes that accounting standards allow profit to include a deduction for machinery and building depreciation, but because these costs are not cash costs:

> "In the short term [they] do not need to be paid out" (p 24).

Consequently:

> "Depreciation ….. does not alter the day to day cash flow of a business. Therefore, in the short term, when looking at the impact of instantly removing Direct Payments, depreciation costs can be excluded so only 19% of farms [across England] would not be able to cover their production costs" (p 24).

Which is an interesting use of the word "only". Nevertheless, the principle underpinning this statement is correct. For example, Harrison and Tranter (1989) stated:

> "Because depreciation is an incoming cash flow item it need not necessarily be used to replace the capital items which are notionally giving rise to it" (p 63).

Undoubtedly farmers do use this "incoming cash flow item" to help tie them over during hard times. But the annual value of depreciation depends on previous investments: a farm already in financial difficulties prior to the withdrawal of Direct Payments may already be using this strategy, and if they have been using it for several years there may be little or no depreciation "incoming cash flow item" remaining to draw on. Moreover, as Harrison and Tranter (2089) point out,

[2] But also, on other factors, such as transition arrangements put in place as we move from full to no Direct Payments, the details of which are not yet decided (see possible options in Defra 2018a, Section 5, p 42-45).

such an adjustment strategy relies on existing capital stock being made to:

> ''keep going at some acceptable level of performance'' (p 63).

This is not always possible, but even when it is, it is likely to lead to an increase in repair and labour costs, outcomes which are not referred to in the calculations presented on page 24 (Defra 2018a), but which will nevertheless further reduce the cash available to compensate 'farmer, spouse and unpaid labour' for their manual and managerial labour.

The use of depreciation in this way has a direct implication for future increases in efficiency - an adjustment strategy discussed in *Moving away from Direct Payments*:

> ''Removal of Direct Payments may be offset in a number of ways, including farm efficiency improvements (reducing inputs or improving outputs) ….'' (p 31).

No doubt efficiency on some farms can be raised further by the use of some or all of the best practices discussed in *Moving away from Direct Payment* (see Box 1). However, if the depreciation allowance is spent supporting incomes rather than banked it cannot later be used to finance capital investments. This will reduce efficiency and competitiveness in the medium- and long-term, and thereby merely delay rather than reduce the number of farmers who leave the sector.

Box 1. Suggestions put forward as to how farm performance can be raised

Improve farm efficiency by increasing the value of outputs (p 34).
Improve farm efficiency by reducing costs (p 31), for example,

- Feed livestock more efficiently to improve feed conversion ratios;
- Nutrient management plan (50% of relevant holdings do not have a NMP);
- Manure management plan (33% of relevant holdings do not have a MMP);
- Test the nutrient content of soil (33% of relevant holdings do not do this);
- Selective breeding, using estimated breeding values (p 33);
- Improved animal and crop health (p 37).

Switch land use into new Environmental Land Management System (p 3 & p 39).
Diversify the use of farm assets (p 31).*
Reduce waste (p 36).
Gain a better understanding of the market;

- Vertically integrate where appropriate (p 36);
- Secure more favourable contracts for produce (p 36).

Undertake financial management practices (p 40), such as

- Produce budgets, gross margins and cash flows, and benchmarking (done on only 33% of farms).

* Though it is noted on page 31 that ''if more farms diversity, for example into tourism, this would increase the supply and thus in turn may lower the return to the farmer'' (Defra 2018a).
(Source: Defra (2018a))

Conclusions

This viewpoint does not offer any comment about the decision to remove Direct Payments, nor does it offer any advice on how that process should be conducted. Rather it argues that the text used in *Moving away from Direct Payments* to examine the consequences of moving away from Direct Payments fails to properly define FBI. As a result, the way FBI is used as a measure of ''profit'' is misleading – FBI is not a measure of profit in the way a businessperson or an informed layman would understand the term.

As a direct consequence of this misuse, *Moving away from Direct Payments* gives misleading implications on farmers' short-, medium- and long-term incomes and business competitiveness. For example, if input prices are either slow to fall, or do not fall at all, the first ''hit'' will be taken by the cash available to compensate 'farmer, spouse and unpaid labour' for their manual work and managerial input during the year. If this happens, farmers may well chose to support their incomes by diverting depreciation – a cash inflow item – away from reinvesting in their business. But this can only provide a temporary lifeline for a proportion of farm businesses, and doing so will have adverse medium- and long-term impacts on farm efficiency and therefore the sector's competitiveness.

The rate of structural change across the sector – which is typically measured by the change in the number and size of farm businesses – will depend on many factors, but ultimately the most important of these will be the level of income at which farmers are prepared to continue to farm, i.e. their own ''supply price''. The willingness of farmers to accept lower private drawings during hard times is described as the ''traditional belt tightening exercise'' associated with family farming (Harrison and Tranter 1989, page 63), and Harrison and Tranter (1989) comment that identifying a farmer's ''supply price'':

> ''Is a notoriously hard [question] on which to shed empirical evidence'' (p 27).

Identifying the impacts of withdrawing Direct Payments on the structure of farming would have been helped by the use of FCI rather than FBI because FCI provides a clearer measure of the profit farm businesses currently deliver after deducting reasonable drawings to support the living of farmers and their families. As such, FCI would provide a better guide of the current strength of the sector, and of the profit/losses farmers would enjoy/need to face following the withdrawal of Direct Payments. This in turn would provide a better guide to the rate at which farmers are likely to leave farming – an issue clearly of importance to farmers and policy makers alike.

REFERENCES

Defra. (2016). Definitions used in the Farm Business Survey. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/557605/fbs-definintions-4oct16.pdf [Accessed September 2018]

Defra. (2018a). Moving away from Direct Payment: Agriculture Bill: Analysis of the impacts of removing Direct Payments. Government Statistical Service. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/740669/agri-bill-evidence-slide-pack-direct-payments.pdf [Accessed September 2018]

Defra. (2018b). *Forecasts of Farm Business Income by type of farm in England – 2017/18. February 2018*. National

Statistics https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/684137/fbs-businessincome-statsnotice-28feb18.pdf

Franks J. R. (2009). A comparison of new and previously preferred measures of farm income. *Journal of Farm Management*, 13(8), p 539-556. ISBN 0014-8059. https://www.ingentaconnect.com/content/iagrm/jfm/2009/00000013/00000008/art00001?crawler=true [Accessed September 2018]

Harrison, A. and Tranter, R.B. (1989). *The changing financial structure of farming*. Centre for Agricultural Strategy (CAS) Report 13, Reading University, England.

Harvey, D. and Scott, C. (2018). Farm Business Survey 2016/2017 A summary from Hill Farming in England. Rural Business Research. https://www.ruralbusinessresearch.co.uk/publications/ [Accessed September 2018]

House of Commons. (2018). The Agriculture Bill (2018): 266. https://services.parliament.uk/bills/2017-19/agriculture.html [Accessed September 2018]

Rural Business Research. (2018). FBS data builder v65b [2.6.a]: Table 13277. http://dev.farmbusinesssurvey.co.uk/DataBuilder/Default.aspx?Menu=Menu&Module=Results&rqREF=013277 [accessed 11th October 2018]

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-05

Socio-economic factors affecting the adoption of GHG emission abatement practices; the case of spring slurry spreading

DOMNA TZEMI[1] and JAMES PATRICK BREEN[2]

ABSTRACT

The agricultural sector in Ireland contributes almost 33% of Ireland's total Greenhouse Gas (GHG) emissions with dairy cows and beef cattle being the biggest source of these emissions (EPA, 2016). Several studies exist indicating that changing the timing of slurry spreading from summer to early spring, would reduce the levels of ammonia emissions (Lalor and Schulte, 2008; Stettler *et al.*, 2003). A knowledge gap, however, exists on the extent to which Irish farmers would be willing to change the time they spread slurry. The main objective of this paper is to investigate the influence of selected personal, farm and economic characteristics on farmers' willingness to spread most of their slurry in early spring. In order to achieve that a binary probit model was used. The results showed that 50% of slurry spread in early spring in Ireland was positively influenced by advisory contact, investment in machinery per hectare and profitability of the farm. While off-farm income and the date farmers turn their cows out to grass had a significant negative effect. The findings of this study could assist advisors and policy makers in relation to the adoption of new practices by farmers.

KEYWORDS: probit model; technology adoption; dairy farmers

1. Introduction

The agricultural sector in Ireland contributed 33% of Ireland's total greenhouse gas (GHG) emissions in 2015. Although these emissions were 5.7% below their 1990 levels, the years 2012, 2013 and 2015 GHG emissions have seen an increase in GHG emissions levels from agriculture. The recent increase in emissions from the agricultural sector are largely due to the abolition of the EU milk quota system in 2015 which has led to higher animal numbers and an increase in milk production (EPA, 2016). Methane (CH_4) and Nitrous Oxide (N_2O) are the main greenhouse gases produced from agriculture with the bulk of these gases coming from the dairy and beef sectors in the case of Ireland. Dairy and beef production in Ireland are predominantly grass based with farmers engaged in rotational grass grazing from mid-spring to mid-autumn and a period of winter housing (3 to 6 months) when animals are fed a diet based largely on conserved grass forage or silage. In pasture-based dairy and beef livestock systems in Ireland, during the winter the majority of manures produced (approximately 80%) are managed as slurry (Hyde and Carton, 2005).

Ireland has been subject to two major global emission legislation protocols in order to diminish the pollution caused by agricultural activity and to regulate the management of nitrate and other nutrients. The Kyoto Protocol and the Gothenburg Protocol (and the subsequent National Emissions Ceilings Directive). Under the Kyoto Protocol Ireland has committed to reducing its GHG emissions and under the Gothenburg Protocol Ireland has committed to reducing emissions of four transboundary air pollutants (SO_2, NOX, VOCs and NH_3) which contribute to regional acidification, eutrophication and local air pollution across Europe.

Lalor and Schulte (2008), stated that of the total nitrogen applied in slurry, only 25% of the nitrogen is available to the grassland when the slurry is applied in the spring and just 5% is available when applied in the summer (Lalor and Schulte, 2008). However, a survey of Irish bovine farmers on slurry management practices conducted in 2003 found that only 31% of slurry was being applied in the spring, which was the optimum time of application in terms of availability of N to the plant, with 52%, 13% and 4% being applied in the summer, autumn and winter, respectively when recovery of nitrogen is poor (Hyde *et al.*, 2006).

Original submitted May 2017; revision received November 2018; accepted December 2018.

[1] Corresponding author: Lincoln International Business School, University of Lincoln, Brayford Pool, Lincoln, LN67TS, United Kingdom. Email: dtzemi@lincoln.ac.uk

[2] School of Agriculture and Food Science, University College Dublin, Ireland. Email: james.breen@ucd.ie

Several studies have reported that changing the timing of slurry spreading from summer to early spring, would reduce the levels of ammonia emissions (Lalor and Schulte, 2008; Stettler *et al*., 2003). Furthermore Schulte and Donnellan (2012) identified the potential for better utilisation of slurry to contribute to a reduction in GHG emissions. Little information exists, however, on the extent to which Irish farmers would be willing to change the time they spread slurry or the factors that influence current slurry spreading practices.

The purpose of this paper is to investigate the influence of selected personal, farm and economic characteristics on the current timing of slurry application on Irish dairy farms. In order to capture the impact of those characteristics on individual farmers' adoption decision, a binary probit model was used. Spreading of slurry is highly dependent on weather conditions and on farmer attitudes, therefore assuming that the spring in 2013 and 2014 were representative of typical spring weather in Ireland[3], it is hypothesised that farmers with better managerial skills (not too high stocking rate,), the ownership of slurry equipment and better land characteristics (date cows let out to grass) are more likely to spread most of their slurry in early spring. This section introduces the Irish agricultural sector and its contribution to GHG emissions focusing on slurry spreading techniques. The following section outlines the background to the research question based on the literature review of technology adoption. The third section introduces the applied methodology. Following this, the data used in the analysis are presented and the empirical results of the model are explained. The last section consists of the results of the model used followed by some final conclusions.

2. Background

Timing of spreading slurry

Timing of slurry application plays a major role in maximizing the availability of N contained within the slurry to the herbage. Winter and autumn are inappropriate months for spreading slurry due to high chances of high leaching losses to watercourses (Smith and Chambers, 1993; Schröder, 2005). Applications in the summer are not recommended as well, as they are more susceptible to losses of gaseous ammonia due to warmer and drier air and soil conditions (Smith and Chambers, 1993; Schröder, 2005). Early spring is deemed to be the best period in Ireland for slurry applications as nutrient uptake by herbage is in its peak and ammonia and leaching losses are relatively low (Carton and Magette, 1999). However, ground conditions (i.e. where the soils are too wet) may constitute a constraint for slurry application. For instance, Lalor and Schulte (2008) noted that in some parts of Ireland during a year of high rainfall, soils may only be dry enough to permit traffic with slurry application equipment for 25 days during the summer.

During the period of slurry storage anaerobic conditions in the slurry store produce methane emissions (Schulte *et al*., 2011). When more slurry is applied in spring the length of the slurry storage period has been found to be reduced by 3.1% on average resulting in a reduction in methane emissions from slurry storage (McGettigan *et al*., 2010; Schulte *et al.,* 2011).

There are a number of reasons for Irish farmers choosing to apply most of their slurry during the summer months, firstly farmers may choose to apply slurry after grass has been harvested for silage and the risks of contamination of pastures are less. Secondly most of the farmers use the splash plate method, however in the case of spring applications with the splashplate method farmers are restricted to only spreading when there is low herbage mass and this often coincides with soil conditions that do not allow soil trafficking without damage. As a result, applications are postponed until after the first cut of silage has been made, when risks of ammonia losses are higher and the N fertilizer replacement value is lower. Therefore, the use of low emission techniques such as trailing shoe and injection which allows slurry spreading in pastures with higher herbage mass, extend the period when slurry can be spread in spring when conditions are better resulting in lower ammonia emissions (Lalor and Schulte, 2008).

Factors affecting technology adoption

There is a large literature on the adoption and diffusion of new technology, with Rogers theory of adoption first being popularized in his book *Diffusion of Innovations (1962)* and widely applied. In general, the literature on the adoption of new agricultural and more environmentally friendly technologies suggests that farmers' decision making depends on a variety of factors, such as economic, structural characteristics of the farm, as well as demographic and personal characteristics (Austin *et al*., 1998; Rehman *et al*., 2007; OECD, 2012; Tornatzky and Klein, 1982)

To begin with, according to neo-classical economic theory individuals are profit maximisers. However, Willock *et al*. (1999) stated that farmers' decision making regarding environmental practices may not be influenced necessarily by the unique goal of profit; it depends on whether the farmer values farming as a way of life or as a business. This implies that farmers' personality, attitudes and objectives have to be considered when investigating the factors that influence their decision making. Therefore, as Vanclay (2004) argued farmers have different adoption behaviours as they think differently, use different methods and practices in their work and have other priorities.

Risk taking is one aspect of the personality that influences adoption decisions. Shapiro *et al*. (1992) argued that individuals that are risk averse avoid adopting new technologies that are seen as high risk, while according to Abadi Ghadim *et al.* (2005) farmers tend to adopt an innovation that is perceived as reducing risk.

In the context of the Irish literature, farm size is typically found to be positively associated with adoption depending on the technology. For instance, while Clancy *et al.* (2011) and Keelan *et al.* (2010) inferred positive relationship between farm size and adoption of energy crops and GM crops respectively, however, the adoption of organic farming was negatively related with farm size (Lapple and Van Rensburg, 2011). This can be explained by small farms' tendency to adopt more labour intensive systems, as small farms can rely on family labour (Hayami and Ruttan, 1985). In the case of organic

[3] Based on a review of weather data from 2008 to 2018 inclusive for 9 weather stations (cso.2018), rainfall levels in the spring of 2013 were slightly lower than average for the period 2008 to 2018, while rainfall levels for 2014 were higher than average but not out of line with other years that experienced high levels of rainfall.

farming specifically, smaller farms might be easier to manage, for instance in terms of meeting the required organic regulations (Lapple and Van Rensburg, 2011).

Economic variables, such as profit are hypothesized to have a positive effect on adoption. Howley *et al*., (2012), found that profitable farms were more likely to use AI, as they acknowledged the benefits of using AI as a reproductive technology instead of natural mating. Other Irish studies, however, failed to conclude a significant relationship between adoption and profit (Clancy *et al*., 2011; Keelan *et al*., 2010).

3. Materials and Methods

The binary probit model

The use of probit and logit choice models to investigate the factors that affect the adoption of a new technology or innovation is widespread in the adoption literature (Feder *et al*., 1985). Linear regression estimation is inappropriate as the basic assumptions of normality and homoskedasticity of the error term are violated (Greene, 2012) as they discern unequal differences between ordinal categories in the dependent variable (McKelvey and Zavoina, 1975 cited in Greene, 2012). When the dependent variable is binary, the appropriate econometric model is either the binary probit model or the binary logit model (Greene, 2012).

The main difference between the two models is that in the logit model the probability of an event is described by a logistic distribution while for the probit model a standard normal distribution is assumed. These models are based on the assumption that farmers will adopt and use the technology that allows them to achieve the highest level of utility (Davey and Furtan, 2008). For this study the probit model is chosen, which was also used in a number of other studies of adoption behaviour (Fernandez-Cornejo *et al*., 2002; Boz and Akbay, 2005; Keelan *et al*., 2010; Clancy *et al*., 2011).

The binary probit model for Y_i is derived from a latent variable model. It is based on a latent variable intended to represent farmers' percentage of slurry spreading in spring. This latent variable is assumed to be determined by a normal regression structure:

$$Y_i^* = x_i^{'}\beta + \epsilon_i,\ \epsilon|\mathrm{x} \sim \mathrm{Normal}\,(0,1) \tag{1}$$

That is, for each person *i* the utility difference between spreading more than 50% of slurry in early spring and spreading less than 50%, is written as a function of personal and farm characteristics, x_i and unobserved characteristics, ϵ_i.

The binary probit model describes the probability that $y_i = 1$ as a function of the independent variables.

$$\begin{aligned} P(y_i = 1) &= P(y_i^* > 0) = P(x_i^{'}\beta + \epsilon_i > 0) \\ &= P(-\epsilon_i \le x_i^{'}\beta) = F(x_i^{'}\beta), \end{aligned} \tag{2}$$

This equation shows the probability that $y_i = 1$ for the given function $F(.)$. Where F is also a function of the cumulative distribution function, which is bound by the [0,1] interval. The parameter β is the parameter to be estimated. The model depends on the vector x_i which contains individual, economic and farm level characteristics.

Estimation of the parameters follows maximum log likelihood estimation

$$\begin{aligned} \mathrm{Log}\,L\,(\beta) = &\sum_{i=1}^{N} y_i \log\, F\,(x_i^{'}B) \\ &+ \sum_{i=1}^{N}(1-y_i)\log(1-F\,(x_i^{'}B) \end{aligned} \tag{3}$$

Substituting the appropriate form for F gives an expression that can be maximized with respect to β (Verbeek, 2004).

The β coefficients in the probit model do not have a meaningful interpretation. Thus, marginal effects were calculated to determine how much each explanatory variable affects the likelihood of spreading or not in early spring. The marginal effects for an ordered probit can be calculated as

$$\begin{aligned} \frac{\partial P(y=1x)}{\partial x_j} &= \frac{\partial P(y=1x)}{\partial x\beta} \cdot \frac{\partial x\beta}{\partial x_j} \\ &= \psi^{'}(x\beta)\cdot\beta_j = \psi(x\beta)\cdot\beta_j \end{aligned} \tag{4}$$

A change in factor x_j does not induce a constant change in the $P(y = 1\ |x)$ because $\psi()$ is a non-linear function of x (Baum, 2006). For instance, an increase in x_j increases (decreases) the probability that $y=1$ by the marginal effect.

Data

The main data source used in this analysis is the Irish National Farm Survey (NFS). The NFS collects data on Irish farms on behalf of the Farm Accountancy Data Network of the European Union on an annual basis since 1972, providing a representative sample of Irish farms. The data used in this study is taken from the NFS for the years 2013 and 2014. Many farmers stay in the sample for several years and the sample has an annual turnover rate of approximately 15-20%. That is, after a specific period, some farms drop out and others replace them, so that the sample is kept representative. In 2013 911 farms participated in the NFS survey representing a national population of 79,103 farms (Hanrahan *et al*., 2014). And in 2014, 798 farms participated in the NFS survey representing 78,641 farms nationally (Hennessy and Moran, 2014).

Data from an NFS supplementary survey provides more detailed information on slurry spreading management for both years 2013 and 2014. It includes among other information data on the type of slurry application method used by farmers as well as the percentage of slurry spread during different periods of the year. This provided a cross-section sample of 639 farms for 2013 and 2014 to be used in this study.

The dependent variable of the binary probit model has two responses; 0 for the farmers that spread 49% or less of their slurry during January to April and 1 for the farmers that spread more than 49% of their slurry from January to April. According to the Food Harvest 2020 Report[4] (DAFF, 2010) farmers who spread 50% or more

[4] The Food Harvest 2020 report outlines a strategy for the development of the Irish agri-food sector for the period to 2020. The report outlined a series of strategic targets for the different sub-sectors of Irish agriculture.

Table 1: Definitions of socioeconomic variables and descriptive statistics

Variable definition and codes	Variable name	N	Mean	Standard Deviation	Minimum	Maximum
Independent variables						
Advisory contact; 0=None; 1=Yes	ADVISORY_CONTACT	639	0.77	0.42	0	1
Date cows let out to grass (in numbers of weeks)	DATE_COWS_GRASS	639	9.31	3.48	1.86	21.29
Slurry spreaders owned by farmers; 1 = equipment present; 0 otherwise	OWN_SLURRY_EQUIPMENT	639	0.77	0.42	0	1
Stocking rate (total livestock units divided by utilized agricultural area in hectares	STOCKING_RATE	639	1.89	0.53	0.39	3.95
Land owned in hectares	LAND_OWNED	639	52.78	31.39	4	243.72
Region South East; 0=farm is located in the Border Midland West; 1=farm is located in South & East	REGION_SE	639	0.75	0.43	0	1
Off-farm employment; 0=no off farm activity; 1=wage/salary or self-employed off-farm	OFF_FARM_EMPLOY	639	0.07	0.25	0	1
Investment in machinery per hectare	INVEST_MACHINERY_HA	639	1017	748.30	0	5177.49
Profitability (farm gross margin in euro[5] per total livestock units)	PROFITABILITY	639	1068.51	285.44	202.53	2438.01
Environmental subsidies; 0=no env/al subsidies; 1=farmers received env/al subsidies	ENV/AL_SUBS	639	0.29	0.45	0	1
Year; 0 = 2013; 1=2014	YEAR_DUMMY	639	0.51	0.50	0	1
Dependent variable	HALF_SPRING_SLURRY	639	0.61	0.49	0	1
Slurry application in Jan-Apr; 0 = 0-49%; 1 = 50-100%						

of their slurry in early spring perform better both environmentally and financially than those who spread less than 50% (Schulte and Donnellan, 2012). Reduced NH_3 losses due to favourable weather conditions, increases the fertiliser replacement value of slurry, which leads to reduction in the total N fertiliser inputs.

Definitions and descriptive statistics for explanatory variables hypothesised to affect timing of slurry spreading are presented in Table 1. Farm characteristics such as the hectares of land owned by farmers (LAND_OWNED) and the region farms are located are hypothesised to influence farmers' decision to spread more than half of their slurry in early spring. The variable region South & East captures geographical, soil and climatic characteristics of farms. The economic characteristics of the farms were captured by the off-farm income, investment in machinery per hectare as well as farm's profitability and the binary variable for the reception of environmental subsidies. The *YEAR_DUMMY* variable was added in order to capture any possible effect that the specific weather effects in the two years 2013 or 2014 might have had on the timing of farmers' slurry spreading.

4. Results

As mentioned above, a binary probit model on the possibility of the farmer considering to spread more than half of their slurry in early spring (January to April) was applied. Table 2 presents the estimation results of the probit model. The statistical significance of the model is defined at 10%, 5% and 1% level. The chi-squared for the probit model is 44.26 and statistically significant, indicating that the hypothesis that all slope coefficients equal zero is rejected. An overall result shows that farmer characteristics, individual and managerial have significant impact on the likelihood of early slurry spreading. The marginal effects from the probit model are presented in Table 3.

Table 2: Results of the binary probit model on the probability of early slurry spreading

Variable	Coefficient	P value
ADVISORY_CONTACT	0.22*	0.078
DATE_COWS_GRASS	-0.05***	0.004
OWN_SLURRY_EQUIPMENT	-0.05	0.699
STOCKING_RATE	-0.08	0.449
LAND_OWNED	0.002	0.315
REGION_SE	0.15	0.238
OFF_FARM_EMPLOY	-0.44**	0.027
INVEST_MACHINERY_HA	0.0001*	0.067
PROFITABILITY	0.0003*	0.089
ENV/AL_SUBS	0.143	0.217
YEAR_DUMMY	0.007	0.943
Loglikelihood	-405.5498	
LR chi2(11)	44.26	
Pseudo R2	0.0517	

Notes:
(***) Indicates the variable is significant at the 1% level.
(**) Indicates the variable is significant at the 5% level.
(*) Indicates the variable is significant at the 10% level.

Beginning with farmers' individual characteristics, farmers who had contact with some agricultural advisors, either from Teagasc or private agricultural advisors, were more likely to spread slurry in early spring. In general, literature has shown that advisory contact along with activities such as participation in discussion groups has a positive influence on famer' decision making (Hennessy and Heanue, 2012).

Only one of the variables that were used to capture farmers' managerial skills showed significant effect on slurry spreading. The result for *DATE_COWS_GRASS*

[5] May 2017, €1 was approximately equivalent to £0.84 and $1.09.

Table 3: Marginal Effects of the probit model on the probability of early spring slurry spreading

Variable	coefficient	p-value
ADVISORY_CONTACT	0.079*	0.076
DATE_COWS_GRASS	-0.018**	0.003
OWN_SLURRY_EQUIPMENT	-0.018	0.699
STOCKING_RATE	-0.031	0.448
LAND_OWNED	0.000	0.314
REGION_SE	0.055	0.236
OFF_FARM_EMPLOY	-0.161**	0.025
INVEST_MACHINERY_HA	0.0001*	0.065
PROFITABILITY	0.0001*	0.086
ENV/AL_SUBS	0.052	0.216
YEAR_DUMMY	0.002	0.943

Notes:
(***) Indicates the variable is significant at the 1% level.
(**) Indicates the variable is significant at the 5% level.
(*) Indicates the variable is significant at the 10% level.

showed that farmers who let their cows out to grass earlier are more likely to spread a larger proportion of their slurry in early spring. One could consider it as a proxy for soil traficabillity and overall weather conditions as farmers let their cows out only when the soil is not too wet (saturated) or heavy. Therefore, the timing of cows' turnout has a positive significant effect on the timing of spreading slurry. *OWN_SLURRY_EQUIPMENT* had no significant effect, although it was expected that farmers who own their slurry spreading machinery are more likely to spread more of their slurry in early spring. As it was assumed that farmers who own their own slurry spreading equipment are likely to have more opportunity to avail of spells of good weather in the spring compared with those farmers who are using contractors as their ability to avail of relatively short periods of suitable weather conditions is linked to the availability of the contractor.

The effect of animal stocking intensity was captured by the variable *STOCKING_RATE* which showed no evidence of a significant effect on slurry spreading. However, a negative relationship between stocking rate and early slurry spreading was expected based on the hypothesis that those farmers with higher stocking rate are less willing to apply more of their slurry in early spring due to concerns in relation to the trafficability of the soil and the implications that this may have in terms of damaging the sward and reducing the future grass availability. A dummy variable for year was used in order to see if there was any significant difference in the early application of slurry between 2013 and 2014, this could have been expected if the weather conditions between the two years were not comparable However the results showed no significant effect.

With regard to farm characteristics, land ownership and the regional location of the farm did not demonstrate any significant influence on slurry spreading. It was expected that farms located in the South and East region would have a positive effect on early slurry spreading. In terms of climatic and soil conditions farms located in SE region are considered more advantaged than the farms located in BMW. That is, better weather conditions and better quality soils are likely to be more trafficable in the early spring, therefore making slurry application easier during periods of less favourable weather conditions when compared with farms with poor soil quality. Ownership of land was assumed to have a positive effect on early slurry spreading based on previous studies. Fernandez-Cornejo *et al.* (2002; 2007) showed that land owners are more likely to adopt new practices because they directly avail of the benefits.

The effect economic variables have on early slurry spreading is examined in this section. Investment in machinery was positively related to technology adoption suggesting that farmers with greater economic capacity and more investments in machinery tend to be more risk takers and make new investments, therefore more likely to adopt new technology or practices. Farmers' employment off the farm showed that farmers who receive salary/wage or they are self-employed off the farm are less likely to spread more than half of their slurry in early spring. This negative relationship can likely be attributed to time constraints with those farmers who are employed off the farm having limited time to spend on spreading slurry during the spring time which is a particularly busy time of the year for Irish dairy farms which are predominantly 100% spring calving.

Farm's profitability was found to be significant in determining changing management practice. As expected, farms with higher profitability are more likely to spread their slurry earlier. A potential explanation could be that more profitable farms tend to perform better than less profitable farms. The environmental subsidies variable failed to show any significant effect on early spreading, although it was assumed that farmers who receive environmental subsidies from their participation in rural environment protection scheme (REPS) were more environmentally aware than those who did not receive any.

The marginal effects from the ordered probit were computed and are presented in Table 3. More details on their computation are explained in Williams (2012). In the case of continuous variables, these results show the effect that a unit change of a continuous variable has on the probability of the farmer spreading more than half of their slurry in early spring. In the case of binary independent variables, marginal effects measure how predicted probabilities change as the binary variable changes from 0 to 1. The marginal effect for advisory contact indicates that farmers who will change from not using to using advisory contact are more likely to spread more than 50% of their slurry in the January to April period by seven percentage points when compared with farmers who do not engage in contact with the advisory services. Likewise, for each delay of one week in the date that farmers let their cows out to grass the probability of spreading more than 50% of their slurry in early spring is reduced by almost 2%. Both investment in machinery and profitability have a positive effect on slurry spreading with the marginal effects being very small numbers, as the unit change refers to €1. If income coming from off-farm sources would be increased by one unit, the probability of spreading more than 50% of farmers' slurry in early spring would be decreased by 16%.

5. Conclusions

The purpose of this study was to investigate the effect that farm and farmer individual characteristics have on the timing of slurry application on Irish dairy farms, with

a particular focus on the proportion of slurry spread in early spring due to the capacity for early slurry application to help mitigate GHG emissions. Technology adoption theory was used as a theoretical framework and taking into account the fact that this framework was developed to empower agricultural advice and policy, the findings of this study provide useful information for those interested in influencing changes in farm management practices that may contribute to reducing environmental externalities such as slurry spreading timing. A probit model was developed to determine any potential influence the selected explanatory variables may have on farmers' decision on spreading slurry in early spring.

Overall the results from the probit model endorse the hypothesis that a number of economic and individual, managerial characteristics can play an influential role in farmer's decision making. Consistent with the results of previous studies (Boz and Akbay, 2005; Islam *et al*., 2013; Lapple and Van Rensburg, 2011) this research has shown that Irish farmers provided with agricultural information are more likely to spread slurry in early spring. This would support previous research that has shown that advisory contact has the potential to instigate technology adoption amongst farmers.

The date farmers turn their cows out to grass showed a negative significant effect. This variable reflects to a large extent the physical characteristics of the farm in terms of the soil quality and drainage as well as the infrastructure on the farm in terms of pathways or roadways for herding cows to and from the fields and local weather effects. Previous research has determined that economic factors such as a farm's profitability or the off-farm income available will positively affect the probability of adopting a new technology (Clancy *et al*, 2011; Keelan *et al*., 2010; Clancy *et al*., 2011). In accordance with these findings this research showed that farm profitability had a positive significant effect on the probability of a farmer spreading more of their slurry in early spring. Despite the expectation for significant effect of farm characteristics, like the region or the land ownership both of them showed no significant effect on slurry spreading.

A lot of attention has been placed on the capacity for changes in management practices to contribute to reducing agricultural GHG emissions, this paper identifies some of the potential challenges to such a strategy, as these changes in management practices may be curtailed by the physical resources or attributes of the farm (e.g., soil quality or date cows can be turned out to grass), the capital resources (e.g. the capacity to invest in machinery) and the perceived riskiness of the change in management practice (e.g. the capacity of the new management practice to support higher stocking rates). The research findings outlined in this paper suggest that national governments have a role to play in encouraging change in practices amongst farmers such as spreading their slurry in early spring. Based on the results of this research, policy makers could take into consideration that more profitable farms are more receptive to changes in management practices. These farms may be more open to changing farm management practices in order to increase their profitability further, or as noted by Levinthal and March (1981) profitable farms with high aspirations are more receptive to changes when their performance expectations are not being met. Therefore, this may require the presence of an agri-environmental scheme for low profitability farms. Incentivising advisory contact could be considered by policy makers as it could possibly influence farmers in changing management practices.

The findings of this study also has implications for the marginal abatement cost curve (MACC) for Irish agriculture studied by Schulte and Donnellan (2012) in terms of redefining the assumptions. More specifically, Schulte and Donnellan (2012) in their estimation of the MAC curve as with MAC curves in general quantified the volume of emissions that could be abated through timing of slurry application on the basis of what is technically feasible to achieve, this approach to the estimation of MAC curves can fail to reflect the likely level of adoption of GHG abatement measures by farmers that will be influenced by a farmers individual characteristics. Therefore, farmer and farm characteristics that this study indicated to influence the adoption of new management practices could be taken into consideration in any future updates of the MAC curve or as part of a sensitivity analysis to consider the abatement potential under levels of adoption. Further research recommended could be on factors that affect farmers adopting new spreading slurry technology since evidence from literature (Lalor and Schulte, 2008) has shown that spreading slurry in early spring using low emission techniques (e.g. trailing shoe) maximizes N- efficiency and minimizes ammonia loss.

About the authors

Domna Tzemi is a PhD candidate in the School of Agriculture and Food Science in the University College Dublin. Her research interests include farm-level modelling and specifically the impact of alternative GHG abatement practices on farms.

James Breen is Assistant Professor in the School of Agriculture and Food Science, in the University College Dublin. His research interests are predominantly in the area of farm-level modelling and specifically in the examination of the impact of alternative agricultural and environmental policies on Irish farmers.

Acknowledgement

We are grateful to Cathal Buckley, Rogier Schulte, Brian Moran for their technical assistance in the paper.

REFERENCES

Austin, E.J., Willock, J., Deary, I.J., Gibson, G.J., Dent, J.B., Edwards-Jones, G., Morgan, O., Grieveb, R. and Sutherlandd, A. (1998). Empirical Models of Farmer Behaviour Using Psychological, Social and Economic Variables. Part II: Nonlinear and Expert Modelling. *Agricultural Systems*, 58(2): 225–241.

Baum, C.F. (2006). An introduction to modern econometrics using Stata, Stata press.

Boz, I. and Akbay, C. (2005). ''Factors influencing the adoption of maize in Kahramanmaras province of Turkey.'' *Agricultural Economics*, 33: 431–440. DOI: 10.1111/j.1574-0864.2005.00305.x

Carton, O.T. and Magette, W.L., (1999). *Land Spreading of Animal Manures, Farm Wastes and Non-agricultural Organic Wastes-End of Project Report Part 1: Manure (and Other Organic Wastes) Management Guidelines for Intensive Agricultural Enterprises*, Teagasc.

Clancy, D., Breen, J., Moran, B., Thorne, F. and Wallace, M. (2011). Examining the socio-economic factors affecting willingness to adopt bioenergy crops. *Journal of International Farm Management*, Vol.5. Ed.4

CSO (2018) Rainfall by Meteorological Weather Station, Month and Statistic. Available to download at https://www.cso.ie/px/pxeirestat/Statire/SelectVarVal/Define.asp?maintable=MTM01&PLanguage=0

Davey, K.A. and W. H. Furtan (2008). Factors that affect the adoption decision of conservation tillage in the prairie region of Canada. *Canadian Journal of Agricultural Economics/ Revue canadienne d'agroeconomie*, 56(3): 257–275. DOI: 10.1111/j.1744-7976.2008.00128.x

Department of Agriculture, Fisheries and Food. (2010). *Food Harvest 2020. A vision for Irish agri-food and fisheries*. Dublin, Ireland, <http://www.agriculture.gov.ie/agri-foodindustry/foodharvest2020/>

EPA (2016). Ireland's Provisional Greenhouse Gas Emissions in 2015. Wexford, Ireland, Environmental Protection Agency.

Feder, G., Just, R.E. and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries, A survey. Economic development and cultural change: 255–298.

Fernandez-Cornejo, J., Klotz-Ingram, C. and Jans, S. (2002). Farm-level effects of adopting herbicide-tolerant soybeans in the USA. *Journal of Agricultural and Applied Economics*, 34(01): 149–163. DOI: https://doi.org/10.1017/S1074070800002200

Fernandez-Cornejo, J., Mishra, A.K., Nehring, R.F., Hendricks, C., Southern, M. and Gregory, A. (2007). Off-farm income, technology adoption, and farm economic performance. United States Department of Agriculture, Economic Research Service.

Ghadim, A.A. and Pannell, D.J.,Burton, M. (2005). Risk, uncertainty and learning in adoption of a crop innovation. *Agricultural Economics*, 33: 1–9. DOI: 10.1111/j.1574-0862.2005.00433.x

Gillespie, J. (2010). Adoption of Recombinant Bovine Somatotropin and Farm Profitability: Does Farm Size Matter? AgBioForum 13(3): 251–262.

Greene, W.H. (2012). Econometric Analysis. New York University.

Hanrahan, K., Hennessy, T., Moran, B. and Kinsella, A. (2014). *Teagasc National Farm Survey Results 2013*. Teagasc.

Hayami, Y. and V. W. Ruttan (1985). Agricultural Development: An International Perspective, Baltimore, MD.

Hennessy, T. and Moran, B. (2014). *National Farm Survey 2014 Results*. Rural Economy Research Centre (RERC), Teagasc.

Hennessy, T. and K. Heanue (2012). Quantifying the effect of discussion group membership on technology adoption and farm profit on dairy farms. *The Journal of Agricultural Education and Extension*, 18(1): 41–54. http://dx.doi.org/10.1080/1389224X.2012.638784

Howley, P., O'Donoghue, C. and Heanue, K. (2012). Factors Affecting Farmers' Adoption of Agricultural Innovations: A Panel Data Analysis of the Use of Artificial Insemination among Dairy Farmers in Ireland. *Journal of Agricultural Science*, 4 (6).

Hyde, B. and Carton, O. (2005). Manure management facilities on farms and their relevance to efficient nutrient use. Proceedings of the Fertiliser Association of Ireland, No. 42.

Hyde, B., Carton, O. and Murphy, W. (2006). Farm facilities survey: Ireland 2003.Teagasc, Wexford.

Islam, M.M., Barnes, A. and Toma, L. (2013). An investigation into climate change scepticism among farmers. *Journal of Environmental Psychology*, 34: 137–15. http://dx.doi.org/10.1016/j.jenvp.2013.02.002

Keelan, C., Thorne, F.S., Flanagan, P., Newman, C. and Mullins, E. (2010). Predicted willingness of Irish farmers to adopt GM technology. *AgBioForum*, 12 (2009), pp. 394–403.

Lalor, S. and R. Schulte (2008). Low-ammonia-emission application methods can increase the opportunity for application of cattle slurry to grassland in spring in Ireland. *Grass and Forage Science*, 63(4): 531–544. DOI: 10.1111/j.1365-2494.2008.00657.x

Läpple, D., Hennessy, T. and O'Donovan, M. (2012). Extended grazing: A detailed analysis of Irish dairy farms. *Journal Dairy Science*, 95: 188–195. http://dx.doi.org/10.3168/jds.2011-4512

Läpple, D. and Rensburg, T.V. (2011). ''Adoption of organic farming: Are there differences between early and late adoption?'' *Ecological Economics*, 70: 1406–1414. http://dx.doi.org/10.1016/j.ecolecon.2011.03.002

Levinthal, D. and March, J.G. (1981). ''A model of adaptive organizational search.'' *Journal of Economic Behavior & Organization*, 2(4): 307–333. DOI: 310.1016/0167-2681(1081)90012-90013

McKelvey, R.D. and Zavoina, W. (1975). ''A statistical model for the analysis of ordinal level dependent variables.'' *Journal of mathematical sociology*, 4(1): 103–120. https://doi.org/10.1080/0022250X.1975.9989847

McGettigan, M., Duffy, P., Hyde, B., Hanley, E., O'Brien, P., Ponzi, J. and Black, K. (2010). *Ireland national inventory report 2010. Greenhouse gas emissions 1990–2008 reported to the United Nations Framework Convention on Climate Change*. Environmental Protection Agency, Johnstown Castle Estate, Wexford.

OECD (2012). *Farmer Behaviour, Agricultural Management and Climate Change, OECD Publishing*. DOI: 10.1787/9789264167650-en

Prokopy, L.S., Floress, K., Klotthor-Weinkauf, D. and Baumgart-Getz, A. (2008). Determinants of agricultural BMP adoption: Evidence from the literature. *Journal of Soil and Water Conservation*, 63(5): 300–311. doi: 10.2489/jswc.63.5.300

Rogers, E.M. (1962). Diffusion of innovations. Simon and Schuster.

Schröder, J.J. (2005). Revisiting the agronomic benefits of manure: a correct assessment and exploitation of its fertiliser value spares the environment. *Bioresource Technology*, 96: 253–261. http://dx.doi.org/10.1016/j.biortech.2004.05.015

Schulte, R. and Donnellan, T. (2012). A marginal abatement cost curve for Irish agriculture. Teagasc submission to the National Climate Policy Development Consultation, Teagasc, Oakpark, Carlow, Ireland.

Schulte, R., Lanigan, G. and Gibson, M. (2011). Irish agriculture, greenhouse gas emissions, and climate change: Opportunities, obstacles, and proposed solutions. Oak Park, Carlow, Ireland: Irish Agriculture and Food Development Authority.

Shapiro, B.I., Brorsen, B.W. and Doster, D.H. (1992). Adoption of double cropping soybeans and wheat. Southern *Journal of Agricultural Economics*, 24: 33–40. DOI:https://doi.org/10.1017/S0081305200018355

Smith, K. and B. Chambers (1993). Utilizing the nitrogen content of organic manures on farms problems and practical solutions. *Soil use and management*, 9(3): 105–111. DOI: 10.1111/j.1475-2743.1993.tb00938.x

Stettler, D., Aschmann, S.G. and Wilson, B.D. (2003). ''A procedure for the determination of storage period for manure storages.'' Oregon, Core 4, Conservation for Agriculture's Future.

Rehman, T., McKemey, K., Yates, C., Cooke, R., Garforth, C., Tranter, R., Park, J. and Dorward, P. (2007). Identifying and understanding factors influencing the uptake of new technologies on dairy farms in SW England using the theory of reasoned action. *Agricultural Systems*, 94: 281–293. http://dx.doi.org/10.1016/j.agsy.2006.09.006

Tornatzky, L.G. and K. J. Klein (1982). ''Innovation Characteristics and Innovation Adoption - Implementation: A Meta-Analysis of Findings.'' *IEEE Transactions on Engineering*, *Management*, 29(1). DOI: 10.1109/TEM.1982.6447463

Vanclay, F. (2004). Social principles for agricultural extension to assist in the promotion of natural resource management. *Animal Production Science*, 44(3): 213–222. http://dx.doi.org/10.1071/EA02139

Verbeek, M. (2004). *A guide to modern econometrics*. 2nd ed. John Wiley & Sons, West Sussex, England.

Williams, R. (2012). Using the margins command to estimate and interpret adjusted predictions and marginal effects. *Stata Journal*, 12(2): 308.

Willock, J., Deary, I.J., Edwards-Jones, G.J., Gibson, G.J., McGregor, M.J., Sutherland, A., Dent, B.J., Morgan, O. and Grieve, R. (1999). The role of attitudes and objectives in farmer decisions making: Business and environmentally oriented behavior in Scotland. *Journal of Agricultural Economics*, 50: 286–303. DOI: 10.1111/j.1477-9552.1999.tb00814.x

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-12

Are farming companies emerging from non-agricultural sector better managed than conventional farms in Japan?

YUKIO KINOSHITA[1] and NOBUO KIMURA[2]

ABSTRACT

Conventional Japanese farmers have faced a longstanding challenge in adapting to a changing business environment. While the deregulation of the Agricultural Land Act in 2009 has led to the entry of companies from the non-agricultural sector into agriculture, another reason seems to be the general capitalisation of the agricultural industry into the wider economy. However, few management studies have analysed these new companies. An important question is whether the corporatisation of farm business is accompanied by the modernisation of farm management techniques. Our study examines crop-farming companies and compares farm management styles of these newly emerging farming entities with those of family-farm-based entities. It is based on 124 questionnaire responses from a sample of 577 posted in 2016. The questions covered human and organisational factors, as well as operational factors. We find no notable advantages in the way companies are managed. Probably because of their inexperience and low dependence on the farming business in terms of sales, our comparison highlights improvements that they need to make for further modernisation of farm management. Both types of entities face similar challenges in raising managerial capabilities.

KEYWORDS: Entry of non-agricultural companies; Modernisation of management; Farm management styles; Managerial capabilities; Farm business growth

1. Introduction

Although conventional family-owned and family-operated farms have been the most common business style in Japanese agriculture, in recent years, their popularity has been considerably waning. Previous literature has highlighted that the tasks carried out by farmers have changed in the modern agriculture of developed countries, where farm businesses were previously mostly owned and operated by families (Gasson and Errington, 1993; Hutson, 1987; Kingwell, 2002). Generally, small family-owned and family-operated farms struggle to adapt to a more competitive environment. Conventional farm management stands in stark contrast to modern farm management, and internationally, this is a barrier to global competitiveness (Kay, Edwards and Duffy, 2012; Kimura, 2008; Malcolm, Makeham and Wright, 2005; Nuthall and Old, 2017; Olson, 2011).

Thus, Japanese farms face the pressing challenge of transitioning from conventional farm management to modern farm management to remain viable (Kimura, 2004; 2008). The Japanese agricultural structure has changed drastically, in recent years. According to the Census of Agriculture and Forestry 2015, farms producing less than a million yen[3], which compromise approximately 60% of the Japanese farm population, account for just 5% of the Japanese agricultural sales volume, whereas farms producing more than 30 million yen, which account for 50% of all the Japanese agricultural sales volume, account for only 3% of the Japanese farm population. That is, although most of the Japanese farms remain small-scale in terms of farm population, the major farms, in terms of business scale, concentrate on a small number of larger farms.

In particular, several agricultural policies have been developed in Japan to boost the corporatisation of family farms as well as the entry of non-agricultural corporations into farming. Along with the ageing of farmers, the number of small family farms has decreased rapidly. In contrast, the number of farming companies[4] increased

Original submitted March 2018; revision received June 2018; accepted December 2018.

[1] Corresponding author: Faculty of Agriculture, Iwate University, Morioka, Iwate, 020-8550, Japan. Phone No: +81 19 621 6130, Fax No: +81 19 621 6130, Email: kinop@iwate-u.ac.jp

[2] Emeritus professor, Iwate University, Morioka, Iwate, 020-8550, Japan.

[3] At the time of writing (December 2017), one Japanese Yen was approximately equivalent to £0.01, $US0.01 and €0.01.

[4] An entity of a farm business with a legal personality distinct from those of the individuals taking part in it can be called either a 'company' or 'corporation.' Which of these words is chosen depends on the country and the case. In this work, 'company' is used to refer to a farming legal person, who often has a relatively small business. 'Corporation' is used to refer to a non-farming legal person, which is usually a larger business than a company. In Japan, farming companies may cover both private companies that are newly emerging in the agricultural sector and existing family farms that have been incorporated.

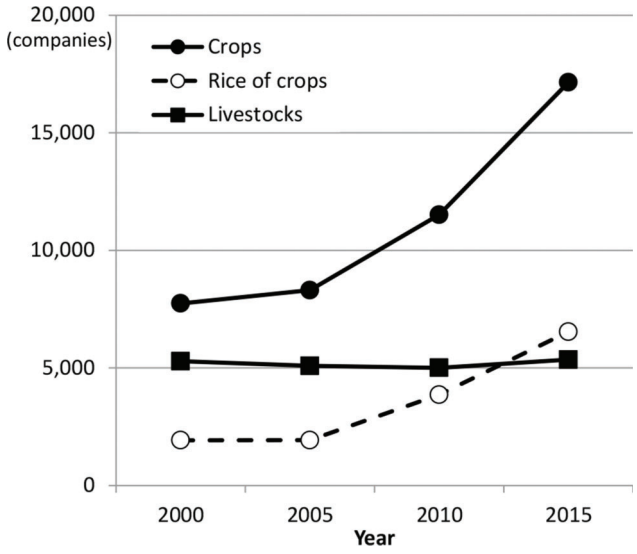

Figure 1: Numbers of farming companies with sales by main product in Japan. Source: Customised data from the Census of Agriculture and Forestry, Ministry of Agriculture, Forestry and Fisheries, Japan.

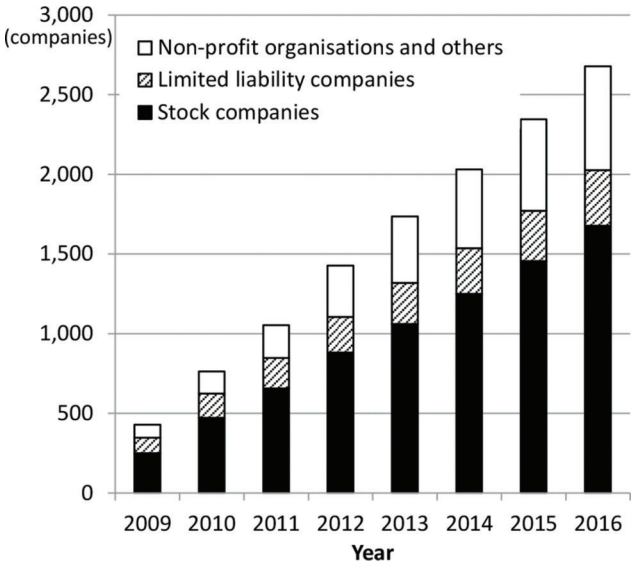

Figure 2: Number of emerging farming companies from the non-agricultural sector. Source: Data derived from the website of Ministry of Agriculture, Forestry and Fisheries, Japan (http://www.maff.go.jp/j/keiei/koukai/sannyu/attach/pdf/kigyou_sannyu-11.pdf).

to 18,857 in 2015, which is roughly the double of that of a decade ago. As a result, farming companies account for almost 30% of the total Japanese agricultural sales volume, and they are much more important because they hire many young farmers (Japanese Ministry of Agriculture, Forestry and Fisheries [MAFF], 2017).

However, Japanese farming companies vary in nature. Historically, before modern farm management made inroads into the crop sectors such as rice, vegetables and fruits, it had already entered the livestock industry. As Figure 1 shows, the number of rice-farming companies exceeded that of livestock-farming companies in 2015. Some Japanese farms were corporatised by one or more business-oriented family farms mainly as a limited liability company or stock company, while one type of Japanese farming company was a community-based farm cooperative composed of many small family farms, often in the form of agricultural producers' cooperative companies, established to conserve farmland.

Besides such farming companies, there has been a six-fold increase in the entry of companies from the non-agricultural sector into the agricultural sector following the deregulation of farmland use, particularly since 2009. As Figure 2 shows, as of 2016, the number of farming companies emerging from the non-agricultural sector had increased to more than 2,500. Most of them began their operations in the food industry including the food-processing sector, food retailers and eating-out sector, in construction or in the non-profit sector. A typical reason for the entry of farming companies from the food sector into agriculture is that they could make use of the crops they produced to generate value addition and to bring product differentiation in their original business. Corporations in the construction industry sometimes entered the farming sector to be seen as contributing to social activities and, thus, meeting the mark to be eligible for public works contracts. Scale and environments of main businesses that such farming companies operated also varied; some are a well-known big business and others are a local small business. Generally, the search for alternative sources of business resources and business opportunities is what motivated farming companies from the non-agricultural sector to enter the agricultural sector in Japan (Japan Finance Corporation [JFC], 2013; Shibuya, 2009).

Only a few management studies have analysed these emerging farming companies in Japan. Some studies (JFC, 2013; Noguchi, 2013; Shibuya, 2009) hypothesise that these emerging companies would generally introduce sophisticated management techniques from their main business to apply to farm business. Supposing that it was true, Noguchi (2013) suggested that further investigation into the farm modernisation practices of these companies could help to provide a perspective on how conventional farm management could be improved; it was thought that these companies would be more serious about farm business given their wider experiences through their main business and would adopt tougher business criteria than conventional family farms would. Meanwhile, other studies (Shibuya, 2011; Yamamoto, 2010) highlight the unsophisticated management styles of farm businesses in these companies. Thus, even if the entry of companies from the non-agricultural sector continues, a key question remaining is whether the corporatisation of farm business is always accompanied by modernisation of farm management techniques.

Therefore, this study assesses the managerial aspects of Japanese farming companies by surveying newly emerging farming companies from the non-agricultural sector and conventional farmers' companies to examine if the former is better managed than the latter, which are often the 'farm–household complexes'. More specifically, our survey investigates the differences in farm management styles between these two groups of farming companies, including the capabilities of the farm manager, organisational factors such as business strategies and orientations, and operational factors such as marketing and on-farm management practices.

This paper proceeds as follows. Part two reviews international and domestic perspectives on the entry of farming companies from the non-agricultural sector into agriculture. Part three considers the analytical framework

and part four explains the survey method and the data. Part five analyses and discusses farm management styles by studying the survey results. Part six concludes by highlighting the challenges for further farm modernisation in Japan.

2. Entry of farming companies from the non-agricultural sector into agriculture

One general reason for the entry of companies from the non-agricultural sector into the agricultural sector is the capitalisation of the agricultural industry in the economic system. Since the more competitive sectors of the economy need the farm sector to become more efficient and capitalised, agriculture sometimes attracts capital from corporations such as those dealing with farm inputs and the various food industries. In other words, the food chain progresses with financing for farms from corporations in the upstream or downstream industries of agriculture. At the same time, farmers adapt to the changing economic environments spontaneously, increasing their scale of operations with advanced technologies or generating non-farming sources of income, to remain viable. This phenomenon is often referred to as the emergence of the 'farm family entrepreneurs' (Magnan, 2012; Pritchard, Burch and Lawrence, 2007) and could be a key factor in the transformation of conventional farm management to modern farm management in a global setting as described in the Introduction.

Another reason for the entry of farming companies from the non-agricultural sector into the agricultural sector is the acquisition of farmland by major corporations and capital institutions seeking alternative opportunities for investments in their businesses (Sippel, Larder and Lawrence, 2017; GRAIN, 2008). This has been increasing rapidly in developed and developing countries especially after the global financial and food crises of the latter half of the 2000s. Such external organisations often explore and acquire farmland ownerships globally to secure scarce food for people in their home countries.

For the past two decades in Japan, the topic of companies from the non-agricultural sector entering the farming sector has been a controversial one in the national farmland policy. The basic principle of the Agricultural Land Act (enacted in 1952) is to promote the ownership of land by its actual user; an individual or company can acquire farmland only if a farmer or members from the company engage principally in on-farm work. The Act did not allow companies from the non-agricultural sector to access farmland rights for half a century. The restriction on ownership by companies has also the practical objective of preventing the speculative acquisition of farmland that would disconnect land prices from the return from its use in agricultural production (Organisation for Economic Co-operation and Development [OECD], 2009). Moreover, because of the recent rapid shrinking of the industry in Japan, promoting competitive farms is becoming a high priority objective in agricultural policy. The pressure to continue to enhance the eligibility of companies to participate in the agricultural sector has increased.

In 2001, the Act was amended to attract capital from food producers or retailers with integrated business relationships for part-share ownership of a farming company. In 2003, the Act was amended again to allow companies from the non-agricultural sector to obtain tenancy rights to farmland on some pilot project sites (the so-called special structural reformation districts), and then in 2005 the Act was further amended to extend this deregulation of farmland use without ownership to broader sites where land abandonment was a pressing challenge, especially in less-favoured areas for farming. As the regulation of farmland use began to be relaxed to make farmland use more accessible for companies from the non-agricultural sector, the societal and environmental impacts of the entry of such farming companies began to be discussed (Hotta and Shinkai, 2016; Muroya, 2015; Ohnaka, 2013). The key concerns were whether they would use the farmland properly and efficiently, and in line with social and environmental considerations, in the host communities. Any company can obtain tenancy rights to farmland in all of Japan following the amendment of the Law in 2009 that clarifies the social and environmental responsibilities of land users, although farming companies from the non-agricultural sector are prohibited still from owning farmland.

In short, in the Japanese context, the main reason behind the emergence of farming companies from the non-agricultural sector is the further capitalisation of agriculture, rather than farmland ownership by international corporations and capital institutions.

3. Analytical framework

This study explores management in the emerging farming companies, and the transition from conventional farm management to modern farm management. Since family-owned and family-operated farms are common business structures, farm entities often present the 'farm–household complex' as individuals, partnerships and, occasionally, private companies (Nuthall, 2011). The modernisation of farm management needs to include all those practices that allow a farm to be separated from the 'farm–household complex' and managed as a business to reduce conflict over capital and labour allocation among families. It should be noted that a modernised farm business can be seen as a business entity with a legal personality that essentially performs the business tasks. More importantly, the corporatisation of farm business is not always accompanied by the modernisation of farm management techniques.

In this study, modern farm management is concerned with the comprehensive framework, rather than important but specific issues such as the scale of farm operations, advanced technologies, efficient labour productivity and shrewd investment and financing. Following Kimura (2004), Kinoshita and Kimura (2016) and Kinoshita, O'Keefe and Kimura (2015), our survey questions focused on three aspects of modern farm management: (I) time modernisation, (II) economic modernisation and (III) functional modernisation. Time modernisation refers to the clear segregation of business hours and private hours. Economic modernisation refers to controlling accounting and finance practices and isolating business budgets from household budgets. Functional modernisation relates to organising and coordinating work duties and the separation of work and family relationships.

Various internal factors that are under the manager's control may affect the aforementioned modernisation

of farm management. Kimura (2004) and Kinoshita, O'Keefe and Kimura (2015) correlated farm modernisation in Japanese and Australian farms with management factors such as the managers' personal managerial capabilities, farmers' intentions of, and attitudes towards, farming, farm business strategies, and production and marketing management. Kinoshita and Kimura (2016) modelled farm modernisation in the Japanese rice industry to examine the influence of such management factors on corporate farm management more directly. The studied farms substantially demonstrated the impact of human factors, as well as organisational and operational factors, on the modernisation of farm management. Likewise, Nuthall and Old (2017) compared personal characteristics of farm managers among family and corporatised farms in New Zealand to examine determinants of legal status of farms, and it highlighted that attitudes and objectives towards farm business were relative to ownership arrangement of their sampled farms.

To understand farm modernisation better, this study focuses on management styles, such as farmers' intentions and managerial capabilities, farm business strategies and various practices in workforce and financial management. Managerial capability is a crucial driver of farm business viability (Kimura, 2008; Muggen, 1969; Nuthall, 2009a; 2009b). Interestingly, Kimura (2008) argued that the ideal farm manager needs the capability and superior skills required to fulfil three functions: entrepreneurship, adaptability and administration. Farm business strategies aim to guide management practice based on farmers' intentions, which have been described in the literature (Kimura, 2004; 2008; Malcolm, Makeham and Wright, 2005; Nuthall, 2009a; Olson, 2011; Kay, Edwards and Duffy, 2012). These intentions refer to the underlying goals of management activities, including the economic, environmental, cultural and social objectives identified as pertinent to farming. Particularly, Kimura (2004) investigated farms' business objectives in terms of a farmer's desire to (1) pass on their farm to their children; (2) earn a livelihood; (3) earn income on par with other industries; (4) optimise profit; (5) enjoy being an innovative farmer; (6) exploit consumer demand and appreciation; and (7) expand the business. Using the same farmer motivations, we categorised farmers' intentions as (i) tradition-directed, that is, they wish to pass on their farms to their children or to enjoy being an innovative farmer; (ii) economy-oriented, that is, their objective is to earn a livelihood, an income commensurate with those in other industries or a profit and (iii) business-minded, that is, they have higher-level objectives, including the exploitation of consumer demand and the appreciation or expansion of their business. Then, we specify popular objectives that follow the progression from conventional to modern farm management.

Thus, farm management styles, which act as fundamental drivers towards modern farm management, are also controllable by farm managers. In the remaining part of the paper, we investigate the differences in farm management styles between the farming companies from the non-agricultural sector and the conventional farmers' companies, using statistical analyses, mainly the chi-square test, of the data collected through surveys given to Japanese crop-farming companies. We also examine marketing management, focusing on the features of agricultural products because it is a matter of concern that most Japanese farmers, who have faced less competitive markets, still have strong ideas of 'product-out' rather than 'market-in' for selling their products.[5]

4. Survey method and an overview of sample data

No public database covers all Japanese farming companies from the non-agricultural sector. Therefore, in this study, we contracted with the two major private credit agencies that maintain a nationwide database covering 3,844 agricultural companies (approximately 20% of the total) and used a reply-paid postal survey to collect data from farming companies emerging from the non-agricultural sector. In February 2016, a questionnaire was posted to 577 newly established agricultural companies identified via directory lists provided by these agencies. By March 2016, this effort had generated 188 responses (response rate of 33%), with 124 usable responses excluding livestock sectors (usability rate was 66%); for, only crop-farming companies that produced no livestock were targeted for the analysis because the popular sectors for emerging farming companies were rice and other crops rather than livestock. The survey questions explored five issues: 1) the operating structure, including resources such as investors from the non-agricultural sector, and the amount of land and labour on the farm and business tools; 2) management attitudes, including the farming purpose and managerial capabilities; 3) business strategies, including goals and specific planning; 4) the workforce and financial management and 5) sales and marketing. It should be noted that the responses that constitute our data, and on which we based our conclusions, were self-assessments by a farm manager rather than that by the compa-11.pdfny chairperson.

The criteria for obtaining results for their business are important to farm managers. However, our survey did not collect data on profitability, such as net farm business income or profit. One reason is that it would be difficult to compare profitability among Japanese sample farms because some farms still have immature accounting arrangements that do not record feasible data. Another is that this study constitutes a preliminary examination of farm management styles in newly emerging companies, and thus, more complex analysis using profitability data is beyond its scope.

Usually, in Japan, farming companies from the non-agricultural sector add an agricultural section into a current (non-agricultural) corporation or set up a subsidiary just for farm business. Whereas no current farmer can invest in those companies that add an agricultural section into a current corporation, current farmers can be co-investors in those corporations that are subsidiaries for farm business because they provide support by offering their farmland and agricultural technical skills and forging a good relationship of the entering farming company with the rural community (Tanaka, 2016). The Agricultural Land Act allows co-investing farmers to make important decisions in the farming companies from the non-agricultural sector. The collected sample was grouped into farming entities from the non-agricultural sector and conventional farming entities, from the

[5] The term 'product-out' refers to selling what they produce. Instead the term 'market-in' refers to producing what sells.

Table 1: Characteristics and statistical summary of the sampled farms

		FCNs (n = 83)	CFCs (n = 41)	Total (n = 124)
Years of operations after corporatising farm business[a**]	Mean	9.831	17.951	12.516
	Median	6.000	10.000	7.000
	SD	11.853	16.288	13.951
Organisation type[b**]				
Stock companies, including former limited liability companies		85.5%	65.9%	79.0%
Agricultural producers' cooperative companies		2.4%	26.8%	10.5%
Others		12.0%	7.3%	10.5%
Main crops (Multiple answers)				
Rice[b]		33.7%	51.2%	39.5%
Beans[b*]		4.8%	19.5%	9.7%
Wheat and Barley[b*]		3.6%	17.1%	8.1%
Open-field vegetables[b]		36.1%	41.5%	37.9%
Greenhouse vegetables[b]		32.5%	24.4%	29.8%
Fruits[b]		22.9%	19.5%	21.8%
Sales of agricultural products (million yen[†])[a]	Mean	60.279	63.719	61.416
	Median	14.635	25.000	15.800
	SD	140.326	143.839	140.920
Number of employee (people)[a]	Mean	12.173	5.220	9.836
	Median	4.000	3.000	3.000
	SD	39.983	7.209	32.939
Sales of agricultural products per employee (million yen[†])[a*]	Mean	4.952	12.208	6.244
Share of agriculture in total business sales[a*]	Mean	54.3%	74.1%	60.8%
	Median	60.0%	90.0%	77.5%
	SD	41.580	34.122	40.239

[a]Mann-Whitney U test and [b]chi-square test were applied between the FCNs and the CFCs.
*denotes statistical significance at the 5% level, and **at the 1% level.
[†]At the time of writing (December 2017), one Japanese Yen was approximately equivalent to £0.01, $US0.01 and €0.01.

viewpoint of the nature of investors in a farming company. Consequently, one group was defined as 'farming companies from the non-agricultural sector (FCNs)' which were invested in solely by non-agricultural corporations, while another group was called 'conventional farmer's companies (CFCs)' which were invested in solely by current farmers or jointly by current farmers and non-agricultural corporations. We used 83 samples of FCNs and 41 samples of CFCs for our analysis. The number of sample respondents may have been too small against a population consisting of roughly 6,000 crop-farming companies, which is estimated from Figure 1; we will test for sample bias later.

Table 1 summarises the respondents from the FCNs and the CFCs in this study. We observed significant differences in years of operations after corporatising farm business, organisation type, sales of agricultural products per employee and the share of agriculture in total business sales, between the FCNs and the CFCs. In brief, the FCNs, taking the form of a stock company, are inclined to continue for a short time which is less than 10 years and to generate sales of agricultural products that are as much as roughly half of their total business sales by producing, often, relatively profitable crops (e.g. vegetables and fruits) with more labour. On the other side, the CFCs, taking the form of an agricultural producers' cooperative company as well as a stock company, are inclined to continue for almost twice the number of years as the FCNs are inclined to and to achieve sales of agricultural products of most of their total business sales by producing, usually, less profitable crops (e.g. rice, beans, wheat and barley) with less labour.

Most of the respondents reported that they were stock companies and that they produced rice or vegetables as their main crops, and that their mean and median average sales of agricultural products were approximately 60 million yen and 16 million yen, respectively. It should be noted that the average sales of agricultural products per employee in the FCNs was exceeded by more than twice that in the CFCs. The respondents constituted a tolerably balanced sample, in terms of organisation type, main crops, amount of labour and labour productivity, with reference to the Census of Agriculture and Forestry 2015 and the 2012 Economic Census. However, they insignificantly constituted a biased sample with a larger scale in terms of sales volume on the mean compared with the population level.

The respondents in our sample are spread across the country. The two groups of farms seemed to produce quite different crops, a difference likely due not to regional conditions but to the nature of farm organisations themselves. For instance, according to the National Survey on Community-based Farm Cooperatives, community-based farm cooperatives have in recent years very often corporatised as agricultural producers' cooperative companies to produce mainly rice, and therefore, the CFCs likely consist partly of community-based farm cooperatives. In addition, considering the differences in the agricultural production structure by region more generally, the northern island of *Hokkaido* stands out as unique in Japan; agriculture in *Hokkaido* is characterised by its low dependence on rice production, which is the central crop in Japan. Rather, *Hokkaido* depends highly on a wide range of non-rice crops, and its farms are much larger than those in other regions (See OECD, 2009). The analysed sample of 124 respondents contains just seven respondents from *Hokkaido*, all of whom did not differ greatly from other respondents in terms of crop type, farm

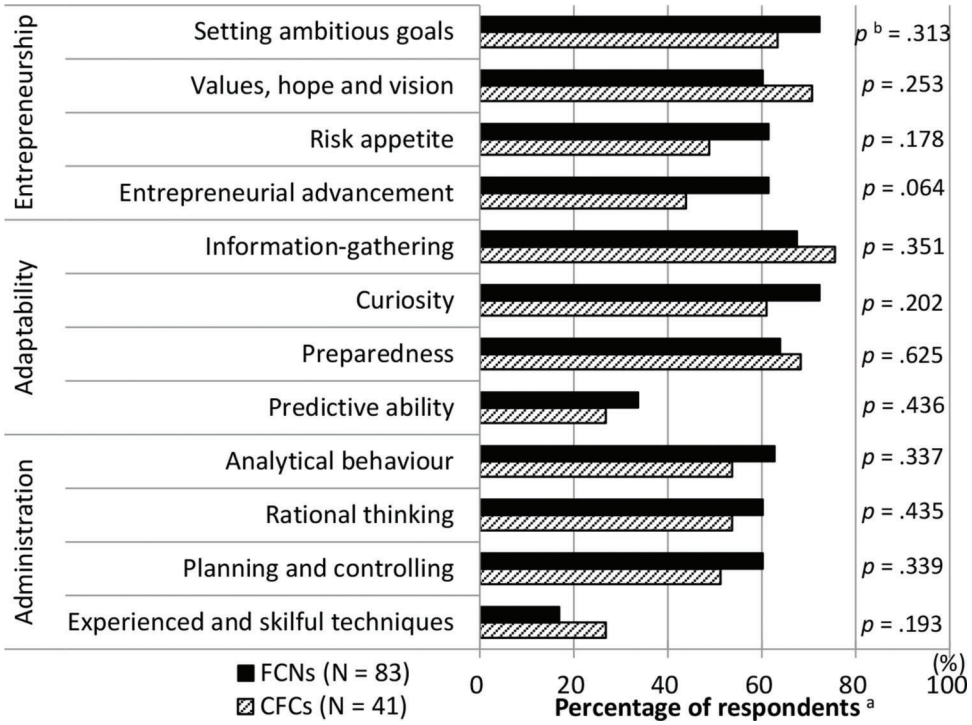

Figure 3: Managerial capabilities of the farmers of sampled farms. a) The proportion of positive responses including 'agree' and 'strong agree' for Likert scales with five levels. b) Chi-square test were applied to the number of positive responses and *p* represents the probability of the differences in each table.

size and number of employees. Thus, our sample is not biased by region and is comparable across regions.

5. Results and Discussion

Managerial capabilities

Figure 3 shows the proportion of positive responses to the 12 questions that explored managerial capabilities relating to the three functions of entrepreneurship, adaptability and administration, argued in Kimura (2008). The responses were self-rated Likert scales with five levels and, in sum, positive responses included 'agree' and 'strongly agree'.

Hypothetically, the FCNs' respondents are expected to have an overwhelming edge in managerial capabilities, given their main (non-agricultural) sector of operation. Overall, no significant difference in the proportions of positive responses to any capability was statistically observed between the two groups, and no clear evidence supporting such expectation was seen from our data. Nevertheless, most of the proportions of positive responses for the FCNs' respondents were higher than those for the CFCs' respondents were. In particular, the FCNs' respondents reported a 10 points higher ratio of positive responses to risky behaviour, entrepreneurial advancement and curiosity, than those for the CFCs' respondents. It should be noted that the FCNs' respondents displayed a strong appetite for risk and entrepreneurial advancement, which conventional farmers in Japan have been lacking (Kimura, 2008). The FCNs' respondents also produced a higher ratio of positive responses to aggressive targets when compared with the CFCs' respondents. On the other hand, the CFCs' respondents reported a 10 points higher ratio of positive response to values, hope and vision than their counterparts did.

Another point to note is that the average proportion of positive responses to all capabilities was around 55% for the both groups, which, overall, revealed managerial capabilities were not great among the sampled respondents. Both the FCNs' and the CFCs' respondents displayed lower administrative capability, in particular, the use of techniques involving experience and skill. The average proportion of positive respondents was as low as approximately 20% for both groups. While the technical skills of the FCNs' respondents were far from perfect because of their inexperience in agriculture, it is of concern that even the CFCs' respondents showed the use of outmoded techniques. Therefore, the improvement of technical skills should be a priority for Japanese farm managers in companies.

Farmers' intentions

Figure 4 shows the proportion of positive responses to 7 questions that investigated farmers' objectives related to the three categories of their intentions, which are presented in the part on the analytical framework. Responses were self-rated Likert scales with five levels and positive responses included 'agree' and 'strongly agree'. By categorising their responses into the three intentions, we found that the CFCs' respondents were more devoted to tradition-directed and economy-oriented farming than the FCNs' respondents were. This was because the CFCs' respondents are inclined to prefer maintaining their life to pursuing the value and growth of business on the farm. This was reflected also, as described in the previous part, in the fact that relatively many agricultural producers' cooperative companies were included among the CFCs' respondents and that such companies are, these days, often community-based farm cooperatives composed of many small family farms, not for profit but for the conservation of their farmland.

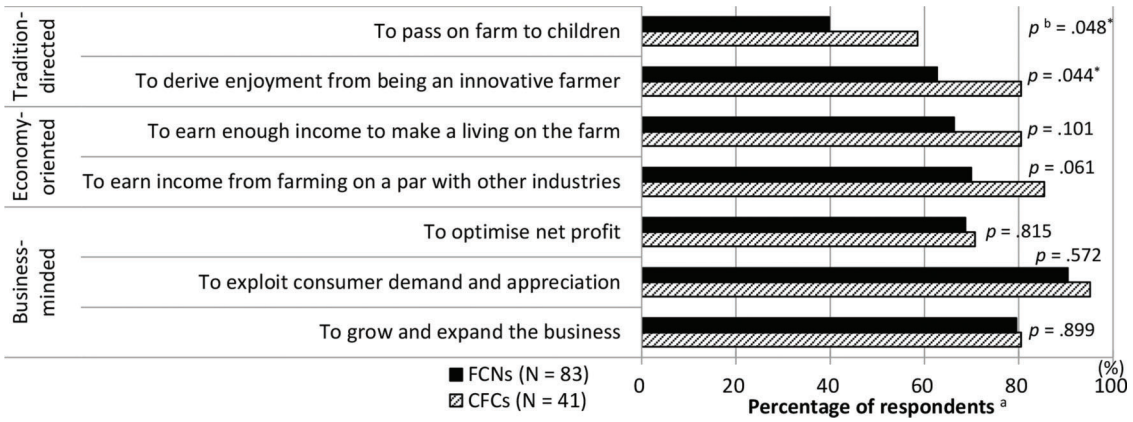

Figure 4: Farming objectives and intentions of sampled farms. a) The proportion of positive responses including 'agree' and 'strongly agree' for Likert scales with five levels. b) Chi-square test was applied to the number of positive responses, and *p* represents the probability of the differences in each table. *denotes statistical significance at the 5% level.

The CFCs' respondents reported a higher proportion of positive responses to passing on their farm to their children, enjoyment of being an innovative farmer, and earning a livelihood and income on a par with other industries, than the FCNs' respondents did. Significant differences in business objectives such as passing on their farm to their children and enjoyment of being an innovative farmer were observed between the two groups. Hypothetically, the FCNs' respondents are greatly inclined to have higher objectives and business-minded intention as per their experiences through the main (non-agricultural) sector of operations. However, no clear evidence supporting such characteristics of FCNs was seen in our data, because both the FCNs' and the CFCs' respondents reported very strongly positive responses to exploitation of consumers' demand and appreciation and expansion of the business. Thus, there seems no perfect shift in farmers' intentions following the progression from conventional to modern farm management, while the CFCs still clung to being tradition-directed and economy-oriented.

Farm business strategies

Strategies for farm business are categorised as capital-intensive strategies (connected with expanding farm acreage, intensifying mechanisation or investing in technology), diversification strategies (introducing new farm enterprises, expanding sales/marketing activities and product differentiation, initiating a food-processing business or developing off-farm investments), restructuring strategies (rethinking the overall enterprise mix or using contractors for better financing), external management strategies (reducing price risk, engaging in less intensive farming for environmental reasons or being community-minded) or a human resource strategy. Figure 5 itemises such farm business strategies and those that are most selected are reported.

Both the FCNs' and the CFCs' respondents showed an inclination towards capital-intensive farming by expanding acreage and intensifying mechanisation. They showed an inclination also towards diversification by expanding sales/marketing activities and product differentiation, and by initiating food-processing business. Applying Porter's three generic strategies (Porter, 1980) to this context, capital-intensive farming can be understood as a cost leadership strategy for Japanese farmers to cope with international competitiveness in price, and diversification as a differentiation strategy for them to survive in domestic markets. In addition, hiring qualified staff, which is different from customary strategies such as capital-intensifying farming and diversification, was a prominent strategy for both of the groups. As ageing farmers and a lack of successors on farms emerge as critical issues, a human resource strategy is becoming more important for the Japanese industry.

A farm business strategy that demonstrated a very significant difference between the two groups was intensive mechanisation while the CFCs' respondents reported an approximately 30 points higher ratio of positive response than their counterparts did. That finding coincides with community-based farm cooperatives that adopt a capital-intensive farming strategy, producing less profitable crops such as rice, beans, and wheat and barley, to continue their operation for conserving farmland. Expanding sales/marketing activities was also a favourable strategy for the CFCs' respondents. On the other side, being community-minded was an interesting strategy for the FCNs' respondents. This is natural because forging a good relationship with the rural community is a necessary condition of success in farm business particularly for farming companies coming from outside.

Marketing management

Marketing is one of the most interesting issues among Japanese farmers. In the previous section we saw that marketing strategies related to expanding sales/marketing activities and product differentiation were favourable to the sampled farms. Our survey also defined marketing management as focusing on features of agricultural products. In Figure 6, all the features in question here are demonstrated, and the ratios following each feature are presented. Around 70% of respondents from the both groups offered safe and trustworthy products, but there were no prominent features other than that of marketing management. The FCNs' respondents reported a notably higher ratio of positive responses to some features such as offering especially fresh products and hard-to-find, rare products, than their counterparts did. Figure 6 shows also that more of the CFCs respondents offered no specific feature and a significant difference in this was statistically observed between the two groups.

The overall feature of agricultural products was limited to offering safe and trustworthy products for the two groups.

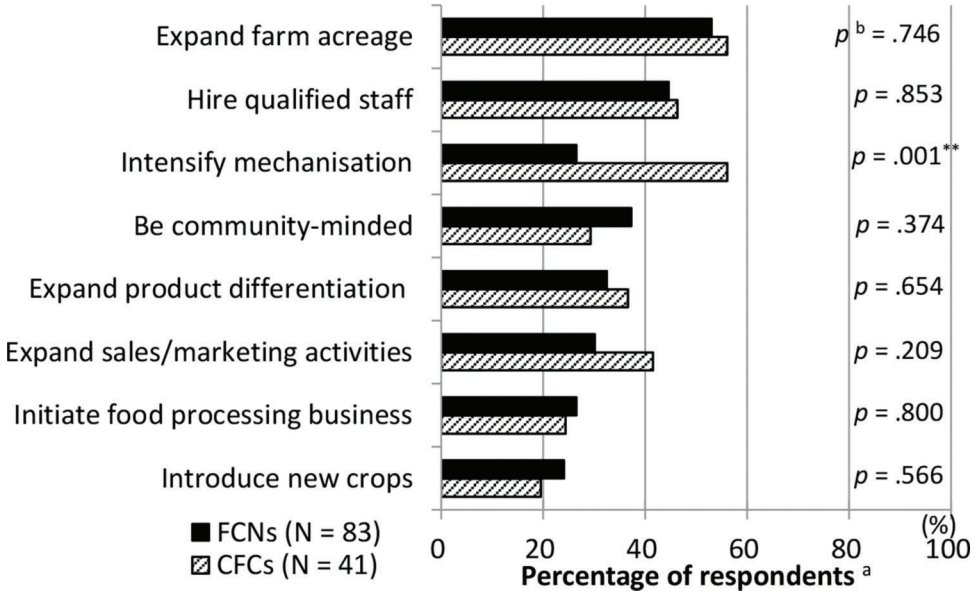

Figure 5: Major strategies of sampled farms. a) The proportion answering with 'yes' to simple yes/no alternatives. b) Chi-square test was applied to the number answering with 'yes', and *p* represents the probability of the differences in each table. **denotes statistical significance at the 1% level.

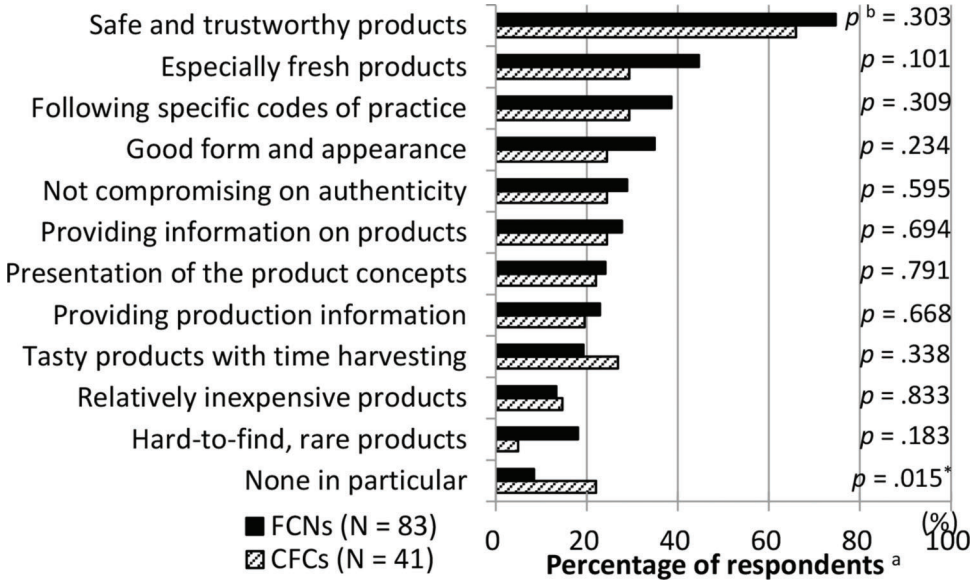

Figure 6: Features of agricultural products as marketing management. a) The proportion answering with 'yes' to simple yes/no alternatives. b) Chi-square test was applied to the number answering with 'yes', and *p* represents the probability of the differences in each table. *denotes statistical significance at the 5% level.

The CFCs' respondents were not particularly inclined to have a strong idea of 'market-in' for selling their products. This was mostly because the CFCs' respondents are always dependent on the Agricultural Cooperatives and just engage in mundane marketing activities to sell their products. By contrast, the FCNs' respondents were inclined to develop differentiated products (for example, greenhouse vegetables and fruits), unlike conventional crops and to find new marketing channels by themselves.

Modernisation of farm management

As described in the part on the analytical framework, the survey included questions about time and about economic and functional aspects to examine farm modernisation. Specifically, the practices for time modernisation are connected to personnel management, those for economic modernisation are connected to accounting and financial management and those for functional modernisation are connected to operational management. In Figure 7, all the practices questioned here are explained and the ratios following each practice are presented.

The FCNs' respondents reported a notably lower ratio of positive responses to hiring employees for time modernisation of farm management. The FCNs' respondents also reported a lower ratio of positive responses to most of the practices for economic modernisation. Surprisingly, they demonstrated a significantly lower ratio of positive responses to double-entry bookkeeping and formal payments to managers and reported approximately a 10 points lower ratio of positive responses to financial analysis and diagnosis than CFCs' respondents, which have been assumed to be 'farm–household complexes', did. For functional modernisation, the FCNs' respondents

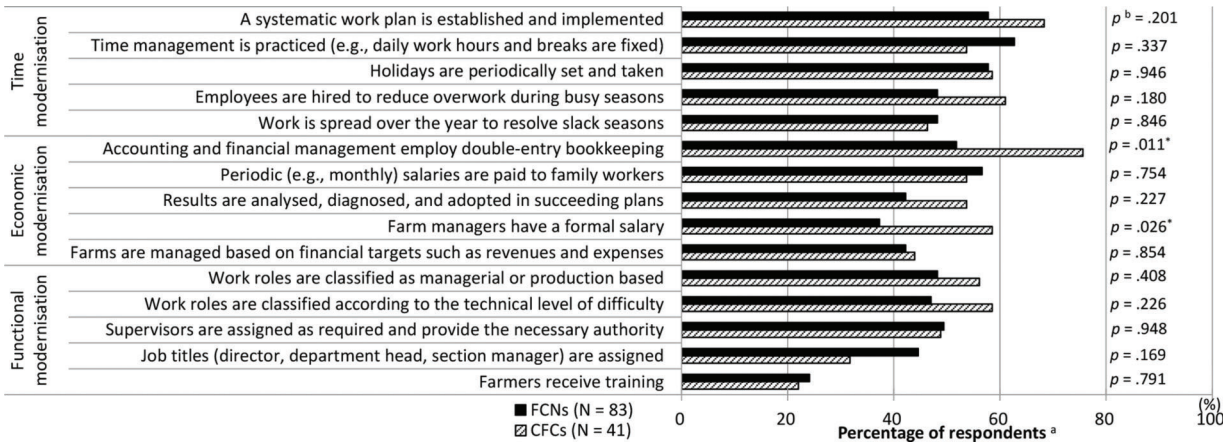

Figure 7: Achieving modernised farm management of sampled farms. a) The proportion answering with 'yes' to simple yes/no alternatives. b) Chi-square test was applied to the number answering with 'yes', and *p* represents the probability of the differences in each table. *denotes statistical significance at the 5% level.

reported a notably higher ratio of positive responses to job titles. As mentioned above, a human resource strategy is becoming more important to Japanese farms. However, it should be noted that only 20% of the two groups responded positively to training for farmers and that this gave rise to a gap between farm business strategy and on-farm practices.

In sum, the farms from the FCNs' respondents were not modernised enough. This was caused presumably by the fact that they had less experience in the farming business and were less dependent on the farming business in terms of sales, compared to conventional farms. In the CFCs' respondents, on the other side, an intimate relationship between farm business and household seemed to fade as farm management was modernised. Especially time and economic modernisation progressed because of work regulation and financial system being officially organised after the corporatisation of conventional farms.

6. Concluding remarks

Analysis of the sample data used in this study shows that farming companies emerging from the non-agricultural sector do not necessarily perform well. FCNs' prominent entrepreneurship, ample hired labour and presumably ample capital would help boost their expansion. However, the average sales volume per employee in the FCNs, regardless of whether it is measured by mean or median, was much lower than that in the CFCs as demonstrated in Table 1. Therefore, the improvement of labour productivity and capital turnover may be further obstacles to the growth of the FCNs. In contrast, labour force, as well as farm investment, enhancement may be critical blocks that CFCs must overcome, rather than the improvement of labour productivity and capital turnover, to boost the expansion of their farm business. This has been a challenge for conventional family farms in Japan for a long time.

Also, our analysis of the survey data does not prove that farming companies emerging from the non-agricultural sector are managed better than conventional farms are. The FCNs' respondents exhibited no high level of managerial capabilities, particularly of techniques involving experience and skill. It is true that most of the FCN respondents' intentions were not tradition-directed or economy-oriented, but it was not as if only the FCNs' respondents had business-minded intentions. The CFC respondents should be much less tradition-directed towards modern farm management. Overall, even farms from the FCNs' respondents have not achieved the modernisation of farm management fully presumably because of their less experience in the farming business and less dependence on farming sales. The FCNs' respondents were just inclined to have a stronger idea of 'market-in' for selling more profitable and differentiated products such as vegetables and fruits when compared with the CFCs' respondents.

As we referred to the literature in the former parts of the paper, farm managers have to change their values, objectives and characteristics to develop further modern farms in a global setting. Nonetheless, there is a perspective that family farms would continue to be a dominant legal status of farms at least in Western countries because they face no current pressure of transforming into corporatised farms (Nuthall and Old, 2017). In the Japanese context, while the agricultural policy has increasingly encouraged the corporatisation of farms, the corporatised farms were not necessarily accompanied with the modernisation of farm management according to results of our analysis. A concern with human resources, such as the further development of the capabilities of farm managers and qualified staff, was common in both FCNs and CFCs. In essence, ideal farming companies always require human resources to organise and manage their business with modern farm techniques. In addition to the policy deregulating farmland use to various people, it is suggested that a political measure supporting educational and strategic investments in human resources will be helpful for Japanese farming companies to truly modernise.

About the authors

Yukio Kinoshita is Associate Professor of Agricultural Economics at the Faculty of Agriculture of the Iwate University. Dr. Kinoshita has conducted many studies within the field of agricultural economics and farm management in Japan and other developed countries. He has also written some practical textbooks of farm business for students and farm managers.

Nobuo Kimura is Emeritus professor of the Iwate University. Dr. Kimura has offered distinguished studies

within the field of farm management and extension services in Japan. He has published many books and papers for academics, extension services and farm managers.

Acknowledgements

This research was supported by JSPS KAKENHI, Grant Number 15K03642. The work is all original research carried out by the authors. This manuscript has been developed based on our poster presentation titled 'Are emerging farming corporations from non-agricultural sector superior in management to conventional farmers in Japan?' at International Farm Management Association 21 Congress, July 2017. There are no conflicts of interest to declare.

REFERENCES

Gasson, R. and Errington, A. (1993). *The farm family business*. Wallingford, UK: CAB International.

GRAIN. (2008). *Seized! The 2008 land grab for food and financial security*. [online] Available at: <https://www.grain.org/media/W1siZiIsIjIwMTEvMDYvMzAvMTVfNTlfMDhfMTI1X2xhbmRncmFiXzIwMDhfZW4ucGRmIl1d> [Accessed 2 December 2018].

Hotta, K. and Shinkai, S. eds. (2016). *Farming businesses empower rural community: New-entries from non-farm sectors*. Tokyo: Norin Tokei Publishing. (in Japanese)

Hutson, J. (1987). Fathers and sons: Family farms, family businesses and the farming industry. *Sociology*, 21(2), pp. 215–29. https://doi.org/10.1177/0038038587021002004.

JFC [Japan Finance Corporation]. (2013). *Survey on corporate entry into agriculture: FY 2012*. *Information Strategy Report: Supplement to AFC forum, 36*. (in Japanese)

Kay, R.D., Edwards, W. and Duffy, P.A. (2012). *Farm management* (7th ed.). New York: McGraw Hill Higher Education.

Kimura, N. (2004). *Growth theory of modern farm business*. Tokyo: Norin Tokei Kyokai. (in Japanese)

Kimura, N. (2008). *Management of modern agriculture*. Tokyo: Nihon Keizai Hyouronsya Ltd. (in Japanese)

Kingwell, R. (2002). Issues for farm management in the 21st century: A view from the West. *Agribusiness Review*, 10, pp. 1–27. Available at: <http://www.agrifood.info/review/2002/Kingwell.pdf> [Accessed 1 May 2018].

Kinoshita, Y. and Kimura, N. (2016). Modeling farm management modernization: Case study of Japanese rice farming corporations. *Journal of Agricultural Science and Technology B*, 6, pp. 307–20. http://dx.doi.org/10.17265/2161-6264/2016.05.004.

Kinoshita, Y., O'Keefe, S. and Kimura, N. (2015). A case study on farm business management styles: A survey of rice farm businesses in New South Wales, Australia, applied to the Japanese context. *The Japanese Journal of Rural Economics*, 17, pp. 52–7. https://doi.org/10.18480/jjre.17.52.

MAFF [Ministry of Agriculture, Forestry and Fisheries]. (2017). *Annual report on food, agriculture and rural area in Japan: FY 2016*. (in Japanese)

Magnan, A. (2012). New avenues of farm corporatization in the prairie grains sector: farm family entrepreneurs and the case of One Earth Farms. *Agriculture and Human Values*, 29(2), pp. 161–75. http://dx.doi.org/10.1007/s10460-011-9327-9.

Malcolm, B., Makeham, J. and Wright, V. (2005). *The Farming game: Agricultural management and marketing* (2nd ed.). Melbourne, Australia: Cambridge University Press.

Muggen, G. (1969). Human factors and farm management: A review of the literature. *World Agricultural Economics and Rural Sociology Abstracts*, 11(2), pp. 1–11.

Muroya, A. (2015). Why does corporate entry into agriculture continue to increase in Japan? *Monthly Review of Agriculture, Forestry and Fishery Finance*, 68(5), pp. 20–35. (in Japanese)

Noguchi, R. (2013). Perspective on management techniques and innovation in farms entering from non-agricultural sectors. In: H. Yagi, M. Takahashi and K. Morita, eds. *Significance of corporate entry into the Japanese agriculture*. Tokyo: Norin Tokei Kyokai. pp. 225–30. (in Japanese)

Nuthall, L.P. (2009a). *Farm business management: The human factor*. Oxfordshire, UK: CABI International.

Nuthall, L.P. (2009b). Modelling the origins of managerial ability in agricultural production. *Australian Journal of Agricultural and Resource Economics*, 53(3), pp. 413–36. http://dx.doi.org/10.1111/j.1467-8489.2009.00459.x.

Nuthall, L.P. (2011). *Farm business management: The analysis of farming systems*. Oxfordshire, UK: CABI International.

Nuthall, L.P. and Old, M.K. (2017). Will future land based food and fibre production be in family or corporate hands? An analysis of farm land ownership and governance considering farmer characteristics as choice drivers. The New Zealand case. *Land Use Policy*, 63, pp. 98–110. http://dx.doi.org/10.1016/j.landusepol.2017.01.018.

OECD [Organisation for Economic Co-operation and Development]. (2009). *Evaluation of agricultural policy reforms in Japan*. Available at: <https://www.oecd.org/japan/42791674.pdf> [Accessed 17 January 2018].

Ohnaka, K. (2013). *Farm management by non-agricultural businesses in Japan: the meanings and challenges*. Tokyo: Nosei Chosa Iinkai Inc. (in Japanese)

Olson, K. (2011). *Economics of farm management in a global setting*. Hoboken, US: John Wiley and Sons Inc.

Porter, M. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. New York: The Free Press.

Pritchard, B., Burch, D. and Lawrence, G. (2007). Neither 'family' nor 'corporate' farming: Australian tomato growers as farm family entrepreneurs. *Journal of Rural Studies*, 23(1), pp. 75–87. http://dx.doi.org/10.1016/j.jrurstud.2006.04.001.

Shibuya, Y. (2009). *Strategic farm business management*. Tokyo: Nikkei Publishing Inc. (in Japanese)

Shibuya, Y. (2011). A study of disengagement factors and farmland maintenance on the entry of firm. *The Japanese Journal of Farm Management*, 49(1), pp. 81–6. (in Japanese)

Sippel, R.S., Larder, N. and Lawrence, G. (2017). Grounding the financialization of farmland: perspectives on financial actors as new land owners in rural Australia. *Agriculture and Human Values*, 34(2), pp. 251–65. http://dx.doi.org/10.1007/s10460-016-9707-2.

Tanaka, Y. (2016). *Incorporation formality and administration for agricultural production corporations to enter into farming*. Tokyo: Nihon Horei Ltd. (in Japanese)

Yamamoto, Y. (2010). Actual condition and characteristics of management of companies entered into agribusiness. *The Japanese Journal of Farm Management*, 48(2), pp. 102–6. (in Japanese)

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-22

Human dynamics and the intergenerational farm transfer process in later life: A roadmap for future generational renewal in agriculture policy

SHANE FRANCIS CONWAY[1,*], JOHN McDONAGH[1], MAURA FARRELL[1] and ANNE KINSELLA[2]

ABSTRACT

The senior generation's reluctance and indeed resistance to alter the status quo of the existing management and ownership structure of their family farm is undoubtedly strong within the farming community. This phenomenon has resulted in extraordinary socio-economic challenges for young people aspiring to embark on a career in farming. The reasons why older farmers fail to plan effectively and expeditiously for the future are expansive, and range from the potential loss of identity, status and power that may occur as a result of engaging in the process, to the intrinsic multi-level relationship farmers have with their farms. These so-called 'soft issues' i.e. the emotional and social dimensions involved, are the issues that distort and dominate the older generation's decisions on the future trajectory of the farm. These really are the 'hard issues'. This paper draws on three interrelated journal articles exploring the complex human dynamics influencing the decision-making processes surrounding farm succession and retirement to put forth a series of recommendations that sensitively deal with problematic issues surrounding generational renewal in agriculture, whilst also ensuring farmers' emotional wellbeing in later life.

KEYWORDS: generational renewal; family farming; succession; retirement; land mobility

1. Introduction

Globally the policy mantra about the survival, continuity and future prosperity of the agricultural sector, traditional family farm model and broader sustainability of rural society seems ultimately to depend on an age-diverse farming population (Ingram and Kirwan, 2011; Lobley and Baker, 2012; Nuthall and Old, 2017). Indeed in Europe, an aging farming population and steady decline in the number of young farm families is reported as being a key factor in the demoralization of rural communities in which the farm is located (Vare *et al*., 2005; Zagata and Sutherland, 2015). Consequently, it is increasingly clear that a major challenge presents itself in the area of intergenerational family farm transfer, so much so that European Commissioner for Agriculture and Rural Development, Phil Hogan, maintains that a priority for future CAP reforms must focus on generational renewal (European Commission, 2017).

Financial incentives to stimulate and entice intergenerational family farm transfer are undoubtedly important, but as argued in this paper, which draws from evidence gathered in the Republic of Ireland, there are more facets to the farm succession and retirement decision-making process that for the most part have been neglected. Indeed, previous research carried out by the lead author of this paper published in Conway *et al*. (2016; 2017; 2018), have opened up considerable debate in this area by delving into the mind-set and mannerism of farmers in later life to help identify the dynamic mass of emotional values attached to the farm and farming occupation 'beyond the economic' (Pile, 1990, p. 147). It is from the lead author's empirical research findings published in Conway *et al*. (ibid) that this paper puts forward a series of recommendations that are necessary to address the future trajectory of the complex area that is intergenerational family farm transfer.

The three interrelated studies published in Conway *et al*. (2016; 2017; 2018) bring to surface the various human dynamics influencing and hindering the older generation's decision-making processes surrounding farm succession and retirement from a different theoretical base, whilst maintaining the same foci. Conway *et al*. (2016) theoretically pioneered the use of Pierre Bourdieu's

Original submitted December 2018; accepted February 2019.

[1] Discipline of Geography, National University of Ireland, Galway, University Road, Galway, Ireland.

[2] Teagasc Agricultural Economics and Farms Surveys Department, Mellows Campus, Athenry, Co. Galway, Ireland.

* Corresponding author: Email: shane.conway@nuigalway.ie

notion of symbolic capital (i.e. resources available to an individual on the basis of esteem, recognition, status, or respect in a particular social setting) to comprehend the psychodynamic and sociodynamic factors influencing the unwillingness and reluctance amongst older farmers towards relinquishing management and ownership of the family farm and retirement. Conway *et al.* (2017) explored the micro-politics and hierarchical power dynamics at play within family farm households through the analytical lens of Pierre Bourdieu's concept of symbolic power, and the exercise of symbolic violence. While finally, Conway *et al.* (2018) applied Graham Rowles' concept of insideness as a theoretical framework to present an insightful, nuanced analysis of the deeply embedded attachment older farmers have with their farms. These studies obtained an in-depth, holistic understanding of the various facets governing the attitudes and behaviour patterns of older farmers towards the intergenerational family farm transfer process by employing a multi-method triangulation design, consisting of self-administered questionnaires (n=324) carried out with farmers in attendance at a series of 'Transferring the Family Farm' clinics hosted by Teagasc, the Agriculture and Food Development Authority in Ireland as well as an Irish adaptation of the International FARMTRANSFERS Survey (n=309), in conjunction with complementary Problem-Centred Interviews (n=19).

Empirical findings from these studies demonstrated how the senior generation's reluctance and indeed resistance to alter the status quo of the existing management and ownership structure of the family farm is undoubtedly strong within the farming community. The reasons why older farmers fail to plan effectively and expeditiously for the future are expansive, and range from the potential loss of identity, status and power that may occur as a result of engaging in the process, to the intrinsic multi-level relationship farmers have with their farms. The common denominator identified was that intergenerational family farm transfer is very much about emotion. These so-called 'soft issues' i.e. the human dynamics involved, are the issues that distort and dominate the older generation's decisions on the future trajectory of the farm. In fact these issues have resulted in intractable challenges for succession and retirement policy over the past fifty years, consequently making them very much the 'hard issues'. Future interventions and research geared specifically towards the needs and wants of the senior generation of the farming community are therefore greatly warranted in order to help successfully mobilise various collaborative farming policy efforts aimed at facilitating land mobility from one generation to the next.

2. Where does this lead us?

In an era of unprecedented transition in global agriculture, particularly in the context of an ageing farming population, calls for and justifies, the development of various incentives to stimulate and entice family farm transfer. Creating an environment whereby enthusiastic young farmers can gain access to productive assets and subsequently improve the competitiveness of the agricultural sector is imperative. While accountants, solicitors and financial advisors all have essential roles to play in this process, the complex array of human dynamics influencing and hindering the older generation's decision-making process (Conway *et al.* 2016; 2017; 2018), suggest that policy makers and practitioners should avoid the often-implicit assumption that financial incentives and the presence of an enthusiastic potential successor are all that is required for a successful intergenerational transfer transition. Such ingredients are essential no doubt but equally crucial is the way in which such professionals are well-informed and consciously aware that the extent of effective intergenerational transfer planning lies heavily upon the senior generation's acceptance and willingness to engage in the process. Effectively an understanding that the senior farmer must be a willing participant in altering the status quo of the farms' existing hierarchical structure, as they have the respect and authority to do so by virtue of their lifelong accumulation of symbolic capital.

Without the incumbent's wholehearted commitment, the likelihood of a successful management transition from the older generation to the successor in waiting is almost impossible. Fundamental action and change in existing and future intergenerational family farm transfer policy and schemes is required if the senior generation is to maintain and sustain normal day to day activity and behaviour on their farms in later life, whilst also 'releasing the reins' to allow for the necessary delegation of managerial responsibilities and ownership of the family farm to their successors. If this fails to materialise, there will continue to be extraordinary socio-economic challenges for younger people aspiring to pursue farming as a career.

3. Positionality: Reflecting on the research process

Before detailing recommendations that sensitively deal with problematic issues surrounding generational renewal, whilst also ensuring farmers' emotional well-being and quality of life in later life, it is first necessary to reflect on how the research process has 'sign-posted' these recommendations. The research process itself involved a multi-method triangulation design, consisting of self-administered questionnaires (n=324) and an Irish adaptation of the International FARMTRANSFERS Survey (n=309) in conjunction with complementary Problem-Centred Interviews (n=19). Approaching the research phenomenon from three different, yet co-equal and interdependent methodological vantage points, counteracted the limitations and biases that stem from using a single method, thus increasing the reliability, validity and rigor of findings. Participation in a 20-hour Farm Succession Facilitation Certification Training programme offered by the International Farm Transition Network (IFTN) at the University of Wisconsin, Madison, U.S.A., in September 2015 during the research process further enhanced the lead author's understanding, and ability to address the complexity of issues surrounding succession planning by successfully equipping them with a comprehensive set of facilitation skills to work with farm families during the process. As this research topic on the issue of family farm transfer is not just a national or even European challenge, but a global one, this was invaluable in obtaining an international perspective on the issue while also enabling the transfer of such knowledge into potential practical

applications and solutions in policy and consultancy domains.

In all, the methodological approach of the study was rigorous, accurate, professional and confidential. Research participants were hugely interested in being involved in the study, and as a result gave freely of their time in providing an honest account of their opinions and experiences of farm succession and retirement. It was this process of self-reflection and introspection on the farmer's part, which ultimately allowed the research to evolve in such a meaningful and practical way. By entering the research participants' life world, the lead author was presented with many invaluable opportunities to conceptualise the intergenerational family farm transfer issue particularly as it relates to exploring the mindset and mannerisms of farmers in later life. These experiences imbued a sense of the importance in bridging the gap between theory and practice and in giving a voice to older farmers whose stories can be marginalised by the larger assemblages of state, ultimately benefiting the research process.

The recommendations presented hereafter, which take into account the human dynamics affecting the process, are very appropriately timed, because 'for too long the policy debate has been conducted with little reference to farmers or to their view of the world' (Winter, 1997, p. 377). Indeed these recommendations demand careful consideration if the existing ambivalence towards intergenerational farm transfer is to be sensitively and successfully addressed. These recommendations are predominately directed at policy makers and key stakeholders who have the means and ability to deliver future interventions, and programmes, that deal with problematic issues surrounding this complex area.

4. Recommendations

4.1 Recommendation 1: 'Farmer-sensitive' policy design and implementation

Regarding the suitability of farm transfer policy strategies put in place in the Republic of Ireland over the past four decades, particularly several short-lived Early Retirement Schemes (ERS), designed to encourage older farmers generating low returns to retire, Conway *et al.* (2016) found that they had little or no regard for older farmer's emotions and were excessively preoccupied with financial incentives to encourage the process. Consequently, a derailment of the process in many cases has been the ultimate outcome. For example, the eligibility requirements for farmers entering the most recent Early Retirement Scheme for Farmers (ERS 3, June, 2007 p.2), was that 'Persons intending to retire under the Scheme shall cease agricultural activity forever'. This largely unsuccessful scheme (it was suspended in October, 2008) was completely oblivious to the mind-set of many farmers as exemplified by Conway *et al.* (2016). While we acknowledge that such economic efforts to confront the issue are important, and indeed have been in many aspects well meaning, Conway *et al.* (ibid) identified that farm transfer policy was underestimating the importance of symbolic capital when discussing the issue of intergenerational family farm transfer.

Symbolic capital defines the farmer as a social being. A key element of symbolic capital for many older farmers comprises being recognised as an active and productive farmer in society, a status which is also central to a farmer's sense of self. However, as symbolic capital is situational, the symbolic capital assigned to a person in one situation may not necessarily carry over into other situations (Christian and Bloome, 2004). Thus, the prospect of going from being an active and productive farmer to permanently ceasing all farming activity upon retirement as demanded in this retirement scheme, compromises the older generation's lifetime accumulation of symbolic capital and forces farmers to face a number of what could be termed, painful realities. These 'realities' come with the consciousness of letting go of one's professional identity, becoming a retiree, becoming more dependent on others, the onset of old age and even impending death. The resultant outcome leads farmers, in many cases to resist 'stepping aside', even where it represents economic common sense to engage in the process. The fact that 'farm operations that would be considered financially sound, well-managed businesses can slowly collapse and fail because the older generation is unable or unwilling to face the contradicting desires of seeing the next generation succeed yet retain the independence and self-identity farming provides' (Kirkpatrick, 2013, p. 3) makes this a major concern.

As it is the senior generation who ultimately decide whether intergenerational family farm transfer occurs or not, even the most sophisticated of programs and mechanisms designed to incentivise farm transfer will be of little benefit if policy makers and extension specialists across the globe are not adequately cognizant and understanding of 'the language of farming' (Burton, 2004, p. 212) and how painful it is for the older generation to 'let go' of their ingrained productivist self-image (Conway *et al.*, 2016). Indeed, as farmers' symbolic capital is vested in the esteem in which he/she is held amongst their peers as a 'good', actively engaged farmer, policies that erode this capital base are likely to be shunned. Therefore, until there is closer congruence of policy aspirations and the symbolic capital of older farmers, the progress towards increased levels of land mobility in Irish agriculture will be an incremental process. However, as there is a deeply ingrained 'rural ideology' that prioritizes the process of handing over the farm within the family, the formulation of intergenerational farm transfer measures which augment rather than detract from the senior generation's cache of symbolic capital, is by no means impossible. It is a recommendation of our research therefore, that any new initiatives to support / encourage the process should not be conceived so narrowly as to ignore possible social consequences or wider issues of human dignity. Both emotional and economic needs must be catered for, and ideally a policy for structural reform in agriculture must be accompanied by a comprehensive set of interventions to deal with the personal and social loss an older farmer may experience upon transferring the family farm. In order to do this, we recommend that future policies and programmes relating to family farm transfer take into account the pervasiveness of symbolic capital and work within this structure to effect change. For example, on its own, and with the numerous perceived negative connotations associated with it identified, perhaps the term 'Early Retirement Scheme' is no longer appropriate language for policy makers to use in a farming context. Perhaps the term 'Farm Progression Scheme' would be more effective as

it portrays a sense of purposefulness rather than one of cessation to an elderly farmer. The development of an appropriate concept of retirement for agriculture, rather than the adoption of what prevails in other sectors of the economy is a task to which policy can connect intergenerational farm transfer measures to the senior generation's ongoing assembly of symbolic capital.

In addition, instead of reporting that farm management decisions are in the hands of a generation who may be more resistant to structural change and growth, policy makers and key stakeholders need to embrace, publicly promote and recognise the older generation's invaluable store of locally specific tacit and lay knowledge developed over years of regularized interaction and experience working on the family farm. As this farm-specific or 'soil-specific' human capital (Laband and Lentz, 1983) knowledge is not easily transferable, communicated or learnable, the family farm may be left in the hands of a young, inexperienced farmer, unable to make competent management decisions without the continued guidance, advice and knowledge of the senior generation. Indeed, Weigel and Weigel (1990), point out that the succeeding generation of farmers may seek to operate independently, yet still be dependent on the life long experience and knowledge of their elders. This may encourage the senior generation to approach the transition with greater enthusiasm and acceptance. The feeling of still being valued and needed in society may reinforce the older farmers' morale and sense of purpose in the face of the gradual diminishment of their physical capacities, all the while offering possibilities for a positive form of ageing experience. The active advisory role ideology and discourse recommended here, may subsequently help to diminish the stigma and defeatist stereotype associated with transferring the family farm and subsequently promote a more positive and wilful attitude towards the process over time. The development of such strategies concerning the emotional wellbeing of elderly farmers has the potential to greatly ease the stresses of the process.

4.2 Recommendation 2: Farm Succession Facilitation Service

Specifically, not unlike elsewhere in the world, Joint Farming Ventures (JFVs), particularly farm partnerships, have recently been promoted within Irish policy discourses as succession strategies that can provide an ideal stepping stone to farm transfer as it provides a function for intergenerational cooperation (Leonard *et al*., 2017), whilst also allowing for greater recognition, financial independence and leadership opportunities for the younger generation (ADAS, 2007). In an attempt to entice and incentivize the uptake of such unconventional ventures, the Irish Department of Agriculture, Food and the Marine launched a Collaborative Farming Grant Scheme in 2015, funded under Ireland's Rural Development Programme (RDP) 2014-2020 and co-funded by the European Agricultural Fund for Rural Development (EAFRD), to 'encourage the establishment of new farm partnership arrangements by contributing to the legal, advisory and financial services costs incurred by farmers in the drawing up of their farm partnership agreement' (DAFM, 2015, p. 1). While appreciating the merits and potential benefits of this scheme, it again has, we would argue, an overly simplified view of the factors influencing the succession process and fails to deal with the complex emotional dynamics facing ageing farmers (Conway *et al*. 2016; 2017; 2018). Conway *et al*. (2016) illustrate that in many cases, the older generation, through their own admission, prioritize the building and maintenance of their personal possession of symbolic capital rather than transferring the family farm, even to their own children. In fact, Conway *et al*. (2017) discovered that the senior generation employ an intricate array of complex strategies and practices of symbolic violence in an effort to sustain and maintain their position as head of the farm. Therefore, while farm partnerships, appear to 'tick all the boxes' in relation to the ideal family farm transfer facilitation strategy as they provide a function for intergenerational cooperation, they will be of little benefit if farm transfer policy fails to consider methods of addressing the micro-politics and management power dynamics at play within family farm households.

The socially recognized and approved authority afforded to older farmers via their formidable store of symbolic capital appears to be a fact of social life within farm households. The challenge for policy makers and practitioners therefore is twofold. They must consider methods in which this power can be legitimately exercised by the senior generation, in the interest of whatever 'good' is at hand (in this case to preserve the crucial intergenerational dynamic of family farming, and allow for the older generation to remain active and productive on the farm, because being recognised as such is central to their sense of self). Secondly however, policy makers and practitioners need to remain cognizant of the fact that such power has the potential to become 'symbolic violence', and act against the good at hand (which, in this case, would involve the inappropriate domination of the younger generation by exploiting their symbolic power as head of the household and farm). Having a clear transitional role for both the incumbent and the successor is seen to be vitally important (De Massis, *et al*., 2008). According to Palliam *et al*. (2011), 'clarification of role, responsibilities, and ownership stakes will give successors the time they need to establish their credibility and independences' (p. 26) to manage the business. This echoes previous family farm literature over the past three decades which has continuously highlighted the reduction in management control as an important element of the process. Salamon and Markan (1984) previously stressed that 'the older farmer must encourage younger family members to be involved, bring them into the decision-making process and permit some sharing of control to maintain peak efficiency' (p. 174).

As every farmer and each family situation is unique, we acknowledge that there are no uniform or easily prescribed solutions to solving this complex challenge, however as suggested by Nuthall and Old (2017), 'changing farmers' objectives and management style needs to be handled professionally' (p. 56). With that in mind, we advocate that the services of a certified Farm Succession Facilitator, trained in accordance with an international best practice model, such as the one offered by the International Farm Transition Network (IFTN) in the U.S.A., is essential; particularly when facilitating discussions between old and young family members' objectives, goals and expectations for the farm. The goal of the IFTN is to support programs and activities that foster

the next generation of farmers. The network believes that programs that help create the opportunity for young people to begin a career in agriculture, particularly by addressing land mobility, must be part of the government's rural development effort.

Role and Duties of the Farm Succession Facilitator

The role of a certified IFTN Farm Succession Facilitator is not to come up with instant solutions, instead they guide and support farm members through the steps of the farm transfer planning process in an unbiased manner. The Facilitator helps address the complex and often problematic succession planning issues encountered by farm families by identifying the unique requirements of each member and then directing them towards the many different tools, resources and strategies needed to achieve a shared transition vision that ensures the future continuity and prosperity of the farm operation. In line with recommendations set out by the IFTN, the facilitation sessions are most beneficial when they take place outside the family home. Bennett (2006), in her ethnographic exploration of power relationships in a Dorset farmhouse, noted that the kitchen table is the centre of the home. The seating position round this table may reflect power dynamics within the family, as the older generation sit in their customary seat at the top of the table (Barclay, 2012). In order to neutralize such a hierarchical household structure, the Facilitator conducts the meeting with farm members at a roundtable in a neutral environment where everyone in attendance must renegotiate their position.

The key roles and duties of an IFTN Farm Succession Facilitator follow a three-step blueprint: Step 1: Where is the farm now; Step 2: Where do you want to be; and Step 3: How do you get there.

1. The first step involves the Facilitator bringing all farm members together to discuss, evaluate and clarify the current status of the farm business, such as confirming its size, financials and efficiency. This process enables members from both generations to obtain and share all the essential components and necessary information required to move through the succession planning process, and work efficiently with other relevant professionals involved. Getting the whole family to sit around a table together during this initial stage of the process also helps the Facilitator to identify those who may dominate discussions around the future direction of the farm, previously brought to light by Conway *et al*. (2017). A skilled IFTN Farm Succession Facilitator does so by gauging how farm members communicate and interact with each other, and also by observing the body language of those involved in these discussions.
2. The second step involves the Farm Succession Facilitator having one-to-one meetings with farm members from both generations. These sessions help the Facilitator to uncover each individual's views, their perceived role on the farm and how they foresee the farm business being dealt with in the future. Following on from these individual meetings, the Facilitator brings all farm members together again to coordinate an open discussion between those involved on any issues and/or disparities that may have arisen from each individual sharing their own values, vision, mission, goals and indeed fears for the future of the farm. As 'unspoken, misunderstood, or different visions in the same family' are reported to 'lead to conflicts' in family businesses (Aronoff and Ward, 1994, p. 75), this is the most important part of the facilitation process. Intergenerational communication is key to effective succession planning. Indeed, Lange *et al*. (2011) argue that closed communication styles in which family members are not encouraged to share their feelings and opinions openly, tend to result in more stress within the family unit and can even result in a 'breakup of the farm and a breakup of the family' (Hicks *et al*., 2012, p. 101). These fruitful discussions towards the latter stage of step two can help clarify expectations and avoid assumptions amongst farm members.
3. The third and final step involves the Facilitator leading thorough discussions on suitable farm transition options and strategies with farm members. Achieving outcomes with a shared understanding and common agreement by engaging in this process will help farm members from both generations to make better informed decisions on the future trajectory of the farm, in a collective manner. As succession planning not only involves the transfer of labour, skills, management and decision making to an identified successor, but also the transfer of assets, building a team of resource professionals to help in the transition process is another fundamental feature of this stage of the facilitation process. Financial analysis from a team of accountants, financial advisors and tax planners for example, is required to ensure the business can support the monetary goals of all farm members. Other services for farms in the process of transitioning, such as a solicitor/attorney, who is well informed of the 'language of farming', is also advisable to assist in the creation of a farm will. Research by Conway *et al*. (2018) discovered that over 40% of older farmers do have a will in place, hence the importance of taking this important step on the path towards successful intergenerational farm transfer.

Throughout this three-step facilitation process, the Farm Succession Facilitator must ensure to keep discussions on track. Tension and even conflict can arise from almost any aspect of the succession plan. If open and honest communication is not developed in the beginning, a seemingly trivial issue can stop a succession plan in its tracks. A skilled Facilitator also ensures that tough questions and emotions are dealt with and various 'what if' scenarios are investigated. By helping farm members navigate through difficult conversations, the Farm Succession Facilitator develops contingencies to address topics such as disagreement, disability, divorce and even death (Wenger, 2010). Several authors have also highlighted that initiating the process of handing over the family business, forces the incumbent to face their own mortality, hence the significance of addressing this topic in a sensitive manner (Bjuggren and Lund, 2001; Pitts *et al*., 2009; Nuthall and Old, 2017).

It is also essential for Farm Succession Facilitators to be acutely aware and knowledgeable of the defence mechanisms and tactics utilized by the older generation to avoid and deter the delegation of managerial responsibilities from occurring (Conway *et al*., 2017). Analytically, so broad however, we acknowledge that Bourdieu's use of the word 'violence' in his concept of symbolic

violence, is contentious and indeed may confuse denotation to such an extent that it may result in such professionals referring to disparate and incompatible events and experiences of succession and retirement whilst referring to the same conceptual apparatus. In recognition of the concept's potential for misinterpretation, we therefore feel compelled to rephrase symbolic violence to 'symbolic authoritarianism' and/or 'symbolic sabotage' when providing Farm Succession Facilitators with an overview of the micro-politics and management power dynamics at play within family farm households.

Furthermore, we recommend that it is also imperative for such professionals to be cognisant of, and empathize with the older generations' emotional needs and cognitive insecurities about succession and retirement, since psychodynamic and socio dynamic deterrents constitute a major obstacle to the development of a plan for the future (Conway *et al.* 2016). Such a holistic understanding and knowledge of the human dynamics of the process will equip succession facilitators on the ground with the necessary credibility, skill, reverence and trust needed to personally engage with older farmers and ultimately strengthen their willingness to address the issue. Indeed, research suggests that effective facilitators need a mix of external insights and local acceptance (Slee *et al.*, 2006).

Farm Succession Facilitation Service implementation

Intergenerational debates about collaborative working processes professionally initiated and guided by a trained Farm Succession Facilitator, will allow for the succession process to be developed, based on a more logical than emotional perspective. According to Nuthall and Old (2017) however 'farmers need a strong incentive to work on their style and objective factors which are holding back succession' (p. 56). There must be a seed that stimulates the need to act. Barclay *et al.* (2007), and previously Glauben *et al.* (2004), highlighted that in many cases the older generation believe that succession is something they should deal with in isolation, without consulting other members of the family or even an outside consultant. Therefore, instead of facilitation being a voluntary service available to farmers, we recommend that existing and future policies and programmes encouraging family farm transfer and supporting younger farmers, insist on a course of mandatory facilitation sessions with a certified Farm Succession Facilitator. Ideally these would be funded or subsidised by the Department of Agriculture, Food and the Marine (DAFM), with the proviso that in order to be eligible to apply and become involved in a Joint Farming Venture, such as a farm partnership for example, such facilitation sessions must be availed of. Effective communication is vital in the farm transfer planning process and such an implementation has the potential to greatly enhance the uptake and success of existing and future policy measures. Furthermore, we recommend that this compulsory facilitation requirement be extended beyond merely supporting those directly considering farm transfer and added as a criteria for all younger farmers hoping to obtain an Advanced Level 6 Certificate in Agriculture (the Green Cert obtained at agricultural universities and colleges in the Republic of Ireland), that qualifies them for stock relief and stamp duty exemptions as 'Young Trained Farmers'. This new module at third level education would stimulate and encourage open lines of intergenerational communication within family farm households, whether they are in the process of farm transfer planning or not, something that currently seems not to be the case. Lange *et al.* (2011) explains that 'the more open the communication style within the family, the less stress that occurs and the easier it is to address stress that does occur (p. 3).

We acknowledge that a voluntary succession mediation service already exists in the Republic of Ireland. The role and indeed usefulness of mediation in the farm transfer planning process is also outlined in Teagasc's Guide to Transferring the Family Farm (Teagasc, 2015). In many ways, facilitation and mediation are similar, but in the most elementary way, they are significantly different: mediation is generally seen as intervention in a dispute (e.g. in marriage separation or divorce) in order to bring about an agreement or reconciliation whereas facilitation is primarily used pre-conflict. Due to the potential negative and conflictual connotations associated with the term 'mediation service', we suggest that the term 'facilitation service' is more appropriate for policy to use in a farm transfer planning context as it may stimulate a more wilful attitude towards the process.

4.3 Recommendation 3: Establishment of a National Voluntary Organisation for older farmers

A third recommendation we would argue for, is that policy makers and practitioners re-examine their dominant focus on economic-based incentives by becoming more aware and knowledgeable of the intrinsic farmer-farm relationship (Conway *et al.*, 2018). Such understanding will be crucial when reforming and developing future initiatives and strategies that seek to encourage the transfer of farm process by prioritising future interventions that maintain the quality of life of those concerned. A significant obstacle to the intergenerational farm transfer process is the rigid inflexibility of the occupational role, where farmers wish to remain 'rooted in place' on the farm and in many cases, have developed few interests outside of farming (Riley, 2012). As there are no bodies or services currently in existence in the Republic of Ireland that specifically represent the needs and interests of the older farmer in rural areas, we recommend the establishment of a national voluntary organisation that specifically represents the needs of the senior generation of the farming community, equivalent to that of younger people in rural Ireland i.e. Macra na Feirme. Macra na Feirme is a voluntary, rural youth organisation in the Republic of Ireland for people between the ages of 17 and 35. Founded in 1944, the organisation now has over 9,000 members across approximately 200 clubs in 31 regions around the country (Macra na Feirme, 2018). One of the organisation's main aims is to help young farmers get established in farming and assist them through learning and skills development.

Suited to the older generation's own interests and needs identified (Conway *et al.*, 2016; 2018), such a voluntary organisation, funded annually by the Government and through membership, would provide the older generation with a support around which they could

remain embedded 'inside' their farms and social circles in later life. A nationwide voluntary organisation, with a network of clubs in every county across the country, would allow older farmers to integrate within the social fabric of a local age peer group, whilst also providing them with opportunities to develop a pattern of farming activities suited to advancing age. This would contribute to their overall sense of insideness, and, therefore, sense of self-worth, amidst the gradual diminishment of their physical capacities on the farm in later life. Collaborating with their younger counterparts in Macra na Feirme on various campaigns and activities would also allow the senior generation to retain a sense of purpose and value in old age.

Similar to Macra na Feirme, this body for older farmers, with their added wealth of experience, would act as a social partner farm organisation together with the Irish Farmers Association (IFA) for example, that would allow them to have regular access to government ministers and senior civil servants, thus providing them with a voice to raise issues of concern. Indeed, such a group could be invaluable with regard to the development of future farm transfer strategies that would truly be cognisant of the human side of the process of intergenerational renewal. An established organisation for older farmers would also allow this sector of society to have a representative on important committees such as the Executive Council of the Irish Farmers' Association (IFA) and the Board of Teagasc for example, and on other relevant stakeholder groups, similar to their younger counterparts.

4.4 Recommendation 4: Occupational health and safety in agriculture awareness

On a related aspect, and while not central to the discussion so far, is the issue of occupational health and safety on the farm. The insight into the senior generation's deeply-embedded sense of insideness towards their respective farms developed by Conway *et al.* (2018) suggests that there is much to be learned from the analysis of the farmer-farm relationship that would benefit this very significant contemporary challenge. Farming is one of the most hazardous occupations in terms of the incidence and seriousness of accidental injuries (Glasscock, *et al.*, 2007). Moreover, agriculture exhibits disproportionately high fatality rates, when compared to other sectors (ibid). With almost half of all farm fatalities in the Republic of Ireland and many other European Union member states involving farmers aged 65 and over (HSA, 2013), this phenomenon requires immediate policy intervention. The deeply-embedded farmer-farm relationship offers potential for understanding why many farmers are unwilling to recognize or accept their physical limitations on the farm (Peters *et al.*, 2008) and instead, continue to traverse spaces that would appear to be beyond their level of physiological competence (Ponzetti, 2003), with subsequent risks to their health and safety. The general satisfaction and well-being that the older generation of the farming community attribute to the daily and seasonal labour-intensive demands of working on the farm in later life, appears to be part of the farming psyche. Such an insight into the intrinsic link to farm attachment in old age and the importance attributed to the habitual routines within the farm setting, will provide the Health and Safety Authority (HSA) and member organisations of the HSA Farm Safety Partnership Advisory committee in the Republic of Ireland with an invaluable understanding of the various actions taken by (or should be taken by) older farmers to handle age-related physical limitations and barriers on their farms. This knowledge will aid in the development of an effective health and safety service tailored specifically to the needs of older farmers.

5. Conclusion

In drawing all these issues together, the recommendations set forth in this paper, are geared specifically towards informing more appropriate, 'farmer-sensitive' generational renewal in agriculture policy directions. Indeed, we would argue that what is put forward here represents what, in all probability, are the first attempts to deal with one of the most challenging agricultural / rural sustainability issues of our time. Issues which have not been explored in any real depth since the late Dr. Patrick (Packie) Commins' proposals in the early 1970s (Commins, 1973; Commins and Kelleher, 1973). The fact that the average age of the farming population is increasing worldwide, means that the recommendations presented in this paper are very timely. As the future success of the family farm business may hinge on its ability to maintain internal stability, existing attitudes towards succession must change in order to make the transition between generations less problematic and more efficient. 'To change the world', Bourdieu (1990, p. 23) argues, one must change the ways of world making, that is, the vision of the world and the practical operations by which groups are produced and reproduced (ibid). A cultural shift on an age-old problem of farm succession requires well-informed and intelligent policy interventions and strategies which understand the complex nature of the process, like those outlined here.

In recognition of the heterogeneity of the farming population however, the ideas presented here should not be viewed as 'one size fits all model' for 'fixing' the farm succession situation. Policy interventions must be geared to the individual circumstances and specific conditions of any given case. This may encourage the senior generation to approach the transition with greater enthusiasm and acceptance. Anyone who considers such recommendations to be too idealistic, should remember that we all inevitably have to face the prospect of letting go of our professional tasks and ties in our old age. No one can avoid ageing and as the lead author of this paper identified in Conway *et al.* (2016; 2017; 2018), most elderly farmers opt to maintain the facade of normal day to day activity and behaviour instead of retiring. As such, this recommendations paper, in attempting to understand and acknowledge the world as farmers perceive it, can be drawn upon to inform future generational renewal in agriculture policy directions and as a consequence prevent older farmers from being isolated and excluded from society almost by accident rather than intention.

About the authors

Dr Shane Francis Conway is a Postdoctoral Researcher in the Discipline of Geography's Rural Studies Research Cluster at the National University of Ireland, Galway.

Dr John McDonagh is a Senior Lecturer in Rural Geography in the Discipline of Geography, National University of Ireland, Galway.

Dr Maura Farrell is a Lecturer in Rural Geography and Director of the MA in Rural Sustainability in the Discipline of Geography, National University of Ireland, Galway.

Anne Kinsella is a Senior Research Economist at Teagasc, the Agriculture and Food Development Authority in Ireland, where she specialises in area of production economics and farm level agricultural economics research.

Acknowledgement

Funding for this project was provided by the National University of Ireland, Galway, College of Arts, Social Sciences, and Celtic Studies Doctoral Research Scholarship Scheme and the Geographical Society of Ireland postgraduate travel award bursary. We would also like to thank Teagasc, the Agriculture and Food Development Authority in Ireland, for their assistance with this research.

REFERENCES

ADAS (Agricultural Development and Advisory Service). (2007). Study of Joint Venture Farming. Defra, London.

Aronoff, C. and Ward, J. (1994). Defining your family business. Nation's Business, May, 74–75.

Barclay, E. and Foskey, R. and Reeve, I. (2007). Farm Succession and Inheritance Comparing Australian and International Trends. Publication Number 07/066. RIRDC, Canberra.

Barclay, K. (2012). Place and Power in Irish Farms at the End of the Nineteenth Century. *Womens History Review*, 21(4), 571–588.

Bennett, K. (2006). Kitchen Drama: Performances, patriarchy and power dynamics in a Dorset farmhouse kitchen. Gender, Place and Culture, 13(2), 49-56. Ball, A. and Wiley, A. (2005) The aspirations of farm parents and pre-adolescent children for generational succession of the family farm. *Journal of Agricultural Education*, 46(2), 36–46.

Bjuggren, P. O. and Lund, L. G. (2001). Strategic decision making in intergenerational successions of small and medium size family businesses. *Family Business Review*, 14, 11–24.

Bourdieu, P. (1990). In other words. Polity Press, Cambridge.

Burton, R. J. F. (2004). Seeing through the 'good farmer's' eyes: towards developing an understanding of the social symbolic value of 'productivist' behaviour. *Sociologia Ruralis*, 44(2), 195–215.

Christian, B. and Bloome, D. (2004). Learning to Read Is Who You Are. *Reading and Writing Quarterly*, 20(4), 365–84.

Commins, P. (1973). Retirement in agriculture: a pilot survey of farmers' reactions to E.E.C. pension schemes. Dublin: Macra na Feirme.

Commins, P. and Kelleher, C. (1973). Farm Inheritance and Succession. Macra Na Fairme, Irish Farm Centre, Dublin, Ireland.

Conway, S.F., McDonagh, J., Farrell, M. and Kinsella, A. (2016). Cease agricultural activity forever? Underestimating the importance of symbolic capital. *Journal of Rural Studies*, 44, 164–176.

Conway, S.F., McDonagh, J. and Farrell, M. and Kinsella, A. (2017). Uncovering obstacles: The exercise of symbolic power in the complex arena of intergenerational family farm transfer. *Journal of Rural Studies*, 54, 60–75.

Conway, S.F., McDonagh, J. and Farrell, M. and Kinsella, A. (2018). Till death do us part: Exploring the Irish farmer-farm relationship in later life through the lens of 'Insideness'. *International Journal of Agricultural Management*, 7(1), 1–13.

DAFM (Department of Agriculture, Food and the Marine) (2015). Coveney launches €3M grant scheme to support collaborative farming, 128/15 [press release].

De, Massis, A, Chua, J.H., and Chrisman, J.J. (2008). Factors preventing intra-family succession. *Family Business Review*, 21(2), 183–199.

European Commission. (2017). Speech by Commissioner Phil Hogan at Mountbellew Agricultural College, 17 February 2017. url: https://ec.europa.eu/ireland/news/commissioner-hogan-mountbellew-agriculture-college_en

Glasscock, D.J, Rasmussen, K. and Carstensen, O. (2007). Psychosocial factors and safety behaviour as predictors of accidental work injuries in farming. *Work and Stress: An International Journal of Work, Health and Organisations*, 20(2), 173–189.

Glauben, T. and Tietje, H. and Vogel, S. (2004). ''The transfer of family businesses in Northern Germany and Austria,'' FE Working Papers 0405, Christian-Albrechts-University of Kiel, Department of Food Economics and Consumption Studies.

Health Service Executive. (2013) Farm Safety Action Plan 2013–2015.

Hicks, J., Sappey, R., Basu, P., Keogh, D. and Gupta, R. (2012). Succession Planning in Australian Farming. *Australasian Accounting Business and Finance Journal*, 6(4), 94–110.

Ingram, J. and Kirwan, J. (2011). Matching new entrants and retiring farmers through farm joint ventures: insights from the fresh start initiative in Cornwall, UK. *Land Use Policy*, 28(4), 917–927.

Kirkpatrick, J. (2013). Retired Farmer - An Elusive Concept. Choices – The Magazine of Food, Farm, and Resource Issues. 2nd Quarter 2013, 28(2), 1-5.

Laband, D.N. and Lentz, B. F. (1983). Occupational Inheritance in Agriculture. *American Journal of Agricultural Economics*, 36, 311–314.

Lange, K.Y., Johnson, J.W., Hudson, D., Johnson, P.N. and Gustafson, B. (2011). Equal or just? In: Intergenerational Allocations within Family Farm Businesses, Southern Agricultural Economics Association Annual Meeting, Corpus Christi, Texas.

Leonard, B., Mahon, M., Kinsella, A., Donoghue, C., Farrell, M. and Curran, T. and Hennessy, T. (2017). The Potential of Farm Partnerships to Facilitate Farm Succession and Inheritance. *International Journal of Agricultural Management*, 6(1), 4–19.

Lobley, M. and Baker, J.R. (2012). Succession and Retirement in Family Farm Businesses. In: Lobley, M., Baker, J., Whitehead, I. (Eds.), Keeping it in the Family: International Perspectives on Succession and Retirement on Family Farms (Ashgate), pp. 1–19.

Macra na Feirme (2018). Strategic Plan 2017- 2023: Rurally Active, Engaging and Transforming.

Nuthall, P. L., and Old, K.M. (2017). Farm owners' reluctance to embrace family succession and the implications for extension: the case of family farms in New Zealand. *The Journal of Agricultural Education and Extension*, 23(1), 39–60.

Palliam, R. and Cader, H.A, and Chiemeke, C. (2011). Succession issues among family entrepreneurs in the countries of the Gulf. *International Journal of Business Administration*, 2(2).

Peters, K.E., Gupta. S., Stoller, N. and Mueller, B. (2008). Implications of the aging process: opportunities for prevention in the farming community, *Journal of Agromedicine*, 13(2), 111–8.

Pile, S. (1990) The Private Farmer - Transformation and Legitimating in Advanced Capitalist Agriculture. Dartmouth, Aldershot.

Pitts, M.J., Fowler, C., Kaplan, M.S., Nussbaum, J. and Becker, J.C. (2009). Dialectical Tensions Underpinning Family Farm Succession Planning. *Journal of Applied Communication Research*, 37(1), 59–79.

Ponzetti, J. (2003). Growing Old in Rural Communities: A Visual Methodology for Studying Place Attachment, *Journal of Rural Community Psychology*, E6(1).

Riley, M. (2012). 'Moving on'? Exploring the geographies of retirement adjustment amongst farming couples. *Social and Cultural Geography*, 13(7), 759–781.

Salamon, S. and Markan, K. (1984). Incorporation and the farm family. Journal of Marriage and the Family, 46, 167–178.

Slee, W. and Gibbon, D. and Taylor, J. (2006). Habitus and style of farming in explaining the adoption of environmental sustainability-enhancing behaviour. Final Report, defra, University of Gloucester Countryside and Community Research Unit.

Teagasc. (2015). A Guide to Transferring the Family Farm.

Vare, M. and Weiss, C.R., and Pietola, K. (2005). Should one trust a farmer's succession plan? - Empirical evidence on the intention-behaviour discrepancy from Finland. Paper presented at the XIth Congress of the EAAE 'The Future of Rural 31 Europe in the Global Agri-Food System', Copenhagen, Denmark, August 24-27, 2005.

Weigel, D.J., and Weigel, R.R. (1990). Family satisfaction in two-generation farm families The role of stress and resources. *Family Relations*, 39(4), 449–455.

Wenger, C. (2010). Components of a Farm Succession Plan, Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA) Factsheet 04–073.

Winter, M. (1997). New policies and new skills: Agricultural change and technology transfer. *Sociologia Ruralis*, 37(3), 363–381.

Zagata, L. and Sutherland, L.A. (2015). Deconstructing the 'young farmer problem in Europe': Towards a research agenda. *Journal of Rural Studies*, 38, 39–51.

REVIEW OF 'STATE-OF-THE-ART' OF RESEARCH

DOI: 10.5836/ijam/2019-08-31

A review of the intuition literature relative to a recent quantitative study of the determinants of farmers' intuition

PETER NUTHALL[1]

ABSTRACT

Through a review of the literature covering the use of intuition for decision making, this article isolates the important intuition determining variables and relates them to recent quantitative intuition research. As most farm decisions are made through intuition farmers, consultants, researchers and students of farm management will find the review valuable when thinking about managerial ability. The literature reviewed is taken from both urban and rural business studies as urban based studies dominate. The search covered all journals and articles in recent decades. The summary, and the quoted quantitative research, consider the variables which can be targeted in improving intuitive skill and provides a basis for thinking about intuition and its improvement within the farming world. It is concluded the most important skill to concentrate on is improving a farmer's self-criticism through using a decision diary in conjunction with reflection and consultation leading to improved decision understanding. But many other variables are also important and contribute.

KEYWORDS: Intuition; tacit knowledge; review of intuition literature; intuition variables; improving intuition; decision methods

1. Introduction

The use of intuition (Hogarth 2010; Kahneman, 2011) is undoubtedly most farmers' main (Ohlmer, 2001) system of decision making and subsequent action. Understanding the development and improvement of a decision maker's intuition is an important area of study leading to enhancing a farmer's achievement of their objectives. Indeed, Hogarth (2010), for example, notes 'the need to educate intuitive responses' (p 338) and stresses the requirement for focused research as intuition is used in all aspects of living. This review covers management decision making, which is also Kahneman's (2011) focus, as well as intuition's relationship to analytical decision processes.

To date there has been only minimal agriculturally based studies on intuition as a decision system. One of the most recent studies (Nuthall and Old, 2018) used data from over 800 farmers to model the determinants of intuition. This review moves toward focusing farm management practitioners, consultants and researchers onto the many aspects underpinning intuition including Nuthall and Old's results.

There are many and varied definitions of what is meant by intuition. Dane and Pratt (2007) reviewed several and effectively noted intuition as being 'the provision of a conclusion reached without formal analysis'. Other definitions range from intuition being the provision of an instant decision without conscious thought, or contemplation, through to a decision based on a full and contemplative mental analysis. While each person's process varies, the idea of a decision without formal analysis seems to make decision sense as a logical definition.

Intuition is very much a psychological construct (Sinclair, 2010) in that it results from the decision maker responding to observed stimuli. It is one of the many psychological processes that give rise to the totality of Homo sapiens. Intuition is also just one of the many decision making theories that appear in the literature. Nuthall and Old (ibid) present a diagram summarizing the range and intuition's position within the schema.

In their quantitative analysis, Nuthall and Old (ibid, p 33), used a structural equation model to calculate regression coefficients which, when compared, indicate the relative importance of the variables they used in explaining a farmer's intuitive skill. They found '*The coefficients*

Original submitted April 2018; revision received January 2019; accepted January 2019.

[1] Corresponding author: Honorary Assoc. Professor, Land Management and Systems Department, Lincoln University, Canterbury, New Zealand (PO Box 85084, Lincoln University, Lincoln, NZ 7647). Email: peter.nuthall@lincoln.ac.nz

(of the variables) *influencing intuition are decision theory knowledge 0.394, decision reflection and critique 0.163, anticipation skills 0.128, experience 0.019, feedback 0.015, observation skills -0.035, and, very importantly, technical knowledge 0.945*'. They also concluded (p 35) that '*Besides the major contribution of decision and technology knowledge to intuition, feedback contributes 4.2%, experience 5.3%, anticipation 35.5%, observation 9.7%, and reflection 45.3%. Overall, each variable has a contribution, but anticipation and reflection stand out, though it is likely experience is a precursor to, particularly, reflection.*' If correct, their information makes it clear where efforts to improve decision ability should concentrate.

Importantly, they also commented (p 36) '*Future studies should collect variables suggested by the literature as being important but not collected in this study*.' The purpose of this review is to use the literature not only to amplify and reinforce the efficacy of the variables used in the Nuthall and Old (ibid) study, but to isolate and assess the additional variables that should be considered in future studies and assessments of intuition. These additional variables could well be important to farmers and others working on improving their intuitive skills and managerial ability. Furthermore, Nuthall and Old (ibid) did not refer to the past research used to isolate the variables that may influence a farmer's intuition, nor discuss the processes involved in assessing and altering the variables isolated. These gaps need coverage which is largely achieved through this review.

To achieve these objectives, the literature on intuition and tacit knowledge (another term used in the literature to refer to, effectively, intuition as defined), was extensively reviewed to discover the extensive list of variables likely to be involved in the development and maintenance of intuition. The five stage grounded theory review process (Wolfswinkel 2013) was largely followed. This involves searching the literature after assessing fields of research, and defining appropriate sources and search terms. Analysis and presentation then occur. The 'grounded' approach concentrates of letting the material introduce concepts and ideas in contrast to judging on preconceived theories and variables.

Google Scholar was used to search for the scholarly articles covering intuition (and 'tacit knowledge') which then provided the entry into the intuition research world. Key words such as 'intuition', 'tacit knowledge, 'farmer decision making', 'decision making psychology', 'decision thinking', 'decision intuition', and similar, were used. Finding initial articles provided further ideas on key word searches. The applicable studies found contained many references which were subsequently checked for likely candidates for further consideration and inclusion. Many articles showed similarities so what appeared the most comprehensive and well researched were included in the review with the others discarded. The end result was over fifty studies being used. To be included the articles had to contribute new ideas about the components determining a decision makers' intuitive ability, methods of acquiring improved intuition, and the variables giving rise to intuition.

The review is divided into sections covering each main area of the factors likely to influence success in the use of intuition. The particular groupings used emerged from the studies themselves together with logic. They included (1) experience, feedback and repetition; (2) training and mentoring; (3) reflection and self-critiquing; (4) intelligence and education; (5) personality; objectives and risk attitude; and, finally, (6) observation and anticipation skills.

The discourse that follows covers each of these areas together with a discussion and conclusions section. An appendix contains a table summarising the variables believed to be important as reviewed together with their source articles.

2. The literature giving rise to the variables likely to be important

After sorting all the literature it was relatively clear what the reviewed authors believed were the variables influencing intuition. These logically fell into a number of categories which were then used to form the sections which follow.

Experience, feedback and repetition

Kolb (1984) talks about learning from a process which involves, firstly, a concrete experience, reflective observation (of the experience), abstract conceptualisation leading to active experimentation. The cycle then repeats itself. Kolb (ibid) maintains that to learn from an experience certain conditions must hold. He lists these as a willingness to learn, an ability to reflect, the possession of analytical skills to conceptualise the experience, and an ability to use the new ideas. Feedback obtained by the decision maker from observing the outcomes of the decisions taken is also relevant to improvement. Effectively an iterative process proceeds. This 'non-formal' learning (Eraut, 2000) creates intuition, though formal learning will also contribute where relevant.

Non-formal learning can be divided into 'implicit learning' and 'reactive learning'. The former, according to Eraut (ibid), involves a well thought out linking of memories with current experience. In contrast, reactive learning involves near spontaneous reflection on past episodes. Whatever the process in developing intuition, Eraut (ibid) quotes Polanyi (1966) 'that which we know but cannot tell' to indicate intuition is seldom directly explainable by the decision maker.

Intuition should use all the relevant pieces of information that are activated from memory and/or observed from the environment (Betsch, 2005, as referenced by Betsch and Glockner, 2010). Nevertheless, if gaps exist, or the material is not accurately observed, intuition will be biased. Additionally, the time available to make a decision can influence the cognitive process. Eraut (2000) notes (p. 129) that where a quick response is necessary 'meta processes are limited to implicit monitoring and short reactive reflections. But … with more time meta processes become more complex … including the framing of problems, thinking about the deliberative process itself … searching relevant knowledge, and introducing value considerations….'.

Effectively he is talking about going well beyond simple pattern matching which refers to matching up the current situation with a mind-stored replica, or similar, that has been faced before for which a decision had been sorted. Klein (2008) and Hogarth (2010) make similar comments. This matching is virtually instantaneous,

whereas with more time reflection is possible and may perhaps change the conclusion.

As noted by Salas *et al*. (2010), the extent of feedback available is important. They also believe decision makers *must* proactively seek input from others who have higher levels of expertise. Sources of feedback can be varied ranging from a manager's spouse through to a professional consultant.

The type and extent of experiences (Salas *et al*., ibid) are important. Armstrong and Mahud (2008) found the length of managerial experience effected the level of 'tacit knowledge' (intuition). They also found people whose learning style was 'accommodating' (Kolb, 1984) (learn from practical experience and from other people) had higher tacit knowledge relative to all others. Furthermore, if the experience is repeated many times the lessons are reinforced (Eraut, 2000), even if modified as the sophistication of the mental analysis improves. Nuthall (1997) found in classroom experiments it took three repeats of a concept before the students understood the ideas involved. It is likely a similar situation exists for managers exposed to a new situation. Dijkstra *et al*. (2013) also concluded experience and knowledge of a domain (specific decision area) impacted on the success of intuitive conclusions.

For feedback, Shanteau and Stewart (1992) note it must be accurate (Plessner *et al*., 2008), diagnostic and timely. And Betsch and Glockner (2010) believe 'coherence' is important in that the pattern of encoded material must make sense to the observer. If not, 'deliberate construction' (i.e. mentally finding what is believed to be a coherent explanation) is instigated to make sense of the material. They also believe 'dual processing' is involved in that analytical processes, perhaps subconsciously, occur in creating intuition.

Luck probably also plays a part in intuition. Hogarth (2010) talks about the forecast prices turning out to be correct thus rewarding the results of intuitive decisions. Furthermore, for example, by chance a person might experience a difficult season early in her/his career so in future has a better prepared intuition following assessing possible solutions following the difficult time.

This review of experience, feedback and repetition show the following variables play a part in the development of successful informed intuition: willingness to learn, learning style, length of managerial experience, type of experience, repetition of similar experiences, degree of active experimentation, and, finally, the frequency, coverage, extent, accuracy, and timeliness of feedback. Whether accurate measurement of all these variables is possible is another matter. Measurement would enable assessing the variables' relative importance in the development of intuition using quantitative models of the process.

Training and mentoring

There is considerable evidence on the value of farmer, and farm family, training (e.g. Xayavong *et al*., 2015). Specifically, Salas *et al*. (2010) believe 'deliberate and guided practice' is important in developing intuition. For 'guided practice' Wagner and Sternberg (1987) note tacit knowledge has features which are all relevant in training content, context, and orientation (theory or practicality). Content is broken into managing oneself, managing others, and managing tasks. Context is divided into local and global, whereas orientation covers the idealistic and pragmatic. Ambrosini and Bowman (2001) refer to work which suggests day to day contact with a mentor in an apprentice-like relationship is very important to developing tacit knowledge. And Andresen *et al*. (2000) believe the skill of the mentors can have a very significant impact on the benefits. The personal relationship between mentor and manager is also important - they propose an 'equal' relationship helps.

Similarly, a peer group can be important (Eraut, 2000) as a source of training and mentoring, potentially providing a rich array of knowledge, beliefs, attitudes and behaviour. Dempsey *et al*. (2001), as noted by Peltier *et al*. (2005), believe sharing of thoughts and feelings is fundamental to reflection. This is where discussion, or mentoring, groups of various kinds come into play. Indeed, Goulet (2013) found managers learn substantial knowledge from manager meetings and discussion.

There is also evidence that the use of management games, decision support (DSS), and expert, systems can also enhance intuition. Nuthall and Bishop-Hurley (1996) found, for example, that farmers absorbed the lessons available from an expert system on animal management and subsequently gave up its formal use. Similarly both McCowan (2012) and McCowan *et al*. (2012) discuss the relationship between altering a farmer's intuition and the use of DSS.

Managers need to be trained to fully use their observations. Eraut (2000) notes the use of a new idea involves a) understanding the situation using prior knowledge, b) recognising the concept or idea is relevant, c) changing it into a form that is more relevant, and d) integrating the new knowledge with other knowledge already held. Similarly Hogarth (2010) notes if intuition can improve through experience there is no reason why with targeted training they will not similarly enhance intuition. Hogarth (ibid) provides suggestions on maximising the benefits of training through a) selecting and/or creating the right environments, b) seeking feedback, c) working on making the 'scientific method' intuitive, and d) shadowing recognised masters. Furthermore, Sadler-Smith and Burke (2009) report research has shown 'devils advocacy', provided by the instructor, can improve decisions in group situations.

The 'scientific method' (https://explorable.com/what-is-the-scientific-method accessed 12/10/2018) refers to creating an hypothesis, gathering data covering the hypothesis, analysing the data through comparing predictions of the hypothesis relative to the gathered data, and coming to a conclusion on whether the hypothesis is not disproven (it is difficult to categorically prove an hypothesis whereas if it is not disproven this is a step in the right direction). In the processes it is important to exercise a critical mind which questions all aspects of such an analysis for their possible fallaciousness.

Kolb (1984) believes different people learn in different ways, though not all researchers accept Kolb's theory in its entirety (e.g. Koob and Funk (2002) list many concerns including statistical issues). Kolb (ibid), as noted, talks about four learning factors - concrete experience, reflective observation, abstract conceptualisation and active experimentation. The specific mix determines how an individual learns. If true, a manager will approach developing informed intuition in her or his unique way.

This review of training and mentoring shows the following variables play a part in developing informed intuition: extent, form and content of training, skill at using the 'scientific method', skill at finding and using 'masters', extent of mentoring, and the quality and form of mentoring (group or individual).

Reflection and self-critiquing

Using Pee *et al.*'s (2000) work, Scott (2010) defines reflection as 'the conscious awareness and questioning of personal experience, a search for alternative explanations and interpretations, and identification of areas for improvement' (p. 438). Perhaps the subconscious does something similar, but exploring the subconscious is difficult (Casey *et al.*, 2005). However, managers that follow proposed reflective processes are more likely to acquire a successful 'informed intuition' (Cerasoli *et al.*, 2018).

Matthew and Sternberg (2009) provide a further definition of reflection believing it constitutes a 'guided critical thinking that directs attention selectively to various aspects of experience, making knowledge typically acquired without conscious awareness explicit and available for examination and modification' (p. 530). They believe the whole process is subconscious. Reality is a continuum from the conscious to the subconscious with the pendulum swinging with the particular situation. Managers think consciously about an experience in some circumstances, and in others they are not conscious of their brain modifying and developing their intuition.

Cox (2005) talks about the need to have a structured reflective process to gain the most from experiences. While using a process is probably beneficial, many managers tend to rely on their subconscious processes to acquire the lessons (Nuthall, 2012).

Furthermore, Eraut (2000) believes an experience largely stays in 'episodic memory' and is quickly lost unless reflection on the experience occurs. The consequent message can then be persuaded into long-term memory. Cope (2003) comments that a bad outcome might be necessary to stimulate a mental review of what went wrong and the decision improvements necessary. Cope (ibid) quotes Argyris and Schon (1974) '(managers) must reflect on this error to the point where they cannot correct it by *doing better what they already know how to do*….' (p. 439). This suggests a manager must review the problem experienced to come up with new rules to resolve any differences. This is called a 'double loop' as new rules or concepts are produced in contrast to more knowledge about an already held concept (van Woerkom, 2004).

Salas *et al.* (2010) support Eraut (ibid) in believing 'self-regulation' is important. They note regulation involves 'conscious monitoring and self-assessment', and that true experts are better at detecting errors and understating why they occurred.

In the same vein Wagner and Sternberg (1987) comment that a person must be able to sort out from the mass of observations which information is relevant (encoding), and then select out the meanings that specifically relate to the decision maker's purpose (selective combination), and thirdly, be able to relate this new information to previously known information to provide a new conclusion. Following any event, they suggest the decision maker should ask what they have learned about their strengths, weaknesses, values and ambitions, and how you would approach a similar situation in the future. Eraut (2000) has similar views and stresses the need to have the ability to consider the practicality and net benefit of proposed changes.

Scott (2010) carried out an experiment with students requiring one group to keep a detailed diary of their learning activities encouraging them to record their reflections. It was very clear that the students with well structured and analysed diaries achieved better grades. Similarly Peltier *et al.* (2005) developed a questionnaire to assess reflective action and concluded the important aspects involved personal reflection, peer reflection (discussions), and instructor or mentor discussions. The degree of each was shown to be correlated with success. They also found 'habitual learning' was negatively correlated with success. By 'habitual' they meant simple learning systems akin to rote approaches.

The concept of keeping a diary appears frequently in the literature. Another example is given by Sadler-Smith and Burke (2009) using Taggart (1997) who suggests an 'intuition diary' containing a write up of the experience, context, distractions, message, source, information and evaluation is valuable.

In reflection over experiences, Andresen *et al.* (2000) believe a decision maker will recall past experiences in conjunction with mentally analysing the current experience. They comment learning is holistic, socially and culturally influenced, and the emotional context in which it occurs influences the conclusion. Effectively, the reflection, which may be subconscious, involves 'the whole person – intellect, feelings and senses' (p. 225). In support of this idea Kolb (1984) quotes Dewey (1938, p. 35) 'the continuity of experience means that every experience both takes up something from those which have gone before and modifies in some way the quality of those that come after…..'. Hogarth (2010) comes to a similar conclusion.

Continuous learning undoubtedly occurs. Scott (2010) believes reflection is a critical part of the process which is characterised by habit at one end of the spectrum, and critical reflection at the other. Scott (ibid) records that Klimoski (2007, p. 495) noted reflection is 'organize or conceptualize what is going on, identify new insights, ...'. Scott (ibid), from her review of the literature, believes a reflective practitioner not only questions why things are done in a certain way, but also considers how their reasoning may at times become self-referential and self-confirming.

Maclellan (2004), as recorded by Peltier *et al.* (2005), believes a component of reflection is dealing with fuzzy ideas to reconcile ambiguity and inconsistency, and also involves recognising one's current knowledge set might be confused, incomplete or misconceived. Reflection provides a purposeful realignment, particularly to those with highly informed and successful intuition. A person might continuously reflect on the conundrums until a resolution emerges.

Other dimensions are listed by van Woerkom (2004) and include experimentation, learning from mistakes, career awareness, critical opinion sharing, asking for feedback, and challenging group think. However, career awareness is unlikely to be particularly relevant for farmers, or other small/medium family businesses.

To encourage learning through reflection, Sadler-Smith and Burke (2009) considered the use of cognitive mapping (making a structured diagram of thoughts surrounding the problem) to identify the causal patterns and accordingly allow reflection on the mental model and how it might be improved. Perhaps this approach has possibilities for farmers given its easily assessed visual properties.

Finally, to obtain maximum benefit from reflection, Cope (2003) quotes various authors to come to the conclusion that organised self-critiquing involving a strict goal is important in contrast to just 'letting it happen' through casual and subconscious reviews. A decision maker should set aside personal time for reflection using a structured decision–outcome review approach. What can also be important is the use of reflective questions being posed with a requirement to consider and conclude on each question.

While carrying out experiments will always be challenging given unobservable cognitive processes, a number of researchers have tried. For example, Matthew and Sternberg (2009) explored the impact of various reflection methods on tacit knowledge. They concluded 'the combined condition and reflection method was significantly different from the control condition' (p. 534). They also believe social factors may be important involving peers and experts. They conclude 'learning requires social interaction, including feedback and collaboration … ' (p. 531).

This review of reflection and self-critique covers many aspects. Overall, the variables that record reflection include hours spent on reflection, whether a structured review process is used, whether peers are involved, the quality of the review (the assessment on whether the decision made was correct; ability to relate past experiences to the current situation; were the critical factors isolated?; and determination of what went wrong), use of benchmarking information available, extent and appropriateness of records kept, use of diaries and written self-reviews of incidents, perseverance in trying to make sense of incidents, ability to assess strengths, weaknesses, opportunities and threats. Measuring many of these variables is difficult as it requires, for example, the subjects to accurately record the hours they spent on reflection, and the nature of the reflection.

Intelligence and education

A manager's inherent intelligence, and subsequent formal education, influences the extent and quality of her or his intuition. The form, type and extent of the educational experience, as well as how it relates to the manager's learning style (Koob and Funk, 2002), will influence the value of the education.

At the same time Wagner and Sternberg (1987) noted 'training … in business schools ... can be useful at times, but not a vital ingredient of managerial success … Ability to learn informally on the job is a critical determinant of managerial success.' (p. 302). But Hogarth (2010) has the view that 'intuition is shaped by learning' (p. 343) and that the learning process subconsciously influences intuition. However, where the skills, understanding and knowledge acquired is incorrect, a person's intuition will be biased. A decision maker, for example, in learning production economics might mistakenly believe equating marginal return with average cost maximises returns subsequently incorrectly informing their intuition. Sadler-Smith and Burke (2009), as a further example, talk about 'confirmation bias' in which a decision maker construes the evidence to confirm their previously held conclusion.

Similarly, as discussed by Hogarth (2010), the decision maker may 'lack the metacognitive ability to correct for sampling biases and/or missing feedback' (p. 343). Checking conclusions will always be important in developing an accurate intuition as well as adherence to the concepts espoused by the 'scientific method'. This requires a constant review of observed material to ensure a person is comfortable with currently held views.

Overall, the important variables are the type and extent of formal education and its suitability for assessing primary production situations. Furthermore, given the nature of primary production, a manager's 'practical intelligence' (ability to assess, and solve, practical issues and problems, both mental and physical (Sternberg *et al.* 2001)) will be important. Whether this can be accurately measured (Sternberg *et al.*, ibid; Wagner and Sternberg, 1987) is another matter. A reasonable level of Standard IQ is also likely to be important, though IQ as an independent variable, while correlated with managerial ability, has been shown to be much less important than experience in developing ability (Nuthall, 2009). However, this research did not isolate intuition as a component of overall managerial ability. Furthermore, Nuthall and Old (ibid), when comparing farmers with successful intuition relative to the remainder, found their level of education and grades were only marginally different.

Personality

Plessner *et al.* (2008) believe emotions can influence decisions, as does Hogarth (2010). For example, disgust decreases risk taking and anger increases it. Salas *et al.* (2010) also noted decision pressure forces some people to rely more on intuition. The feeling of pressure relates to a manager's personality. Furthermore, some managers have a natural curiosity to understand situations they encounter and this personality factor may well influence the development of intuition (known as 'openness' in the five factor model (Matthews and Deary, 1998). Most psychologists accept personality is made up of five factors: openness, conscientiousness, extraversion, agreeableness and neuroticism).

Salas *et al.* (2010) note some people are more disposed to formal deliberation than to using intuition (some people reach for their calculator, others not). They also believe the nature of the decision influences whether intuition is used in that complex situations might require intuition relative to simple decisions such as a decision on which fertiliser supplier to use. Here a simple logical analysis may well suffice. Overall, personality influences the choice of using logic relative to intuition with each decision maker being unique over the choice of decisions in which to use a formal analysis.

Densten and Gray (2001), as noted by Peltier *et al.* (2005), contend that learning is a function of the personality factors open mindedness, responsibility and willingness to make change. It is suggested those with a closed mind will most probably learn little from experience and reflection. No doubt there is a continuum between being completely objective and open minded through to a state of having a totally closed mind. Peltier *et al.* (ibid) believe

reflective critiquing is not an innate trait and must be learnt. A novice manager is probably a novice 'reflector'.

Leonard and Insch (2005) discovered 'cognitive self-organisational skills' were a factor in tacit knowledge. They also concluded 'social skills' were important for obtaining information. Both these factors are related to personality.

Finally, Fang and Zhang (2014) explored the five factor model of personality (Matthews and Deary, ibid) and how it related to tacit knowledge. Using a version of Wagner and Sternberg's (1991) test for tacit knowledge they discovered 'agreeableness' (trust, compliance, modesty, altruism) was significantly correlated with the level of tacit knowledge as was 'conscientiousness' and 'anxiety' (neuroticism). These results further suggest personality is a basic factor in the development of successful tacit knowledge.

Overall, the literature does point to personality being a factor in intuition. As the five factor personality model is considered (Matthews and Deary, ibid) the basis of many of the traits mentioned, it is important these component variables are included in any model of intuition.

Objectives and risk attitude

Salas *et al*. (2010) also note that strong 'goal setting' is important as it provides focus and a desire to achieve. They also comment that, as part of motivation, self-efficacy beliefs, goal orientations, and a drive for success in contrast to a fear of failure are all important in developing an informed intuition.

Leonard and Insch (2005), in experiments with MBA students, came up with a similar conclusion in finding 'cognitive self-motivation' was an important ingredient to tacit skills. As part of a manager's objectives, the attitude to risk must also be important if not only as an incentive to improve, but also as a factor in creating decision rules that reflect the decision maker's objectives.

Glockner and Witteman (2010) also relate objectives to the development of intuition. They discuss the formal classic expected utility model, 'utility' being an overarching measure of attaining a farmers' set of objectives (Anderson *et al*., 1977), but note few decision makers seem to follow this model in the development of their intuitive conclusions. Using expected utility requires a full search of alternatives, but Glockner and Witteman (ibid) point out few have the cognitive ability nor patience to follow the theory. In contrast the decision maker uses a simplified objective system that might, for example, seek a solution which 'satisfices'. Their intuition develops accordingly.

Glockner and Witteman (ibid) also referred to lexicographic objectives where the range of outcomes from a decision are given priorities. They stressed a decision maker that uses this system will similarly develop an intuition reflecting this objective structure.

If a farmer does not have clear and strong goals, there is no yard stick for assessing alternative decisions. Consequently the decision makers' intuition will be confused, inconsistent and confounded. To allow for all these issues, a model must include variables which measure the strength and type of objectives held as well as a farmer's risk attitude. A farmer's 'locus of control' (a measure of a farmer's belief in the control s/he has over outcomes (Nuthall, 2010).) might also be relevant.

Observation and anticipation skills

Any decision must relate to the current resource situation. In addition, to assess alternative decisions, managers must be able to successfully forecast, either intuitively, or consciously, outcomes for each alternative course of action. Taylor *et al*. (1998) believe mental simulation is important for success in these attributes. Overall, a manager must be an accurate and comprehensive observer as well as having an ability to anticipate prices, outcomes and conditions.

In this regard, Salas *et al*. (2010) note that successful CEO's are able to categorise complex situations more quickly than novices. It is suggested this is related to semantic networks in the brain in which pieces of knowledge are connected so that schemas represent patterns which have developed through experience. However, this process is totally dependent on observing the current situation accurately, as are all processes which rely on knowing the current state of the business and its environment.

Salas *et al*. (2010) review experiments where 'mental simulation' is associated with the successful use of intuition. Simulation must both recall the past allowing pattern matching, and anticipate likely future outcomes from intuitively proposed action. One study they quote covering these points is Klein and Crandall (1995). Klein (2003), and Gaglio (2004), also talk about mental simulation to facilitate the use of experience to relate to a decision.

Salas *et al*. (2010) review work on pattern matching and believe that if a decision maker does not find a match they seek more information to better understand the current situation. They also talk about 'sense making' which is invoked when the decision maker does not make immediate sense of an observation. The process involves problem detection, problem identification, anticipatory thinking, forming explanations, identifying explanations, discovering inadequacies in initial explanations, and projecting the future. Similarly, Dreyfus and Dreyfus (1986) talk about invoking 'implicit monitoring' when a situation is 'not feeling right'. Overall, both simple logic and the literature show the importance of both comprehensive and accurate observation, and an ability to anticipate likely outcomes from alternative decisions, in the development and use of informed intuition, or in decision making in general.

To include these aspects in a model, results from tests of observational skill are relevant provided they specifically relate to the manager's situation. Any test should include the variables important to the specific industry situation under consideration (prices and costs, regulations, markets, resource levels, condition of resources, and production relationships are likely to be the main examples). For simulation capabilities, both of past and future situations, specific tests would be necessary which provide scenarios and require the manager to choose from possible outcomes.

3. Discussion and Conclusions

For most farmers the efficacy of the components of his/her intuition change with time provided the lessons available from the concomitant experiences are observed and processed correctly. Indeed Dreyfus and Dreyfus (1986), as quoted by Eraut (2000), developed a model of

skill acquisition in which the following stages were defined - novice (rigid adherence to taught rules or plans), advanced beginner, competent, proficient and, finally, expert (no longer relies on rules, guidelines or maxims). Some managers do not progress through all stages. And some will believe they have progressed but in reality their internal models and assumptions will be biased and misleading. An important question here involves whether the biases can be identified and the managers assisted in overcoming them.

To ensure the improvement of intuition, it is worth noting Hogarth (2010) comments intuition is codified knowledge in a personalised form which includes procedural knowledge, process knowledge, experiential knowledge and impressions in episodic memory. When assessing decision situations a manager must learn to use each of these personal resources.

Similarly, Kayes (2002) believes people who clearly understand learning is a process of self-discovery, and who challenge their own personal assumptions and beliefs, who question the actions of others and have an understanding of managerial practices, will become effective leaders. In the farm management case, the decision maker is the leader of the farm, and the leader of her/his colleagues.

What Sadler-Smith and Burke (2009) propose may summarise the reality of the process used by a manager in developing his 'informed intuition'. They talk about a rational analysis/intuitive mixed model involving the steps: 1) intuitively sensing the problem, 2) logically considering the situation, 3) developing an intuitive, integrated, picture, 4) rationally articulating the situation and identifying alternatives, 5) sensing the value of the alternatives, 6) logically assessing the alternatives, 7) conducting a 'gut feel' check on the alternative selected and then, finally, carrying out the decision. In reality, however, the process may well have more steps which could be dynamic rather than linear.

The literature on intuition, and related issues, makes it clear intuition is a complex subject involving all aspects of human decision making.

When comparing farmers with successful intuitive skills with those somewhat less skilled Nuthall and Old (ibid) found their technical and decision method knowledge measures were over 200% different. They divided their sample of farmers into three groups based on their level of intuitive skills, and compared the top and bottom groups and came up with the percentage differences in each variable recorded. Other important significant differences included aspects of personality (e.g. 315% difference for conscientiousness), of farmer objectives (e.g. 437% difference for the 'community supporter'), feedback factors (e.g. 258% difference for the 'professional conferrer'), and similar. Surprisingly, there was little difference in the educational level and grades attained not that these variables can be changed as they are historic.

However, in assessing these quantitative results it must be remembered they relate to 'snapshot' data as they reflected the situation when the questionnaire was completed. If several snapshots had been collected at, say, yearly intervals some of the dynamic aspects may have modified the conclusions in that, for example, the changes may have led to emphasizing specific variables.

Further changes in Nuthall and Old's (ibid) quantitative results may occur if the additional variables isolated by this review were included. Given the limit of an eight page postal questionnaire choices had to be made, and some variables would have required a personal interview. A comparison of those used compared with the literature review lists shows the additional items which might have been included are farmer learning characteristics; types and frequency of experiences; further details of feedback (frequency, coverage, accuracy and timeliness); extent, form and content of training courses undertaken; ability of the mentors used and the form of mentoring; and critical skills of the manager (scientific method); details of reflection including time spent and form of reviewing, use of benchmarks, extent of records and diaries and their use; details of observation systems and methods (time spent on different variable observations), ability in mentally simulating likely outcomes; and the processes used in changing attitudes and skill levels and how successful they had been in the past.

As noted earlier, another factor not isolated from the literature review, nor the quantitative study, that could well impinge on intuition is a farmer's Locus of Control (Nuthall 2010) which reflects the farmer's belief in how much control over outcomes is possible. A further issue is the farmer's family background and early experiences which similarly does not feature. It has been shown, as would be expected, these experiences influence managerial ability quite markedly (Nuthall 2009).

Overall, it is clear where a farmer's efforts must go when working on improving their decision skills using a range of methods one of which might well be through advised farmer decision review groups (Nuthall, 2016) and related self-critique which was shown to be very important in the quantitative work. Perseverance in using diaries and mentors is likely to have value. Nuthall (1997) has shown three exposures to an idea is often required to comprehend an issue even when using the best learning approach for an individual which is likely to involve practical experience, mentors and peer groups. The review has also shown attention to detail related to each variable is important. For example, feedback must be accurate, diagnostic and timely as stressed by the reviewed articles.

The quoted quantitative study also made it clear the main variables isolated by this review do contribute to intuition even if at differing levels. It is similarly likely many of the additional variables listed would further help explain the development of expert and informed intuition. This would mean the contributions of the quantified variables in the Nuthall and Old (ibid) study would decline. The critical question is whether their relative importance would change.

Another area of potential importance not covered in the review is the relationship between intuition and entrepreneurship. An entrepreneurship reviewer (Baldacchino *et al*., 2015) believes much more work is required in assessing this factor. Another general review (Akinci and Sadler-Smith, 2012) lists out the areas in which they believe future research should proceed and should be consulted by prospective researchers.

Overall, this review has highlighted the additional variables that need to be included in future research in addition to providing much needed details of the important variables impacting on intuition. There is, however,

room for many more valuable studies on the development and use of farmer intuition particularly with an emphasis on further developing successful training and improvement methods.

About the author

Peter Nuthall is an Honorary Associate Professor in Agribusiness Management at Lincoln University.

Acknowledgement

Lincoln University for funding support, and the research journals of the world, and the authors of all the research articles reviewed.

REFERENCES

Akinci, C. and Sadler-Smith, E. (2012). Intuition in management research: a historical review. *International Journal of Management Reviews,* 14:104–122.

Anderson, J., Dillon, J. and Hardaker, J. 1977. Agricultural decision analysis. Ames, Iowa: Iowa State University Press.

Andresen, L., Boud, D. and Cohen, R. (2000). Experience based learning: contemporary issues. pp. 225–239 in Foley G., (Ed) Understanding Adult Education and Training. Allen and Unwin, Sydney.

Argyris, C. and Schon, D. (1974). Theory and practice: increasing professional effectiveness. Jossey-Bas, San Francisco.

Armstrong, S. and Mahud, A. (2008). Experiential learning and the acquisition of managerial tacit knowledge. *Academy of Learning and Education,* 7:189–208.

Baldacchino, L., Ucbasaran, D., Cabantous, L. and Lockett, A. (2015). Entrepreneurship research on intuition: a critical analysis and research agenda. *International Journal of Management Reviews,* 17:212–231.

Betsch, T. (2005). Preference theory – an affect based approach to recurrent decision making. pp. 39–65. In T. Betsch and S. Haberstroh (eds). *The routines of decision making*. Mahwah, NJ: Erlbaum.

Betsch, T. and Glockner, A. (2010). Intuition in judgement and decision making: extensive thinking without effort. Psychological Inquiry. *An international Journal for the Advancement of Psychological Theory,* 21: 279–294.

Casey, B., Tottenham, N., Liston, C. and Durston, S. (2005). Imaging the developing brain: what we have learned about cognitive development? *Trends in Cognitive Sciences,* 9: 104–110.

Cerasoli, P., Alliger, G., Donsbach, J., Mathieu, J., Tannenbaum, S. and Orvis, K. (2018). Antecedents and outcomes of informal learning behaviors: a meta-analysis. *Journal of Business Psychology,* 33:203–230.

Cope, J. (2003). Entrepreneurial learning and critical reflection. Discontinuous events triggers for higher level learning. *Management Learning,* 34:429–450.

Cox, E. (2005). Adult learners learning from experience: using a reflective practice model to support work based learning. Reflective Practice. *International and Multidisciplinary Perspectives,* 6:459–472.

Dane, E. and Pratt, M. (2007). Exploring intuition and its role in managerial decision making. *Academy of Management Review,* 32:35–54.

Dewey, J. (1938). Experience and education. Collier Books, New York.

Dijkstra, K., ven der Pligt, J. and van Kleef, G. (2013). Deliberation versus intuition: Decomposing the role of expertise in judgement and decision making. *Journal of Behavioral Decision Making,* 26:285–294.

Dreyfus, H. and Dreyfus, S. (1986). Mind over machine. The power of human intuition and expertise in the era of the computer. Basil Blackwell, Oxford.

Eraut, M. (2000). Non-formal learning and tacit knowledge in professional work. *British Journal of Educational Psychology,* 70:113–136.

Fang, H. and Zhang, S. (2014). A structural model of enterprise managers' tacit knowledge and personality traits. *Social Behavior and Personality,* 42:783–798.

Gaglio, C. (2004). The role of mental simulations and counterfactual thinking in opportunity identification process. *Entrepreneurship Theory and Practice,* 28:533–552.

Glockner, A. and Witteman, C. (2010). Beyond dual-process models: a categorisation of processes underlying intuitive judgement and decision making. *Thinking and Reasoning,* 16:1–25.

Goulet, F. (2013). Narratives of experience and production knowledge within farmers' groups. *Journal of Rural Studies,* 32:439–447.

Hogarth, R. (2010). Intuition: a challenge for psychological research on decision making. *Psychological Inquiry,:, An International Journal for the Advancement of Psychological Theory,* 21:338-353.

Kahneman, D., 2011. Thinking fast and slow. New York: Farrar, Straus, and Giroux.

Kayes, D. (2002). Experiential learning and its critics: preserving the role of experience in management learning and education. *Academy of Management Learning and Education,* 1:137–149.

Klein, G. and Crandall, B. (1995). The role of mental simulation in naturalistic decision making. In Hancock, P., Flach, J., Caird, J., Vincente, K., (Eds). Local Applications of the Ecological Approach to Human-Machine Systems. Mahwah: Lawrence Erlbaum Associates, 2:324-358.

Klein, G. (2003). The power of intuition. Doubleday, New York.

Klein, G. (2008). Naturalistic decision making. Human Factors. *The Journal of the Human Factors and Ergonomics Society,* 50:456–460.

Klimoski, R. (2007). Introduction: promoting the 'practice' of learning from practice. *Academy of Management Learning and Education,* 6:493–494.

Kolb, D. (1984). Experiential learning; experience as the source of learning and development. Englewood Cliffs, New Jersey.

Koob, J. and Funk, J. (2002). Kolb's learning style inventory: issues of reliability and validity. *Research on Social Work Practice,* 12:293–308.

Leonard, N. and Insch, G. (2005). Tacit knowledge in academia: a proposed model and measurement scale. *The Journal of Psychology,* 139:495–512.

Maclellan, E. (2004). How effective is the academic essay? *Studies in Higher Education,* 29:75–89.

Matthew, C. and Sternberg, R. (2009). Developing experience-based (tacit) knowledge through reflection. *Learning and Individual Differences,* 19:530–540.

Matthews, G. and Deary, I. (1998). Personality traits. Cambridge University Press, Cambridge UK.

McCown, R. (2012). A cognitive systems framework to inform delivery of analytic support for farmers' intuitive management under seasonal climatic variability. *Agricultural Systems,* 105:7–20.

McCown, R., Carberry, P., Dalgliesh, N. and Foale, M. (2012). Farmers use intuition to reinvent analytic decision support for managing seasonal climatic variability. *Agricultural Systems,* 106:33–45.

Nuthall, P. and Bishop-Hurley, G. (1996). Expert Systems for Animal Feeding Management, Part 2: Farmers Attitudes. *Computers and Electronics in Agriculture,* 14: 23–41.

Nuthall, G. (1997). Learning how to learn. The social construction of knowledge acquisition in the classroom. pp 77. In: Proceedings of the 7th Biennial Conference of the European Association for Research in Learning and Instruction. Athens, Greece.

Nuthall, P. (2006). Psychometric testing for assessing a farmer's managerial ability. Conference paper. *2006 NZ Agricultural and Resource Economics conference proceedings*. Nelson.

Nuthall, P. (2009). Modelling the origins of managerial ability in agricultural production. *Australian Journal of Agricultural and Resource Economics,* 53:413–436.

Nuthall, P. (2010). Should farmers' locus of control be used in extension? *The Journal of Agricultural Education and Extension,* 16:281–296.

Nuthall, P. (2012). The intuitive world of farmers – the case of grazing management systems and experts. *Agricultural Systems,* 107:65–73.

Nuthall, P. (2016) The intuitive farmer …. Inspiring management success. 5M publishing, Sheffield.

Nuthall, P. and Old, K. (2018). Intuition, the farmers' primary decision process. A review and analysis. *Journal of Rural Studies*, 58:28–38.

Ohlmer, B. (2001). Analytic and intuitive decision making – Swedish farmers' behaviour in strategic problem solving. Montepellier: Proceedings of the 3rd EFITA conference, pp. 609–614.

Peltier, J., Hay, A. and Drago, W. (2005). The reflective continuum: reflecting on reflection. *Journal of Marketing Education,* 27:250–263.

Plessner, H., Betsch, C. and Betsch, T. (2008). Intuition in judgement and decision making. Lawrence Erlbaum Associates, New York.

Polanyi, M. (1966). The tacit dimension. Routledge and Kegan Paul, London.

Sadler-Smith, E. and Burke, L. (2009). Fostering intuition in management education. *Journal of Management Education,* 33:239–262.

Salas, E., Rosen, M. and Diaz Granados, D. (2010). Expertise-based intuition and decision making in organisations. *Journal of Management,* 36:941–973.

Scott, S. (2010). Enhancing reflection skills through learning portfolios; an empirical test. *Journal of Management Education,* 34:430–457.

Shanteau, J. and Stewart, T. (1992). Why study decision making? Some historical perspectives and comments. *Organizational Behavior and Human Decision Processes,* 53:95–106.

Sinclair, M. (2010). Misconceptions about intuition. *Psychological Enquiry,* 21:378–386.

Sternberg, R., Forsythe, G., Hedlund, J., Horvath, J., Wagner, R., Williams, W., Snook, S. and Grigerenko, E. (2000). Practical intelligence in everyday life. Cambridge University Press, Cambridge.

Taggart, W. (1997). Discovering and understanding intuition. *Exceptional Human Experience: Studies of the Intuitive, Spontaneous, Imaginal*, 15:174-188.

Taylor, S., Pham, L., Rivkin, I. and Amor, D. (1998). Harnessing the imagination: mental simulation, self-regulation, and coping. *American Psychologist,* 53:429–439.

van Woerkom, M. (2004). The concept of critical reflection and its implications for human resource development. *Advances in Developing Human Resources,* 6: 178–192.

Wagner, R. and Sternberg, R. (1987). Practical intelligence in real world pursuits. The role of tacit knowledge *Journal of Personality and Social Psychology,* 49: 436–458.

Wagner, R. and Sternberg, R. (1991). Tacit knowledge inventory for managers. Psychological Corporation, San Antonio.

Wolfswinkel, J., Furtmueller, E. and Wilderom, C. (2013). Using grounded theory as a method for rigorously reviewing literature. *European Journal of Information Systems,* 22: 45–55.

Xayavong, V., Kingwell, R. and Islam, N. (2015). How training and innovation link to farm performance: a structural equation analysis. *Australian Journal of Agricultural and Resource Economics,* 59:1–16.

Appendix

A summary of the important intuition related variables is provided in the Table below. It contains the general information and skill categories likely to be relevant, and a list of variables likely to be important in explaining intuition. Each skill area has the important literature associated with the area listed.

Appendix Table: Factors important in determining a farmer's intuition (the table references have been numbered and alphabetised. Where a reference appears in subsequent areas only its number is included).

General area	Specific variables	References
Experience, feedback & repetition	Willingness to learn	1 Armstrong & Mahud (2008)
	Learning style	2 Betsch (2005); 3 Betsch & Glockner (2010); 4 Eraut (2000)
	Repetition of experiences	
	Degrees of experimentation	5 Klein (2008); 6 Kolb (1984)
	Feedback (frequency, coverage extent, accuracy, timeliness)	7 Hogarth (2010); 8 Nuthall (1997); 9 Plessner (2008); 10 Salas *et al*. (2010); 11 Shanteau & Stewart (1992); 15 Dijkstra *et al*. (2013).
Training & mentoring quality	Extent, form & content of training	4,6,7,8, 12 Ambrosini & Bowman (2001)
	Finding and using 'masters'	13 Andresen *et al*. (2000)
	Extent of mentoring and its form	14 Dempsey *et al*. (2001); 15 Goulet (2013); 16 Koob & Funck (2002)
	Skill at using 'scientific method'	17 Peltier *et al*. (2005); 18 Sadler-Smith & Burke (2009); 19 Wagner & Sternberg (1987); 20 Xayavong *et al*. (2015)
Reflection & self critique	Hours spent on reflection	4,6,7,10,13, 17, 18, 19
	Structured reviews	21 Argyris & Schon (1974)
	Quality of reviews	22 Cope (2003); 23 Cox (2005)
	Use of benchmarking	24 Dewey (1938); 25 Klimoski (2007)
	Extent and type of records	26 Maclellan (2004)
	Use of diaries and reviews thereof	27 Matthew & Sternberg (2009)
	Making sense of incidents	28 Nuthall (2012); 29 Pee *et al*. (2000)
	Assessment of strengths, weaknesses, opportunities & threats	30 Scott (2010); 31 Taggart (1997); 32 Van Woerkom (2004)
Intelligence & education	Practical intelligence	7,18,19, 33 Koob & Funck (2002)
	Type and extent of education	34 Nuthall (2009); 35 Sternberg *et al.* (2000)
Personality	Components of the five factor personality model	7,9,10,17, 35 Densten & Gray (2001); 36 Fang & Zhang (2014); 37 Leonard & Insch (2005); 38 Matthews & Deary (1998); 39 Wagner & Sternberg (1991)
Objectives & risk attitude	Strength & type of objectives	10,37, 40 Glockner & Witteman (2010)
	Risk aversion/preference	41 Nuthall (2010)
Observation & anticipation skills	Observation skill level in each area of relevance	10, 42 Dreyfus & Dreyfus (1986); 43 Klein & Crandall (1995)
	Mental simulation skills in each area	44 Klein (2003), Gaglio (2004)
General	Ability to change attitudes and systems	7,18,42, 45 Kayes (2002)
	Leadership skills	
	Improvement process	

VIEWPOINT

DOI: 10.5836/ijam/2019-08-41

Making an impact on Parliament: advice for the agricultural community

DAVID ROSE[1]

ABSTRACT

The UK Parliament performs an important role in shaping policies and legislation, including those related to agriculture. Parliamentarians (MPs and Peers) and the staff supporting them often want to use evidence to inform the passage of legislation and the scrutiny of government policy since it decreases the chances of making a bad decision. This viewpoint explores how communities of science and practice working in the agricultural sphere can engage with Parliament to ensure that evidence informs decision-making. It makes five recommendations: (1) know how to **engage** with parliamentary processes, (2) **communicate** relevant evidence in a clear and concise fashion, (3) ensure that evidence is **credible**, (4) work with trusted **knowledge brokers**, and (5) **persevere** over a long timescale.

KEYWORDS: Agriculture Bill; Evidence-based policy; Evidence-informed policy; Parliament; Science communication; Science-policy

Introduction

The UK Parliament performs an important role in shaping policies and legislation, including those related to agriculture. However, based on the implicit assumption that policy is mainly shaped by the Executive (government), rather than the Legislature (parliament), science-policy scholars have tended to focus on the former rather than on how evidence is sourced and used in parliaments (Kenny *et al.*, 2017a). This is a significant gap in the existing literature because legislatures can play a key policy role (Goodwin and Bates, 2015), as evidenced by the influence exerted by the UK Parliament in the Brexit debate. There is now an extensive literature providing advice to communities of science, policy, and practice on how to improve the use of evidence in policy-making (see Cairney; 2016; Parkhurst, 2017; Oliver and Cairney, 2019). Such advice, however, has rarely been based on empirical studies of evidence use in legislatures where different processes operate as compared to government.

The utility of understanding how and why evidence is used in legislatures is clear; ultimately it will improve the chances that evidence submitted by scientists and practitioners will be used in policy-making. In the agricultural sphere, the UK Parliament plays a key role in shaping related policy and legislation. At the time of writing, it is considering the suitability of the Agriculture Bill, which is planned to pass through Parliament in the coming months. Many other Bills that come before Parliament also relate to aspects of food and farming, which allows MPs and Peers to debate and amend content. Select Committees regularly scrutinise the policies of the Department for Environment, Food and Rural Affairs (Defra) and conduct inquiries into issues related to food, farming, and the environment.

A report led by University College London (UCL) and the Parliamentary Office of Science and Technology (POST) (Kenny *et al.*, 2017b) investigated how the UK Parliament sourced and used evidence. It found that evidence was deemed useful by people in Parliament, but various factors determined whether a piece of information was likely to be used or not. The most important factors related to the credibility of evidence, whether it had been received in a timely manner, and also to how clearly it was presented to a mainly non-expert audience. Observation of committee processes also found that evidence could feed into Parliament through key individuals, including specialist advisers to Select Committees, through House Library staff, or via MPs and Peers themselves (see Kenny *et al.*, 2017b for more detail).

In light of this report, this viewpoint makes five recommendations for how agricultural communities of science (e.g. researchers) and practice (e.g. land managers, advisers) can better engage with Parliament to improve uptake of evidence. It makes five recommendations: (1) know how to **engage** with parliamentary processes, (2) **communicate** relevant evidence in a clear and concise fashion, (3) ensure that evidence is **credible**, (4) work with trusted **knowledge brokers**, and (5) **persevere** over a long timescale (see Figure 1). Ultimately, this will improve

Original submitted April 2019; accepted May 2019.

[1] Corresponding author: School of Environmental Sciences, University of East Anglia, Norwich Research Park, Norwich, NR4 7TJ. Email: david.rose@uea.ac.uk

Figure 1: Five key components of effective parliamentary engagement (based on Kenny *et al.*, 2017b)

the chances that policies and legislation related to food, farming, and the environment are evidence-informed and hence more likely to work in practice.

In making the distinction between science and practice, this viewpoint makes no judgement on which type of evidence is most important for policy-making. In other words, in accepting that Parliament is meant to represent the views of all citizens, it provides advice about how evidence of all types (e.g. 'scientific', experiential etc.) can be best communicated to parliamentarians and their staff. This follows one of the main findings of the UCL/POST report, which discovered that people in Parliament interpreted evidence broadly and welcomed different kinds of information from a variety of sources (Kenny *et al.*, 2017b).

1. **Engage with parliament – know who and when to contact**

   A key message from the UCL/POST report was the need to know how Parliament works, which enables more effective engagement (Kenny *et al.*, 2017b). There are a variety of ways in which evidence about food, farming, and the environment could feed into Parliament. Select Committees, for example, scrutinise government policy and legislation. The Environment, Food and Rural Affairs Committee will generally be the most relevant group for agriculture and they regularly conduct inquiries which make a real difference[2]. A formal call will be made for written evidence with a terms of reference, which can be responded to by individuals or groups with an interest in the specific inquiry. When scrutinising the Agriculture Bill, written evidence was submitted by academics, trade union bodies, industry groups, charities and not-for-profit organisations, farming groups, and other individuals[3]. Subsequent oral evidence may be called for from the pool of written correspondents and the committee will rarely use any other information as part of their formal inquiry. Being aware of calls for evidence, including timelines, is thus vital – policy windows regularly open where evidence about issues related to food and farming will be needed, and thus relevant parties must be ready to seize upon them (see Kingdon, 2003; Rose *et al.*, 2017). It is usually best to submit evidence using the online form, although committee staff can be contacted if different formats are preferable, and individuals not wishing to respond themselves can work with organisations to influence joint responses. In the UCL/POST study, Select Committee staff reported that evidence received early in an inquiry has the most potential to influence its scope (Kenny *et al.*, 2017b).

[2] See https://www.parliament.uk/business/committees/committees-a-z/commons-select/environment-food-and-rural-affairs-committee/inquiries/ for ongoing and past inquiries by the Environment, Food and Rural Affairs Committee.

[3] Sources of evidence submitted to the Agriculture Bill https://www.parliament.uk/business/committees/committees-a-z/commons-select/environment-food-and-rural-affairs-committee/inquiries/parliament-2017/agriculture-bill-17-19/publications/

Evidence can also feed into Parliament through All-Party Parliamentary Groups (APPGs), which are more informal cross-party gatherings of parliamentarians interested in specific issues (Kenny *et al.*, 2017b). There are many such APPGs related to farming and organisers of these groups can be contacted via details listed on the formal register[4]. They regularly invite individuals with expertise on particular issues to speak to them, but cannot do so unless they are aware of your knowledge and interest in engaging with them. These parliamentarians might then feed what they learn into Chamber debates and committees on which they sit. This means that taking a proactive approach by writing to individuals and groups, such as your constituency MP, interested Peer or APPG, can be a good way of getting your evidence into Parliament.

2. **Communicate clearly and openly**
People in Parliament have limited time and are generally not experts on agriculture. Hence, evidence submitted to Parliament must be communicated in a concise and relevant style without assuming a high level of understanding or including unnecessary jargon (Geddes *et al.*, 2018; Kenny *et al.*, 2017b). This advice is relevant for all types of person seeking to engage with Parliament on agriculture issues. For an agricultural scientist, it may be better to provide a concise overview of what the body of evidence says, rather than providing long-winded results of individual papers. If links to studies are provided, then these should be open access, and preferably prefixed with a short abstract covering its key conclusions and recommendations.

3. **Be credible**
Credibility has been ranked as a key component of evidence use in the UK Parliament (Geddes *et al.*, 2018; Kenny *et al.*, 2017b). This is interpreted broadly in Parliament, with particular types of evidence being considered credible (e.g. statistics), and suspicion being cast towards sources that are known to have 'an axe to grind'. When presenting evidence to Parliament, it is important to provide credible evidence which supports your view. This could be peer-reviewed evidence or experiential knowledge as long as information is provided to justify a particular interpretation. Evidence submitted to committees is usually made publicly available online and thus care should be taken with regard to content and tone. Caution may be applied to working with particular organisations who may be treated with some caution due to their political stance (see next point).

4. **Work with trusted third parties**
Many individuals, including academics, advisers, and land managers will lack the time or specialist skills needed to engage with Parliament effectively. Whilst communication skills can be enhanced, working with trusted 'knowledge brokers' (see Bednarek *et al.*, 2018) can be a useful way of feeding information into parliamentary decision-making. These groups have a track record of communicating science clearly to policy-makers, and can thus bridge the gap between scientists, practitioners, and parliamentarians. Various agricultural groups regularly engage in formal parliamentary processes, including trade unions (e.g. NFU, Farmers' Union of Wales), other agricultural groups (e.g. Countryside Land and Business Association, Soil Association), industry (e.g. Arla Foods), environmental groups (e.g. RSPB, National Parks authorities), and learned societies [see footnote 2]. Developing relationships with these organisations, and sending relevant information to them, can be a good way of engaging with Parliament. The Knowledge Exchange Unit at POST is another good organisation to work with.

5. **Persevere**
Policy change can be slow and incremental, or sudden and unexpected (see Owens, 2015). However, 'direct hits' between evidence and policy, in other words quick policy change after receipt of evidence, is much rarer than incremental change (Owens, 2015). Relationships with individual parliamentarians, for example through local constituency MPs or links with APPGs, can be slow and challenging to build. Trusting relationships with third party organisations who may communicate on your behalf can be equally challenging to establish. All of this is made more difficult if key points of contact keep changing, which is symptomatic of larger organisations including in policy (Sasse and Haddon, 2019). Above all, however, we should not expect immediate impact from the evidence that we submit to Parliament, but regular and sustained engagement, including the maintenance of personal relationships, should improve the ability of our evidence to cut through (Owens, 2015).

Concluding remarks

Effective engagement with the UK Parliament (and devolved parliaments), and legislatures across the world, is important if communities of science and practice in agriculture are to ensure that policies and legislation related to food, farming, and the environment are evidence-informed. Whilst the democratic nature of decision-making means that we can never guarantee that our evidence will be used to shape policy, we can take steps to improve the likelihood that our evidence is influential. This initially requires a clear understanding of how Parliament works and how evidence might be fed into formal and informal parliamentary processes. Once routes into Parliament are understood, and trusted third party organisations are identified to help with engagement, communication should be clear, evidence-based, and simple, and preferably sustained over long timescales. I invite readers to put these recommendations into practice and to play their part in improving the use of evidence related to agriculture in Parliament.

About the Author

David Rose is a Lecturer in Geography at the University of East Anglia. He uses social science approaches to investigate the social and ethical implications of agriculture 4.0 and uses participatory methodologies to support user-centred design of agri-tech.

[4] https://publications.parliament.uk/pa/cm/cmallparty/190327/contents.htm (register as of March 2019).

Acknowledgement

This viewpoint is based on work led by the Department of Science, Technology, Engineering and Public Policy at UCL and the Parliamentary Office of Science and Technology. Thank you to Drs Chris Tyler, Caroline Kenny, and Abii Hobbs for leading this work, and to the Houses of Parliament and ESRC for supporting it. The School of Environmental Sciences at the University of East Anglia also supported travel to seminars which underpinned this viewpoint.

REFERENCES

Bednarek, A.T., Wyborn, C., Cvitanovic, C., Meyer, R. and Colvin, R.M. *et al.* (2018). Boundary spanning at the science-policy interface: the practitioners' perspectives. *Sustainability Science*, https://doi.org/10.1007/s11625-018-0550-9.

Cairney, P. (2016). The politics of evidence-based policymaking. Palgrave Pivot, London, UK.

Cairney, P. and Oliver, K. (2018). How Should Academics Engage in Policymaking to Achieve Impact? *Political Studies Review*, https://doi.org/10.1177/1478929918807714.

Geddes, M., Dommett, K. and Prosser, B. (2017). A recipe for impact? Exploring knowledge requirements in the UK Parliament and beyond. *Evidence & Policy*, https://doi.org/10.1332/174426417X14945838375115.

Goodwin, M. and Bates, S. (2015). The 'powerless parliament'? Agenda-setting and the role of the UK parliament in the Human Fertilisation and Embryology Act 2008. *British Politics,* 11 (2), 232-255.

Kenny, C., Washbourne, C-L., Tyler, C. and Blackstock, J.J. (2017a). Legislative science advice in Europe: the case for international comparative research. *Palgrave Communications,* 3, Article number: 17030.

Kenny, C., Rose, D.C., Hobbs, A., Tyler, C. and Blackstock, J. (2017b). The Role of Research in the UK Parliament. Volume One and Volume Two. London, UK, House of Commons.

Kingdon, J. (2003). *Agendas, Alternatives, and Public Policies*. 2nd ed., Longman, New York, USA.

Owens, S. (2015). *Knowledge, Policy, and Expertise*. Oxford University Press, Oxford, UK.

Parkhurst, J. (2017). *The politics of evidence: from evidence-based policy to the good governance of evidence*. Routledge Studies in Governance and Public Policy. Abingdon, Oxon, Routledge.

Rose, D.C., Mukherjee, N., Simmons, B.I., Tew, E.R., Robertson, R.J., Vadrot, A.B.M., Doubleday, R. and Sutherland, W.J. (2017). Policy windows for the environment: Tips for improving the uptake of scientific knowledge. *Environmental Science and Policy*, http://dx.doi.org/10.1016/j.envsci.2017.07.013.

Sasse, T. and Haddon, C. (2019). Moving On: The cost of high staff turnover in the civil service. London: Institute for Government.

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-45

Using high tunnels to extend the growing season and improve crop quality and yield: assessing outcomes for organic and conventional growers in the U.S. Midwest

ANALENA B. BRUCE[1], JAMES R. FARMER[2], ELIZABETH T. MAYNARD[3] and JULIA C.D. VALLIANT[4]

ABSTRACT

High tunnels are a low-cost technology that can strengthen local and regional food systems by facilitating the production of high-quality fruits and vegetables during and beyond the frost-free growing season. The potential for high tunnels to improve crop quality and yield has been established with research trials, but there is a lack of research on the farm-level impacts of high tunnels, or comparisons between organic and conventional farming systems. This survey of high tunnel users in the U.S. Midwest state of Indiana finds that farmers have been successful with extending the growing season, as nearly half of the respondents are now harvesting in the cooler months and planting earlier in the spring. Farmers also reported significant increases in the productivity and quality of their crops year-round, and improvement in their farm's economic stability. Farm-level impacts were similar for farmers using organic and conventional farming practices, although farmers using organic practices were more likely to increase their off-season production than their conventional counterparts. Overall, high tunnels hold potential as a tool for increasing the availability of fresh vegetables and fruits for local food systems, thus increasing the viability of Midwest farms.

KEYWORDS: agricultural technology; high tunnels; hoophouses; organic farming; local food systems

Introduction

The use of high tunnels has increased immensely in the past decade, particularly among small-scale growers selling directly to consumers. High tunnels, also known as hoophouses, are plastic-covered structures used for growing plants that are constructed directly over the soil and heated by passive solar energy. The infrastructure protects plants from adverse weather conditions, such as heavy rains, winds, frosts, and sudden temperature fluctuations, as well as safeguarding crops for early planting and later harvesting (Carey *et al*., 2009; Knewtson *et al*., 2010). Research trials have shown great potential for high tunnels to increase the yield, quality, and shelf life of fresh fruits, vegetables, and flowers, in both organic and conventional systems (Carey *et al*., 2009; O'Connell *et al*., 2012). Growing under cover gives farmers greater control over growing conditions and crop nutrition, and a layer of protection from insects and diseases (Waldman *et al.,* 2012). High tunnels show potential to be an important technology as society works to create agricultural systems capable of meeting increased demand for healthy, sustainable crops.

While high tunnels have only received attention relatively recently in the U.S., they have been popular in parts of Asia and Europe since the 1970s (Enoch and Enoch, 1999; Lamont, 2009; Orzolek, 2011) and seem increasingly important to U.S operations.

High tunnel infrastructure is of interest to a wide international audience because it requires relatively little

Original submitted August 2017; revision received February 2019; accepted February 2019.

[1] Corresponding author: Assistant Professor, Dept. of Agriculture, Nutrition, and Food Systems, University of New Hampshire, Kendall Hall, 129 Main Street, Durham, NH 03824, USA. Email: anabruce@indiana.edu

[2] Associate Professor, O'Neill School of Public and Environmental Affairs, Indiana University, 1315 E. 10th St., Bloomington, IN 47405, USA. Email: jafarmer@indiana.edu

[3] Extension Specialist and Clinical Engagement Assistant Professor, Dept. of Horticulture and Landscape Architecture, Purdue University, 625 Agriculture Mall Dr., West Lafayette, IN 47907, USA. Email: emaynard@purdue.edu

[4] Postdoctoral Research Fellow, The Ostrom Workshop in Political Theory and Policy Analysis, Indiana University Bloomington, 521 N. Park Avenue, Bloomington, IN 47405, USA. Email: jdv@indiana.edu

capital for construction and operation, even for small family farms with limited financial and human resources (U.S. Agency for International Development [USAID], 2008). They are also particularly well suited to maximizing income on small and marginal pieces of land (Huff, 2015; International Center for Agricultural Research in the Dry Areas [ICARDA], 2015). In the global south, high tunnels have been utilized to increase food security, and provide viable livelihood opportunities in rural communities as a low-cost alternative to greenhouses for smallholders to improve the quality and consistency of export crops (USAID, 2008; ICARDA, 2015). Growing crops in high tunnels also offers a strategy for dealing with adverse weather conditions posed by climate change, as they protect plants from excess moisture and damaging rains but maintain soil moisture and require less irrigation in drought conditions (Beckford and Norman 2016; Lawrence, Simpson, and Piggott, 2017).

High tunnel production allows farmers to even out the seasonality of production, balancing the highs and lows of the production year, to tackle the labor puzzle that poses a challenge for farmers (Waldman *et al*., 2012). Farmers are able to capture a premium for locally grown specialty crops, and in particular for produce grown late and early in the year (Conner *et al*., 2010; Orzolek, 2013; Waldman *et al*., 2012). The infrastructure addresses seasonal constraints, allowing for extended fruit and vegetable production in climates with a limited growing season, thus, presenting an opportunity to increase the availability of fresh produce for local markets. In addition, the capacity to offer fresh produce more consistently throughout the year supports farmers who use direct marketing to develop their customer base, thereby increasing the viability of farms that produce specialty crops for local food systems (Arnold and Arnold, 2003; Conner *et al*., 2009). The infrastructure also presents an opportunity to increase the availability of fresh produce for off season farmers' markets, restaurants, grocery stores, and food hubs, potentially expanding local and regional food systems in regions with a limited growing season, such as the U.S. Midwest.

The High Tunnel Initiative is a governmental program that has promoted and increased the adoption of high tunnels in the U.S. The High Tunnel Initiative (HTI) was established as a pilot program in 2009 by the U.S. Department of Agriculture (USDA) to assess the potential environmental benefits of high tunnels (NRCS 2016). After strong participation in the first three years, the initiative became a conservation practice standard in 2014 that made it available in all states. The HTI program is offered through the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) (NRCS, 2014). The program provides a cost-share incentive of up to 90% or up to a dollar amount set by each state, whichever is less, that is paid out as a reimbursement to farmers who construct a new high tunnel. The goals of the EQIP HTI program are to reduce nutrient and pesticide runoff, improve plant and soil quality, reduce energy use through reduced transportation from farm to market, and increase the availability of fresh food for local food markets. Since 2016, NRCS allowed states to decide whether to offer high tunnels as a state initiative or a conservation practice that's available as part of the general EQIP program, giving states the option of keeping the initiative as a separate program to promote the practice and increase high tunnel use in their state (NSAC 2016).

The HTI was first piloted in 2009 as part of the Know Your Farmer, Know Your Food initiative of the USDA. The Know Your Farmer, Know Your Food initiative brought together staff from across the USDA to coordinate, share resources, and publicize USDA efforts related to local and regional food systems (Farm News, 2009; KYF, n.d.; NRCS, 2011). The initiative was designed to support diversified farms, ranches, and businesses in regional food networks, with the goal of strengthening the connection between farmers and consumers, reinvigorating rural economies, promoting job growth, and increasing healthy food access in America (KYF, n.d.). Thus, from its inception the high tunnel program was oriented towards small-scale and diversified farms that sell directly to consumers through local food systems. Exploratory research also indicates that high tunnels have been strongly utilized by small-scale, diverse farms that do direct marketing (Carey *et al.* 2009; Low *et al.* 2015). There is also an overlap between farms that sell into local food markets and small-scale, diversified farms that use organic or ecological practices (Ahearn and Newton 2009).

Between 2010 and 2015, the high tunnel initiative has supported farmers in constructing over 14,000 high tunnels on farms in all 50 of the U.S. states (NRCS, 2016). The program has so far committed over $93 million in cost shares to support farmers in obtaining high tunnels. Between 2010 and 2013 the number of high tunnel contracts increased, with the most significant jump between 2011 and 2012, increasing by more than 70% (National Sustainable Agriculture Coalition [NSAC], 2014). In FY 2015 NRCS supported 1,830 high tunnel contracts, which is relatively consistent with the number of contracts in 2014, but a decline from 2012 and 2013 (NSAC 2016). This is likely due to the removal of a cap on the maximum high tunnel size in FY 2014 that likely contributed to larger contracts and a subsequent decline in the total number of contracts NRCS was able to fund (NSAC 2016).

In 2012, the Indiana division of the USDA NRCS implemented the cost-share program for high tunnels through EQIP that other states had been offering since 2009. Demand from specialty crop farmers in Indiana for this program has been overwhelming, according to the NRCS, with 169 tunnels constructed on farms in Indiana between 2012-2014. In this paper we present findings from a survey of 104 Indiana farmers who have used high tunnels on their farms, to understand farmers' success in using high tunnels to extend the growing season, increase produce quality and yield, and improve farm viability.

Broader significance

So far, most research on the potential of high tunnels to enhance specialty crop production comes from research trials and small case studies (Biernbaum, 2013; Carey *et al*., 2009; O'Connell *et al*., 2012; Waldman *et al*., 2012). To date, we found just one study that has assessed the benefits of high tunnels for local food systems, through GIS mapping of high tunnels obtained through the EQIP program, and a survey of 30 Virginia farms with high tunnels (Foust-Meyer and O'Rourke, 2015). There are no studies that we could identify that evaluate

the extent to which high tunnels are meeting the potential identified in research trials when they are integrated into existing farms. Given the federal funding dedicated to the high tunnel cost-share program as a conservation practice, policymakers will need to decide how much to continue to invest in high tunnels (NSAC, 2014). Thus our goal was to learn directly from farmers who have been using high tunnels to understand how well the technology is meeting its potential in the real world. Our findings will allow researchers, extension educators, policy makers, and farmers to better understand the potential impacts and benefits of high tunnels where research on the farm-level impacts of high tunnel use is limited (Conner *et al*., 2010).

High tunnels and organic growing

Because high tunnels have been popularized by influential organic farmers as a boon for organic and diversified farms (Coleman, 2009), we also compare farmers who use organic practices to those who do not, to understand if there are any differences in their experiences with using high tunnels. To date, there is a lack of research assessing how outcomes of high tunnel production are parallel or divergent between high tunnel users growing organically versus conventionally. This is important because organic practices contribute to preserving genetic diversity, building organic matter in the soil, reducing pesticide and nutrient runoff, and using less energy (Bengtsson, Ahnström, and Weibull, 2005; Gomiero, Pimentel, and Paoletti, 2011). Therefore it's possible that use of organic practices in high tunnels could support the environmental goals of the EQIP program. There is some evidence that high tunnels can support low input and organic production practices by limiting pest and weed pressures (Blomgren and Frisch, 2007; Carey *et al*., 2009; O'Connell *et al*., 2012). On the other hand, while high tunnels can enhance growing conditions, they can also create ideal conditions for diseases such as fluvia leaf mold of tomatoes if proper management is not implemented and may also increase certain pest pressures (Ingwell *et al*., 2017; Johnson, Grabowski, and Orshinsky, 2015; O'Connell *et al*., 2012). However, existing research on the benefits of high tunnels for organic production is mostly limited to field trials of specific crops.

Methods

Given that a composite listing of high tunnel growers does not exist, the project team developed a list of high tunnel users in Indiana for this exploratory study. We sought contact details through the Indiana NRCS office, garnering a list of 143 names (with city and county of residence). We then used online databases (whitepages.com and county GIS platforms) to garner mailing addresses. We also solicited mailing addresses for high tunnel users from Purdue University Extension and added names of our personal/professional contacts who have a high tunnel. This convenience sampling approach limits the generalizability of the study's results.

In total, the project team composed and administered a questionnaire to 178 farms with high tunnels, offering both paper and electronic options for responding. Every survey included a $5 incentive to support participation (Singer, 2002). Following a modified Dillman tailored-design survey method, the survey was mailed to 164 of the contacts using a four-phase contact approach (see Dillman, Smyth, and Christian, 2014).

The survey consisted of 6 sections. Section 1 (Introduction) included questions about farm location, number of high tunnels, EQIP funded high tunnels, and descriptive details on use of high tunnel. Section 2 (Value of high tunnel for your farm) included questions about the utility and impact of the high tunnel. Section 3 (Sales from the high tunnel) queried farmers about distribution mechanisms. Section 4 (High tunnel production) asked farmers the crops they produce in the high tunnels, production issues, research needs, and common practices. Section 5 (Your entire farm operation) asked about farm characteristics and economics. Finally, section 6 (Demographics and conclusion) asked about personal demographic characteristics and opportunities or challenges with the high tunnel (Bruce *et al.*, 2017).

Data were analyzed using SPSS 23.0. We used descriptive statistics to calculate general results for demographic variables, farm characteristics, and distribution type. Based on farmer response, we created a dichotomous variable for comparing farmers that (1) grow organically or are certified organic (n=65) vs. (2) farmers that use conventional methods for production (n=38). Chi-square analysis was used to explore the differences in categorical variables such as distribution method, gender, and education. Analysis of Variance (ANOVA) was used to compare results from the continuous variables and Likert-scales for high tunnel management practices and experience with high tunnels between those farming organically and conventionally.

Results

We distributed 178 surveys to Indiana high tunnel growers. A total of 118 were returned (6 were electronic), 9 with insufficient addresses, 4 noting their high tunnel was not yet erected, 1 person did not actually have a high tunnel, and 1 person reported the survey was too personal to complete. Thus, 103 were deemed usable from an adjusted sample of 164 (62.8% response rate).

First, we present general characteristics of the farmers that responded to our survey (see Table 1). The average respondents' age was 36.9, with the vast majority being the farm owner (92.2%), and male (72.8%). Nearly half of respondents had earned a bachelor's degree or higher (48.5%). The average respondent had been growing in a high tunnel for 5.3 years, with the median at 4 years. Generally speaking, respondents had been farming for nearly two decades in total (median 18.5), with 21.9% farming for 5 years or less. Most respondents had a gross farm income of less than $49,999 per year, with nearly 20% making less than $5,000 yearly from their farms. We also compared organic growers to conventional growers, finding that organic growers farmed significantly less acres (median 6) compared to their conventional counterparts (median 40) (see Table 1).

Farm characteristics

Over 81% of respondents are using their high tunnel in USDA Plant Hardiness zone 5, with 17.5% in Plant Hardiness Zone 6. The average proportion of specialty crop revenue to total farm revenue was 40.8% (26.25% median). The mean relative rurality score, which quantifies on a continuous scale how urban vs. rural a county

Table 1: Descriptive, ANOVA, and Chi-Square comparison results of demographic and farm characteristic data overall and between organic and conventional farmers

	All respondents	Organic Farmers	Conventional Farmers	
Group size (n)	103	65	38	
Mean age	36.9	36.5	37.7	
Gender (% male)	73.8	69.2	81.6	
Median Household income from farm (%)	25.0	20.0	35.0	
**Educational Attainment (%)*				*
Some high school	11.7	7.7	18.4	
High school/GED	15.5	13.9	18.4	
Some college	16.5	16.9	15.8	
Associates/Tech	7.8	7.7	7.9	
Bachelor's	33.0	35.4	28.9	
Grad	15.5	18.5	10.5	
Total	100.0	100.0	100.0	
***Farm*'s Gross Income (%)				**
Less than $5,000	20.0	23.8	13.5	
$5,000-$9,999	13.0	15.9	8.1	
$10,000-$49,999	32.0	34.9	27.0	
$50,000-$149,999	23.0	19.0	29.7	
$150,000-$349,999	2.0	1.6	2.7	
$350,000-$499,999	5.0	1.6	10.8	
$500,000-$999,999	4.0	3.2	5.4	
$1,000,000+	1.0	0.0	2.7	
Total	100.0	100.0	100.0	
****Acres farmed (%)*				***
Mean	62.8	32.0	115.6	
Median	17.00	6.00	40.00	

$P < .05$*; $p < .010$**; $p < .001$***.

is, was 0.35450 (<.1=most urban to >.9 = most rural) (Waldorf, 2007). Most farms were smaller than 30 acres (20.4%), with 41.7% being .5 to 10 acres in size. 18.4% of the farms were larger than 100 acres. The mean farm size was 62.8 acres (17 median acres). Respondents noted that on average they raise 9.7 acres in specialty crops (3 median acres). To put this in context, the average Indiana specialty crop farm had 21.5 acres in specialty crop production and produced $200,000 in market value of specialty crops (mean), according to the most recent USDA Ag Census (2015).

We also asked farmers about their distribution practices for their specialty crops. Most of the farmers participating in the survey sell 50% or more of their product directly to consumers (see Table 2). Table 2 describes the markets used by farmers, as well as the proportion of the specialty crops distributed through each distribution mechanism. Notably, 22% of farmers who responded to the survey also market at least some (between 1-50%) of their products through grocers, restaurants, or other institutions (see Table 2). The chi-square analysis did not reveal any statistically significant differences in marketing strategies between the organic and conventional growers.

High tunnel usage

Nearly half of the respondents had only one high tunnel (48.5%). The mean number of high tunnels owned was 3.07 per farm, with organic growers averaging 3.15 and conventional growers averaging 2.92 (see Table 3). Most (76.2%) respondents spent less than $5,000 out-of-pocket on constructing their new infrastructure. The average high tunnel size was 5,540 ft^2, with a median size of 2,880 ft^2. Based on the project's primary focus and methods for acquiring contact details for high tunnel users, we oversampled EQIP participants, which accounted for 73.8% (n=76) of our respondents. Among all respondents, 47% had only an EQIP funded high tunnel. Few respondents used Farm USDA Service Agency (FSA) financing to cover their portion of high tunnel costs: 6.8% of all respondents and 5.5% of EQIP participants.

We asked participants to list their top six most financially important high tunnel crops and thematically grouped them and calculated frequencies for the listed crops. Greens crops (salads, spinach, kale, micro greens, etc.; frequency (f)=126) were most often listed among the top six crops by Indiana high tunnel producers who responded to our survey, followed by tomatoes (f=87), peppers (f=28), root vegetables (f=28), cucumbers (f=25), beans (f=19), herbs (f=15), and raspberries (f=12). We also calculated the percentage of farmers in the survey who are growing greens, tomatoes, and both greens and tomatoes, because these were the two most financially important crops. Of the growers who responded to our survey, 78 grow tomatoes (75.0%), 56 grow greens (53.9%), and 42 grow both (40.4%). This selection of crops is broadly similar to international trends, with the following crops being produced most frequently in high tunnels in countries around the world: tomato (Solanum lycopersicum), pepper (Capsicum annuum Grossum group), cucumber (Cucumis sativus), muskmelon (Cucumis melo), and lettuce (Lactuca sativa) (Lamont 2009). The most notable difference with Indiana growers is the emphasis on growing a greater diversity of salad greens than just lettuce, although greens such as spinach and Swiss chard are also commonly grown in other countries.

We also asked about how their farm uses high tunnels, and farmers responded with a percentage of the high tunnel area dedicated to various crop types. Those who grow vegetable/melon/ herbs in tunnels use 86.7% of the high tunnel area to produce these crops. For those who grow berries or tree fruit, 38.8% of the high tunnel is used for those crops. Those growing flowers and bedding

Table 2: Cross-tabulations and Chi-square Results (no differences were detected) for Percent of High Tunnel Products Moved Through Various Distribution Mechanisms

	Overall (n=103)	Organic Farmers (n=65)	Conventional Farmers (n=38)
Sold direct to consumer			
0%	13.6%	15.4%	10.5%
1-50%	13.6%	13.8%	13.2%
50-99%	35.0%	38.5%	29.0%
100%	37.8%	32.3%	47.3%
Total	100.0%	100.0%	100.0%
Sold direct to grocer, restaurant, or institution			
0%	64.0%	60.0%	71.0%
1-50%	22.3%	26.1%	15.8%
50-99%	9.7%	10.8%	7.9%
100%	4.0%	3.1%	5.3%
Total	100.0%	100.0%	100.0%
Sold direct to aggregator, food hub, or other distributor			
0%	89.3%	90.8%	86.8%
1-50%	7.8%	7.7%	7.9%
50-99%	2.9%	1.5%	5.3%
100%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%
Sold direct to food processor			
0%	97.1%	96.9%	97.4%
1-50%	2.9%	3.1%	2.6%
50-99%	0.0%	0.0%	0.0%
100%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%
Sold/donated direct to food bank or similar initiative			
0%	62.1%	75.4%	65.8%
1-50%	34.0%	35.4%	31.6%
50-99%	2.9%	3.2%	0.0%
100%	1.0%	0.0%	2.6%
Total	100.0%	100.0%	100.0%

Table 3: Descriptive, ANOVA, and Chi-Square comparison results of high tunnel management overall and between organic and conventional farmers

	All respondents	Organic Farmers	Conventional Farmers	Significance Level
Group size (n)	103	65	38	-
Acres owned (mean)	41.25	27.06	66.39	*
Acres in specialty crops	9.72	7.63	13.22	-
Years farming	21.61	20.31	24.00	-
Years using high tunnels	5.29	5.05	5.71	-
Gross farm Income of $50,000 or more (%)	35.0%	25.4%	51.4%	**
Total square feet of high tunnel space	5540.94	5138.44	6222.94	-
How many high tunnels on farm	3.07	3.15	2.92	-
Percentage of household income farm supplies (%)	36.3	32.2%	43.5%	-
Dollar value of farm's sales through high tunnels	$9852.86	$11,725.00	$7044.64	-
Growing more than 2 crops	77.7%	91.2%	56.8%	***
Growing more than 6 crops	51.1%	71.9%	18.9%	***
Winter harvesting (harvesting between Nov-March because of high tunnels)	68.0%	81.5%	44.7%	***

$P<.05$*; $p<.010$**; $p<.001$***.

plants use 17.6% of their high tunnel area for the ornamental crops. Notably, berries and tree fruit are also commonly grown in high tunnels elsewhere (Janke *et al.* 2017; Weber 2018). Of the farms participating in the survey, 6.1% of their high tunnel area was being used for storage. Among these planting priorities, a significant difference was found between organic and conventional growers, with conventional growers dedicating a higher percentage of their high tunnel space to berry and tree fruit production (X^2=0.003).

High tunnel management in conventional and organic systems

Of the farmers who responded to our survey, 52.4% are using organic practices but not certified organic, and 6.8% were certified organic. The fact that the majority of farmers using organic practices are not certified is not surprising because the majority of farmers included in this analysis are marketing their products directly to consumers, and thus are able to communicate about their practices without the added cost and record keeping requirements of certification (Veldstra *et al.* 2014). For the remainder of this paper we refer to farmers as using organic practices (N=65), whether certified or not. Organic farmers in this study generally owned less acres (X^2 = 0.012) and their farm income was lower (X^2 = 0.009), as just 25.4% had farm incomes of $50,000 or more, compared to 51.4% of conventional farmers in this study who earned over $50,000 from their farms (see Table 3). The farmers using organic practices were similar to their conventional counterparts in terms of the number of acres they managed in specialty crops, with conventional farmers managing slightly more acres (13.22 mean, compared to 7.63 mean acres for organic) (see Table 3). In addition, there was a statistically significant difference between the two groups in terms of their farm income level, with a greater percentage of conventional farmers reporting a farm income of $50,000 or more compared to organic farmers (see Table 3). In other ways the two groups were not significantly different. The groups were similar in terms of their farming experience and the number of years they had been using high tunnels, as well as the percentage of their household income that came from the farm and the dollar value of their high tunnel sales (see Table 3). There was not a significant difference between organic and conventional growers in the total square footage of high tunnel space or the number of high tunnels managed by each group (see Table 3).

The farming production systems that organic and conventional farmers used to manage their high tunnels differed in some important ways. The organic farmers used high tunnel production systems that emphasized crop diversity and utilized more complex crop rotations in their high tunnels. Our Chi-square analysis found a significant difference between what organic and conventional farmers were growing (X^2=0.000) with organic farmers planting a greater diversity of crops that include a variety of greens and other crops to complement tomato production. Specifically, 76.3% of conventional growers do not grow greens, while 72.3% of organic growers do grow greens (X^2= 0.000). Similarly, 65.8% of conventional growers grow just tomatoes and not greens, whereas 50.8% of organic growers grow tomatoes and greens (X^2= 0.000). In general, there were significant differences between the organic and conventional growers in terms of the level of crop diversity they maintained in their high tunnels. As shown in Table 3, 91.2% of organic farmers grow more than 2 kinds of crops (X^2= 0.000) and 81.5% grow more than 6 kinds of crops (X^2 = 0.000), such as kale, swiss chard, spinach, arugula, tomatoes, and peppers (see Table 3).

High tunnel economics

Among respondents to this survey, 27.2% grossed between $1,000 and $9,999 annually on specialty crop sales from their farm (field and high tunnel), with another 26.2% making between $10,000 and $49,999. The mean sales for specialty crops produced per high tunnel were $9,852.86 annually ($4,000 median). We did not find statistical differences between organic and conventional growers in gross specialty crop sales from their farms in general. Eighteen respondents made less than $999 annually on specialty crops sales. Almost a fourth (23.5%) of respondents made the majority of their specialty crop revenue through products grown in a high tunnel. The mean dollar per square foot of total revenue respondents received per year on their high tunnel was $1.70 ft^2 (median $1.00 ft^2). However, 32.0% of respondents indicated that they would not buy another high tunnel without NRCS funding (39% were somewhat likely or very likely and 29% were neutral on the idea) (Mean=3.05 / Median=3.00).

Season extension with high tunnels

One of the most important benefits of growing in high tunnels is the potential to extend the growing season, particularly in parts of the world with a limited growing season. In our survey we asked growers to report the months that they are now growing or harvesting crops, when they were not before, because of their high tunnels. Of the growers who responded to the survey, 46.6% and 35.9% of them said they are now growing crops in December and January, respectively, when they were not before using a high tunnel. In addition, 64.1% are now harvesting from their high tunnels in November, 45.6% in December, 35.9% in January, and 35.0% in February, when they did not harvest crops in those months before. Figure 1 illustrates the season extension potential of high tunnels by charting the frequency of increased production and harvesting by month because of high tunnels. It is important to note that while most definitions of high tunnels say they are not heated, in practice some are: 3.9% of respondents reported routinely heating the structure to keep the temperature optimum for crop growth; 6.8% keep it above freezing in winter; and 19.4% heat occasionally for frost or freeze protection.

In comparing organic to conventional growers, organic growers were much more likely to use their high tunnels to extend harvest into the winter, as 81.5% of them reported harvesting during the winter months when they were not before, compared to 44.7% of conventional growers reporting winter harvesting (see Table 3). Winter harvesting was measured as harvesting during any month between November and March. It is likely that this difference in winter harvest is related to differences in crop choice: three-quarters of organic growers grow greens–nearly all of which are cool season crops– while only about one-quarter of conventional growers grow greens, focusing instead on tomatoes, which cannot tolerate winter conditions in high tunnels.

High tunnel experience

We asked a series of general likert style questions about farmers' experience with their high tunnels. When queried about the utility of the high tunnel, most respondents found them to be useful to extremely useful (on a 1-5 scale: 1=not at all useful; 2=somewhat useful; 3= useful; 4=very useful; 5= extremely useful). Increasing yields is another important potential benefit of high tunnel production, and we asked farmers to estimate yield in the high tunnel compared to yield in the field by

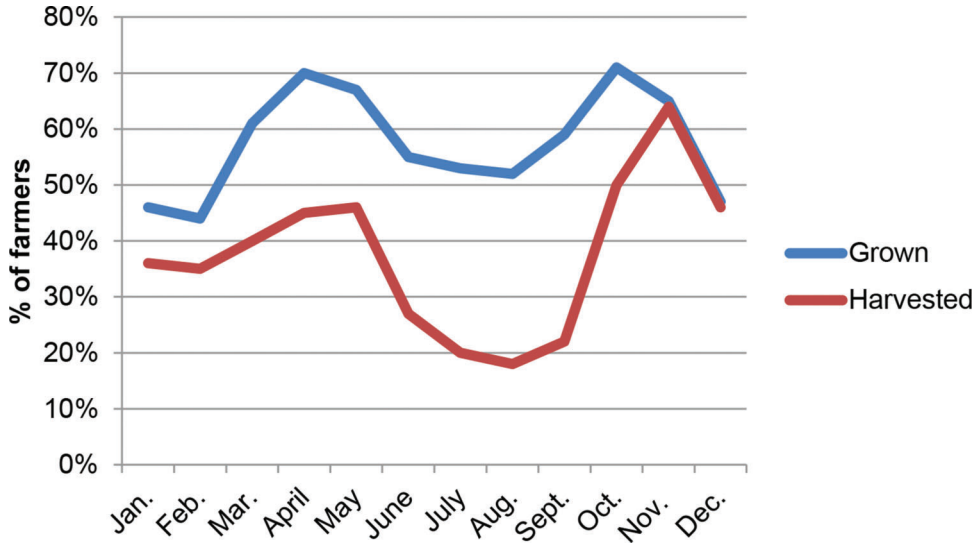

Figure 1: Months farmers are now growing more or now harvesting specialty crops, because of their high tunnels

selecting a response ranging from 'decreased 50% or more' to 'increased 50% or more', or 'do not know'. Just over 43% of the farmers in our survey reported that growing in a high tunnel increased their yields by 25-50%, a very significant increase. Furthermore, another 14.6% reported that growing in high tunnels increased their yields more than 50%. In addition, 16% noted an increase of 5-25%, 6.8% of respondents were neutral on the matter (suggesting they did not experience much change in yield), and 18.4% of respondents said they did not know.

We asked farmers to consider their overall experience in growing specialty crops and compare growing in the high tunnel to growing in the field in general (see Table 4, third set of items). Overall, farmers most noted the improvements to quality of harvested product (4.7/5), disease problems (e.g. fewer problems) (4.20/5), and weed problems (e.g. fewer problems) in the crop (4.19/5) by growing crops in high tunnels. Interestingly, conventional farmers reported that high tunnels aided in disease management more than organic farmers did (p = 0.024). Improving quality of harvested products also garnered a high mean score when farmers rated the ways the high tunnel is useful (see Table 4, first set of items; 3.89= very useful).

Similarly, farmers responded to a series of prompts about the potential of high tunnels for extending the growing season (on a 1-5 scale: 1=not at all useful; 2=somewhat useful; 3= useful; 4=very useful; 5= extremely useful, see Table 4). The mean score for the high tunnel usefulness in increasing fall/winter/spring production was 4.01 (very useful), which was statistically different between the two groups, with organic growers scoring it higher ($p > .001$). While respondent scores on harvesting warm season crops earlier in the season was at 3.89, harvesting warm season crops later in the season (3.62) and harvesting cool season crops in the coldest of months (3.26) received lower scores. Additionally, organic farmers were more apt to score the latter point significantly higher than their conventional counterparts ($p > 0.001$). Still, respondents indicated that high tunnels were between useful and very useful for increasing cash flow in fall/winter/spring (3.37).

In alignment with EQIP/NRCS goals, we queried farmers about how they perceive high tunnels affecting their farm's economic stability, improving their quality of life, increasing crop yields, and reducing negative environmental impacts (see Table 4). High tunnel user respondents agreed that growing in a high tunnel allowed them to significantly increase crop yields (4.80/6), improve the farm's economic stability (4.78), improve quality of life (4.52), and reduce negative environmental impacts (4.44) (see Table 4). The increase in yield documented by this response could reflect yield increase per unit area for a specific crop and/or increased production due to do double or triple cropping; the question was a general question about the whole farm impact of high tunnels. There were no significant differences between organic and conventional farmers on their assessment of these impacts (see Table 4).

Discussion

Based on our survey findings, farmers are able to offer fresh produce for an additional one to four months of the year, and significantly improve the quality and yield of their crops with high tunnels. Given that the majority of our survey respondents have been using high tunnels for less than 5 years, many in their first season, these results suggest that high tunnels can lead to relatively quick success. Given that many growers in our study reported income from their high tunnels that exceeded the cost of their out of pocket investment in just one growing season (not accounting for production costs), it shows economic potential for small farms. Analysis of the data for this study suggests three salient ideas worthy of discussion: (1) generally speaking, farmers are benefitting from high tunnel infrastructure investments, (2) high tunnels are not only supporting production during the cooler months, but also throughout the growing season, and (3) organic producers experience a similar level of benefits as conventional growers, except for disease problems in the crop (they reported less benefit), and season extension (they reported higher success). This section provides more depth on each of these points, as well as the study's limitations and directions for future research on specialty crop production in high tunnels.

Table 4: Farmer perspective on (1) usefulness of high tunnels, (2) overall farm improvements, (3) growing in high tunnels compared to field production, and (4) likelihood of future investment in high tunnels. P values indicate significance levels between the two groups as determined by ANOVA

	Overall	Organic Growers	Non-Organic Growers	Significance Level
	Mean (SE)	Mean	Mean	
Usefulness 1-5 Likert-style scale(1=not at all useful; 2=somewhat useful; 3=useful; 4=very useful to 5=extremely useful)				
Increasing overall farm profit	3.8 (0.105)	3.9	3.6	-
Adding products/diversifying	3.3 (0.120)	3.4	3.2	-
Increasing fall/winter/spring production	4.0 (0.107)	4.3	3.6	***
Harvesting warm season crops earlier in the season	3.9 (0.103)	3.9	3.9	-
Harvesting warm season crops later in the season	3.6 (0.106)	3.6	3.6	-
Harvesting cool season crops earlier in the coldest of months	3.3 (0.154)	3.7	2.4	***
Increasing cash flow in fall/winter/spring	3.4 (0.136)	3.6	2.9	*
Shifting some of the summer workload to fall/winter/spring	2.8 (0.131)	2.9	2.6	-
Improving quality of harvest products	3.9 (0.103)	3.9	3.9	-
Reducing pest problems	3.3 (0.127)	3.3	3.3	-
Overall Farm Improvements 1-6 scale(1=strongly disagree; 2=disagree; 3=slightly disagree;4=slightly agree; 5=agree; 6=strongly agree)				
Improved farm's economic stability	4.8 (0.108)	4.9	4.6	-
Improved quality of life	4.5 (0.106)	4.6	4.3	-
Significantly increased crop yields	4.8 (0.096)	4.8	4.8	-
Significantly reduced negative environmental impacts	4.4 (0.115)	4.5	4.4	-
Production in High Tunnel vs in Field 1-5 Likert-style scale(1=extremely worse; 2=slightly worse; 3=no change;4=slightly improved; 5= extremely improved)				
Disease problems in the crop	4.2 (0.101)	4.0	4.5	*
Insect problems in the crop	3.8 (0.113)	3.9	3.9	-
Weed problems in the crop	4.2 (0.093)	4.2	4.2	-
Vertebrate pest problems	3.8 (0.123)	3.7	4.1	-
Maintaining soil quality	3.7 (0.120)	3.8	3.6	-
Quality of harvested product	4.7 (0.062)	4.7	4.7	-
Future Investment in High Tunnels 1-5 scale(1=not at all likely; 2=not very likely; 3=neutral; 4=somewhat likely; 5=very likely)				
Likelihood of your farm investing in a high tunnel without NRSC cost-share.	3.0	3.2	2.8	-

$p > .05$*; $p > .010$**; $p > .001$***.

General benefits from high tunnel infrastructure investment

The potential for high tunnels to improve specialty crop production and extend the growing season has been established with research trials and small case studies across varied locales (Blomgren & Frisch, 2007; Carey *et al.*, 2009; Conner *et al.*, 2010; Lamont, 2009). So far, there is a lack of research assessing the real-world application and benefits of high tunnels for specialty crop producers who integrate tunnels into their existing farms. This study provides evidence that in the state of Indiana, growers have had a positive experience with integrating high tunnels into their farm businesses.

Most survey respondents reported that their tunnels are useful or very useful for increasing production, extending the growing season and improving the quality of their products. The farmers who responded to the survey either slightly agreed or agreed that high tunnels improved their farm's economic stability and reported that high tunnels are between useful or very useful for increasing their overall farm profit. About half of our respondents are now harvesting from their high tunnels in the cooler months or planting earlier in the spring, when they were not able to previously. The farmers who provided information to this study, most of them operating small direct-market farms, clearly find the investment in a high tunnel to be beneficial.

High tunnel impacts on production

The signature benefit of high tunnels is their potential to extend the growing season. This is important because the lack of fresh local produce during the colder months is a major obstacle to the development of farm-to-institution programs and rebuilding year-round local and regional food systems in areas with a limited growing season (Martinez *et al.*, 2010). In Indiana, farmers are using high tunnels to extend the growing season into the colder months of October, November and December; thereby adding to the months their farms are earning revenue, and potentially capturing a premium at winter farmers markets or winter CSAs. Many farmers are also experiencing success with getting a head start in the spring, allowing them to offer high value crops such as tomatoes earlier in the summer that garner a premium price.

Another important benefit of growing in high tunnels is the improvement growers experienced with the quality and yield of their crops. In our study, over half of respondents have experienced improvements in their crop yields, some of them dramatic improvements. This finding coincides with research trials and field experiments that have found similar results (O'Connell *et al.*, 2012). In terms of quality improvements, farmers' responses ranged from a slight to significant improvement in the quality of their crops in the tunnel. In the write-in section where we asked about the opportunities from their perspective,

farmers also indicated the high tunnel led to improvements in produce quality, resulting from less insect and disease damage, the extended season for longer harvests, and utility of growing tomatoes in the high tunnel during the summer months.

Our finding that approximately half of respondents are not growing in the colder months indicates that for a major portion of those using the infrastructure, the focus is on bolstering production in the traditional growing season, including taking advantage of earlier planting dates and extended fall harvest possible in the high tunnel, as well as improved product quality. This in part explains why many of the write-in responses focused heavily on tomatoes, which a majority of farmers were planting in their high tunnels. Extending the growing season is an often-stated goal of high tunnels, but for farmers in Indiana that does not necessarily mean growing in the winter; extending the summer growing season proves valuable for many.

Organic vs. conventional growers' experience with high tunnels

The survey also provided some interesting findings regarding the extent to which high tunnels are complimentary to the use of organic farming systems. By comparing organic to conventional growers, our survey showed divergence in farmers' use of the season extension benefits of high tunnels by growing practices. The organic growers who responded to the survey were more likely to report benefits from harvesting cool season crops earlier in the coldest of months, increasing production in the fall, winter and spring, and in turn increasing cash flow during these months that are generally slower in sales. Given their emphasis on production and harvesting in the cold season, it is not surprising that the organic growers report growing a greater number of crops than their conventional counterparts, as they are growing crop types that do well in the cold season in addition to those that do well in the summer.

Both organic and conventional growers reported yield increases in high tunnels. This raises the question of whether high tunnels provide a bigger difference in improvement of yields of organic crops versus conventional, given that lower yields have historically been a challenge for organic producers (Seufert, Ramankutty, and Foley, 2012). While many of the organic farmers said their tunnels were helpful for dealing with pests and weeds, others are experiencing pest and disease problems specific to the tunnels that limit some of this benefit. In particular, the organic growers in the survey were less likely than their counterparts to report benefits in reducing disease problems (though the mean score on disease was still relatively high overall). It is possible that the organic growers simply have fewer options available for dealing with diseases that may be more problematic in high tunnels, or that they already experience superior disease control and hence are less likely to observe dramatic differences. Another possibility is that this difference is related to the preference of organic farmers in this study for growing greens. Reduction of some fungal diseases on tomatoes is commonly reported in high tunnels, thus tomato growers report needing fewer fungicide applications to manage these diseases in high tunnels compared to the field (Johnson, Grabowski, and Orshinsky 2015). In contrast, high humidity in winter tunnels promotes disease problems for leafy greens.

Limitations and future research

There are a number of limitations to this study. Our sample size of 103 (62.8% response rate) is relatively small and limits our ability to make broad generalizations about high tunnel users. However, the total number of growers using high tunnels in Indiana is relatively small, as NRCS reported funding the construction of just 160 tunnels on farms in Indiana since 2012 (NRCS, 2014). Considering the number of high tunnels in Indiana relative to our final sample of 103, our sample is a pretty strong representation of high tunnel users in Indiana. Our sample should not be considered representative, given that the compilation of the sample from the NRCS list and via extension contacts leaves out high tunnel users who we did not contact, and thus could change the results if we had access to the contact data of those individuals. Given that no such lists are available, research funding to support the creation of a more comprehensive database of potential respondents would enhance the sampling and in turn better capture any possible divergence in the high tunnel experience. Finally, while our research in Indiana (U.S.A.) is useful in the larger conversation on high tunnel research, the geographic locale and the climate zones in particular should be critically considered as experiences and outcomes of high tunnel usage will vary greatly across regions, in different ecological contexts, and with different soils.

Overall, while farmers reported that their high tunnels were either useful or very useful for increasing their cash flow in the off-season, the survey also indicates situations where the potential benefits of tunnels are not being realized, and these provide directions for future research. For instance, conventional growers are less likely to use high tunnels to increase cash flow in the off-season. The fact that around half of our respondents are not harvesting in the colder months raises some questions we hope to explore in future research. Farmers found tunnels valuable for harvesting warm season crops earlier in the season, but not quite as valuable for harvesting warm season crops later in the season. This finding probably reflects the fact that tomatoes are one of the most popular and successful crops grown in high tunnels, both among our respondents in Indiana, in other parts of the country, and around the world (Knewtson *et al.*, 2010; O'Connell *et al.*, 2012). The price premium for early season tomatoes, in addition to their value in attracting customers to a direct-marketer can explain the early season value; while harvesting later in the season doesn't provide those same benefits.

Future research is also warranted to investigate a larger sample of organic and conventional growers in order to offer a stronger comparison between management styles. This project was able to assess differences on a farm level, but could not document differences between organic and conventional high tunnel benefits for any particular crop, because the mix of crops grown in tunnels differed between the management styles. Thus, we could not conclude that the same differences between organic and conventional would be found if the same crops were produced in the two systems. A larger sample could allow for teasing out of differences by crop. In addition, it would be useful to explore the impacts of long-term high tunnel use on soil health in future research. For example, we are investigating whether

there is an increase in pest or disease pressure in the high tunnel over time because the soil is protected from freezing temperatures that would otherwise break pest life cycles, or a buildup of salts or other minerals because the soil is not flushed by heavy rains.

Conclusion

This survey indicates that high tunnels are strengthening specialty crop production on farms in the U.S. Midwest state of Indiana. Growers report a number of benefits from growing with high tunnels, including improvements to their crop harvests, quality, and overall farm viability. These grower reports provide the first survey-based confirmation that favorable results documented in research trials and small case studies carry through to the farm level when a high tunnel is integrated into an existing operation. Because the majority of these farmers have been using their high tunnels for less than 5 years, the results also serve as a baseline to which future responses can be compared. The positive outcomes suggest that although there is a learning curve to growing with high tunnels, benefits can be realized in a relatively short time period.

Although only Indiana farmers responded to the survey, it seems likely that similar results would be found in other U.S. Midwest states with comparable agricultural environments. In other parts of the world with differing agro-ecological contexts and differing markets, perceived economic and social benefits will likely differ. Some of the findings may be cautiously considered for other regions with the caveat that growing conditions and overall context is important to consider.

In this work we were able to identify farmer reported measurable impacts on one of the goals of the HTI: the availability of fresh produce. Our study shows that high tunnels assist growers in both increasing their crop yields and extending the growing season, thereby increasing the supply of fresh produce for local food markets where most respondents sell their products. Furthermore, our study finds that high tunnel usage improved these farms' economic stability and to a lesser extent their overall farm profit. This suggests the potential for continued increases in the supply of fresh food for local markets as some of these operations grow into larger enterprises. Assessing whether high tunnels are or are not meeting the other stated goals of the HTI–reducing nutrient and pesticide runoff, improving plant and soil quality, reducing energy use through reduced transportation from farm to market–is beyond the scope of the survey data.

Organic and conventional farmers for the most part agreed on the benefits of high tunnels. Differences were related to season of production (organic growers reported more production and harvest in the fall/winter/spring) and disease (organic growers did not see as much benefit in reducing disease as conventional growers). Recognizing the similarities and differences in these production systems will enable researchers and educators to more effectively address needs for new knowledge and production recommendations.

Overall, our survey provides evidence that high tunnels are enhancing specialty crop production in Indiana and increasing the viability of farms that supply local food systems.

About the authors

Analena Bruce is an Assistant Professor in the Department of Agriculture, Nutrition, and Food Systems in the College of Life Sciences and Agriculture at the University of New Hampshire. Dr. Bruce's research is focused on agriculture and food systems, and policy governing science and technology in the food system.

James Farmer is an Associate Professor in the O'Neill School of Public and Environmental Affairs at Indiana University. Dr. Farmer's research focuses on sustainable behavior and decision-making within the sectors of community food systems and natural resources.

Elizabeth Maynard is a Clinical Engagement Assistant Professor in the Department of Horticulture and Landscape Architecture at Purdue University. Dr. Maynard's integrated horticulture research and extension program informs and empowers vegetable producers to improve their operations to the benefit of themselves, their communities, and society at large.

Julia DeBruicker Valliant researches the public health implications of agricultural policies and the role of farmers as leaders of health movements. She is postdoctoral Research Associate with the Ostrom Workshop of Indiana University, USA.

Acknowledgement

The authors thank the farmers who participated in this study, and the extension educators at Purdue who have supported the project. This work was supported by the Indiana State Department of Agriculture Specialty Crops Block Grant program under Grant # SCBG-15-002. The funder played no role in the study.

REFERENCES

Beckford, C.L. and Norman, A. (2016). Climate Change and Quality of Planting Materials for Domestic Food Production: Tissue Culture and Protected Agriculture. In *Globalization, Agriculture and Food in the Caribbean*, Palgrave Macmillan UK. pp. 189–215.

Bengtsson, J., Ahnström, J. and Weibull, A.C. (2005). The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology*, 42, pp. 261–269. doi: 10.1111/j.1365-2664.2005.01005.x

Biernbaum, J. (2013). Water, soil and fertility management in organic high tunnels. Available at: http://www.hrt.msu.edu/assets/PagePDFs/johnbiernbaum/HighTunnelWaterSoilFertility2013-10pgs.pdf [Accessed February 10, 2015].

Blomgren, T. A. and Frisch, T. (2007). *High Tunnels: Using Low Cost Technology to Increase Yields, Improve Quality, and Extend the Growing Season*. University of Vermont Center for Sustainable Agriculture. Available at: www.uvm.edu/sustainableagriculture.

Bruce, A.B., Farmer, J.R., Maynard, E.T. and Valliant, J.D. (2017). Assessing the impact of the EQIP High Tunnel Initiative. *Journal of Agriculture, Food Systems, and Community Development*, 7(3), pp. 159–180.

Carey, E.E., Jett, L., Lamont, W.J., Nennich, T.T., Orzolek, M.D. and Williams, K.A. (2009). Horticultural crop production in high tunnels in the United States: A snapshot. *HortTechnology* 19, pp. 37–43.

Church, A. (1993). Estimating the effect of incentives on mail survey response rates: a meta-analysis. *Public Opinion Quarterly,* 57, pp. 62–79.

Coleman, E. (2009). *The winter harvest handbook: Year-round vegetable production using deep-organic techniques and*

unheated greenhouses. White River Junction, VT: Chelsea Green Publishing.

Conner, D.S., Montri, A.D., Montri, N. and Hamm, M.W. (2009). Consumer demand for local produce at extended season farmers' markets: guiding farmer marketing strategies. *Renewable Agriculture and Food Systems*, 24, pp. 251–259. https://doi.org/10.1017/S1742170509990044

Conner, D.S., Waldman, K.B., Montri, A.D., Hamm, M.W. and Biernbaum, J.A. (2010). Hoophouse contributions to economic viability: Nine Michigan case studies. *HortTechnology*, 20, pp. 877–884.

Dillman, D. A., Smyth, J. D. and Christian, L. M. (2014). *Internet, phone, mail, and mixed-mode surveys: the tailored design method*. John Wiley & Sons.

Foust-Meyer, N. and O'Rourke, M.E. (2015). High tunnels for local food systems: Subsidies, equity, and profitability. *Journal of Agriculture, Food Systems, and Community Development,* 5, pp. 27–38. doi.org/10.5304/jafscd.2015.052.015

Gomiero, T., Pimentel, D. and Paoletti, M.G. (2011). Environmental impact of different agricultural management practices: conventional vs. organic agriculture. *Critical Reviews in Plant Sciences*, 30, pp. 95–124. http://dx.doi.org/10.1080/07352689.2011.554355

Huff, P. (2015). *Extending the Growing Season*. Institute for Agriculture and Trade Policy. [Online]. Available at: http://www.iatp.org/files/2015_04_02_SeasonExtension_PH_0.pdf

ICARDA. (2015). Protected agriculture: productive use of marginal land. Available at: http://www.icarda.cgiar.org/tools/protected-agriculture

Ingwell, L.L., Thompson, S.L., Kaplan, I. and Foster, R.E. (2017). High tunnels: protection for rather than from insect pests? *Pest. Manag. Sci*, 73: 2439-2446. doi.org/10.1002/ps.4634

Janke, R.R., Alta-mimi, M.E. and Khan, M. (2017). The use of high tunnels to produce fruit and vegetable crops in North America. *Agri-cultural Sciences,* 8, 692–715. https://doi.org/10.4236/as.2017.87052

Johnson, A., Grabowski, M. and Orshinsky, A. (2015). *Leaf mold of tomato*. [online] University of Minnesota Extension. Available at: http://www.extension.umn.edu/garden/fruit-vegetable/plant-diseases/leaf-mold-tomato/index.html [Accessed November 21, 2016].

Lamont and William J (2009). Overview of the use of high tunnels worldwide. *HortTechnology*, 19, pp. 25–29.

Lawrence, J., Simpson, L. and Piggott, A. (2017). Protected Agriculture: A Climate Change Adaptation for. Natural Resources Management: Concepts, Methodologies, Tools, and Applications: Concepts, Methodologies, Tools, and Applications, 140.

Low, S.A., Adalja, A., Beaulieu, E., Key, N., Martinez, S., Melton, A., Perez, A., et al. (2015). Trends in U.S. local and regional food systems(AP-068). U.S. Department of Agriculture, Economic Research Service. Retrieved from Cornell School of Hospitality Administrationsite: http://scholarship.sha.cornell.edu/articles/1058

NRCS (2011, January 7). USDA provides update on seasonal high tunnel pilot [Press release]. Available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/newsroom/?cid=STELPRDB1040764

NSAC. (2014, October). Environmental Quality Incentives Program; Helping farmers and ranchers share the costs of addressing natural resource concerns. [NSAC Blog]. Available at: http://sustainableagriculture.net/publications/grassrootsguide/conservation-environment/environmental-quality-incentives-program/

O'Connell, S., Rivard, C., Peet, M.M., Harlow, C. and Louws, F. (2012). High Tunnel and Field Production of Organic Heirloom Tomatoes: Yield, Fruit Quality, Disease, and Microclimate. *HortScience*, 47, pp. 1283–1290.

Orzolek, M.D. (2013). Increasing Economic Return to High Tunnel with Specialty Crops. Proc. On High Tunnel Horticultural Crop Production. Ed. L. Jett. *Acta Hort*, 987. ISHS 2013.

Seufert, V., Ramankutty, N. and Foley, J.A. (2012). Comparing the yields of organic and conventional agriculture. *Nature, 485*, pp. 229–232. doi:10.1038/nature11069

Singer, E. (2012, October 3-4). *The use and effects of incentives in surveys*. Presentation at the National Science Foundation. Retrieved November 2, 2014 from: https://iriss.stanford.edu/sites/all/files/EDGE/SingerOctober.pdf

United States Agency for International Development, USAID. (2008). *Protected Agriculture in Jamaica; A Reference Manual*. Available at: http://pdf.usaid.gov/pdf_docs/pnaeb744.pdf

USDA Ag Census. (2015). Results from 2012 Ag Census. Available at: http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1, Chapter_2_US_State_Level/

USDA Ag Census. (2015). Specialty Crops. Available at: https://www.agcensus.usda.gov/Publications/2012/Online_Resources/Specialty_Crops/SCROPS.pdf

Veldstra, M.D., Alexander, C.E. and Marshall, M.I., (2014). To certify or not to certify? Separating the organic production and certification decisions. *Food Policy*, 49, pp. 429–436.

Waldman, K.B., Conner, D.S., Biernbaum, J.A., Hamm, M.A. and Montri, A.D. (2012). Determinants of Hoophouse Profitability: A Case Study of 12 Novice Michigan Farmers. *HortTechnology*, 22, pp. 215–223.

Waldorf, B., (2007). What is rural and what is urban in Indiana Purdue Center for Regional Development Report, 4.

Weber, C.A. (2018). High tunnel performance of seven floricane red raspberry cultivars in western NY. *Journal of the American Pomological Society*, 72(4), pp. 251–259.

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-56

New entrants and succession into farming: A Northern Ireland perspective

CLAIRE JACK[1], ANA CORINA MILLER[2], AUSTEN ASHFIELD[3] and DUNCAN ANDERSON[4]

ABSTRACT

Traditionally, family-farm businesses have been passed down through a number of generations and the facilitation of a smooth transition from one generation to another is central to the profitability, continuity and sustainability of the business. There are many factors which can impact on an individual beginning to manage a farm in their own right. This study seeks to determine the barriers to new entrant farmers in Northern Ireland through a survey of young farmers/new entrants to farming. The results from the survey show that the profitability of the farm business, the age of the farmer when they identify a successor, the stage in the household lifecycle when a successor is identified, the wider dynamics of the family household and the role of the wider rural economy affect the success of new entrants to farming.

KEYWORDS: Succession; family-farm; barriers; new entrants

1. Introduction

There is a renewed interest, from both a policy and industry perspective, in how to encourage new entrants into farming and how best succession and inheritance can be planned for and facilitated. Family-farm businesses tend to operate as sole trading businesses (self-employed) or in partnerships and very rarely involve individuals from outside of the family in the management and decision-making processes. Traditionally, family-farm businesses have been passed down through a number of generations and it is this tradition of family succession which can create structural difficulties in farming and presents one of the biggest barriers for new entrants to farming. Succession is considered one of the biggest challenges facing many family businesses (Benavides-Velasco *et al*., 2013) and the facilitation of a smooth transition between generations is central to the profitability, continuity and sustainability of the business. Intergenerational transfers within family businesses continues to be a focus for researchers within the family business literature (Brockhaus, 2004; Ward, 2004; Lockamy *et al*., 2016). Previous research has identified several factors why businesses fail to establish a successful transfer between the generations such as; process, financial, individual, context, relationship and governance, (De Massis *et al*., 2008; Lockamy *et al*., 2016). Davis and Harveston (1998), and Ward, (1997, 2004) highlight that only a limited number of family businesses are transferred successfully to the next generation and indeed many do not survive, failing shortly after transfer.

In this context, family-farm businesses are no exception and the nature of family-farm transfers can be influenced by family dynamics which can have a significant impact on the success or otherwise, of farm transfers (Taylor and Norris, 2000; Venter *et al*., 2005). Bowman-Upton (1991), found that succession decisions are more complicated as the number of children (as potential successors) in the household increases. The span of time that the owner/manager of a business and their spouse/partner have been together has also been shown to influence the succession process (Wilson *et al*., 1991). Moreover, reluctance on the part of the older generation to pass on the farm business due to for example, a lack of provision for retirement or concerns about how the business will be run when it would be handed over, have all been shown to impact on the success and sustainability of the farm business into the future (Bowman-Upton, 1991).

The main policy instruments available to governments to assist with farm transfer have been financial e.g. tax relief or grant based schemes. However, historically, there has been no strategic long-term EU policy in place to encourage the timely transfer of farms. Early retirement schemes were used in the past, aimed at reducing the average farmer age and increasing the entry of young farmers. However, these schemes were found to be of limited effect as they only succeeded in incentivising

Original submitted January 2018; revision received April 2019; accepted April 2019.

[1] Corresponding author: Agri-Food and Biosciences Institute, Newforge Lane, Belfast, BT9 5PX, United Kingdom. Email: claire.jack@afbini.gov.uk

[2] Centre for Public Health, Queen's University Belfast, Belfast, BT12 6BJ, Northern Ireland. Email: A.Miller@qub.ac.uk

[3] Agri-Food and Biosciences Institute, Newforge Lane, Belfast, BT9 5PX, United Kingdom. Email: austen.ashfield@afbini.gov.uk

[4] Agri-Food and Biosciences Institute, Newforge Lane, Belfast, BT9 5PX, United Kingdom. Email: duncan.anderson@afbini.gov.uk

farmers who were already close to retirement, (Caskie *et al*., 2002; Hennessy, 2014). An alternative to early farm retirement schemes is the new entrant schemes, and while there is a paucity of information on the success of new entrant schemes, indications are that new entrant schemes could be more effective than early retirement schemes at restructuring the sector (Davis *et al*., 2013).

Outside of these issues around succession and inheritance, there are other issues that have been shown to create barriers for new entrants to farming. The sustainable profitability of the farm is a major difficulty for new entrants into the industry with most farms not able to support an additional family member (ADAS, 2004). Milne and Butler (2014) found that long working hours, often in inclement weather conditions can, alongside the uncertainty of returns, deter new entrants to the farming industry. Accessing training and knowledge, as well as the location of the farm when it comes to accessing off-farm labour to secure additional income, were also identified as barriers by Milne and Butler (2014). Moreover, low land mobility and high capital input combined with low levels of farm profitability have made it very difficult for new entrants to enter farming through the purchase of a farm (Matthews, 2014).

The structure of farming in Northern Ireland (NI) is somewhat different compared to the United Kingdom (UK) but not unlike that found in other EU member states. The majority of farms are very small, family owned and operated businesses. Some 77 percent of NI farms are categorised as very small; that is, requiring less than one Standard labour unit[5], therefore, generally not big enough to provide full-time employment for one person, (DAERA, 2018a). About two thirds of the smallest farms specialize in beef and sheep production. Over half of these farms are managed on a part-time basis, either by combining them with income from off-farm employment or self-employment or in the case of older farmers, with pension income, (Jack *et al*., 2009). Over the last decade, the number of farms in NI has been relatively constant with 24,900 farms reported in 2018 (DAERA, 2018b) and an average land area per farm of 40.9 hectares compared to an average of 79.9 hectares in the UK and 34.3 hectares for the EU-15, (DAERA, 2018a).

In view of the current structure of family-farm businesses in Northern Ireland, changes within the sector might provide challenges for the existing workforce. The sector is being driven by new innovations and technologies with farm operators being encouraged to adopt these new practices in order to increase farm productivity, maintain or increase profitability and ensure farm business sustainability. Younger farmers tend to be more efficient and innovative compared to older farmers (Potter and Lobley, 1996; Lobley *et al*., 2010; Howley *et al*., 2012) as well as contribute most to fostering innovation and resource efficiency within the industry (Dellapasqua, 2010). However, the farming population in the EU is on-average an ageing population (Eurostat Yearbook, 2016) and, therefore, from the perspective of sector sustainability, there is an increased need to encourage more young people into farming.

At a family-farm business level, there has been limited research undertaken to examine and explore the nature of barriers to new entrants to farming. While some barriers to farming may be universal (i.e. apply to all farms for example, how succession is managed) others could be quite regional in nature or specific to farm type (i.e. the ability to secure off-farm employment to make the farm more sustainable and the type of employment available will be influenced by the spatial location of the farm). The aim of this paper is to examine the nature and extent of barriers to new entrants into farming in a Northern Ireland context.

2. Data description and methodology

To explore fully the nature of these barriers at a Northern Ireland level, a survey of new entrants to farming was conducted by the Agri-Food and Bioscience Institute (AFBI) in Northern Ireland. The survey aimed to explore the experience of young farmers/new entrants to farming, focusing on their levels of education and training, whether they were currently farming full-time or part-time, what other employment they were engaged in (if any), their attitudes to farming as a career and the barriers and issues around establishing a sustainable farm business. The survey was initially piloted in an on-line format in February 2015 with forty-two agriculture students undertaking a level 2 course. The responses to the pilot (20 completed) identified some minor editorial revisions to the questionnaire.

Respondents were recruited from a cohort of part-time students undertaking a tailored Level 2 course in agriculture designed to support the provision of the new 'Young Farmers Scheme' under the 2014-2020 CAP reform[6]. The students were undertaking the course through evening classes, over a twenty week period at various venues throughout Northern Ireland. An email with the link to the online survey was sent to all the 2,200 Level 2 registered agriculture students in mid-February 2015. The questionnaire remained 'open' for six weeks and follow up reminder emails were sent to the students through their tutor before the online survey closed.

In total, 420 completed responses were received from the students participating on the course, giving a response rate of 19 percent. This response rate would be quite typical for current web-based questionnaires, (Deutskens *et al*., 2004 and Tobin *et al*., 2012). Although this sample group is not statistically representative of all new and perspective entrants to farming across the farming population in Northern Ireland, the results provide a useful insight into intentions and attitudes and the perceived barriers to entering farming from the perspective of this defined cohort group.

The average farm size was 40.8 hectares of owned land while 60 percent of respondents indicated that they also rented some land. The main enterprises of those surveyed[7] were beef cow enterprises, (50 percent), sheep, (22 percent), beef finishing, (12 percent), dairying, (11 percent), and other (i.e. pigs, poultry, arable (5 percent). Seventy six percent of those surveyed had some form of employment outside farming, with 78 percent working full-time, 19 percent working part-time (less than 30 hrs per week) and the remainder employed in casual/

[5] Standard labour unit = 1900 hours. In UK agricultural statistics, business size is described in terms of five SLR size bands (very small, small, medium, large, and very large).

[6] The course was delivered by the College of Agriculture Food and Rural Enterprise (CAFRE).

[7] The main enterprise being defined as the one which contributes most to farm business income.

seasonal employment. Fifty five percent of the respondents indicated that they work 30 hours or less per week on the farm, the majority of whom, 40 percent, work between 15 and 30 hrs per week on the farm. Eighty eight percent of the respondents were males and 12 percent were female. The average age of respondents was 35 years and had on average, attained a higher level of education compared to the wider farming population in Northern Ireland. The highest level of qualification for 17 percent of those surveyed was a professional qualification while a further 23 percent had a degree level qualification. In terms of farm ownership, the majority of the farms were owned by the respondent's family, 98 percent, with 55 percent being owned by the same family for more than sixty years. Forty eight percent of respondents self-reported that their role on the farm was both working on the farm and a 'joint-decision maker', mainly in conjunction with their father and/or mother. Twenty six percent of respondents described themselves as both working on the farm and being the sole decision maker. A fifth of respondents indicated that they were the current legal owners of the farm, with 74 percent indicating that they became owners through inheritance, the remainder, 26 percent having purchased the farm/land. Although a significant percentage, these land purchases could be within families as sales of farms land through private treaty, which is a common method of sale within the Irish agricultural market, (Jordan, 2019). Three quarters of respondents indicated that they had been making the day-to-day decisions on the farm for 5 years or less with 46 percent making the main day-to-day decisions on the farm for the last 1 or 2 years.

3. Results

Barriers to new farming entrants

Respondents who indicated that they would be interested in establishing a new enterprise in their own right on the existing farm were asked to rank the main difficulties/barriers which they thought they would encounter when establishing their new enterprise (Figure 1). Securing finance was identified as the main difficulty followed by the lack of profitability in existing farming enterprises and the availability of land.

Respondents were then asked to respond to a range of statements in relation to what they perceived to be some of the difficulties/barriers for young people entering farming. The responses are represented in Figure 2. Individuals owning farms but not actually farming (non-farming landowners) were considered the main barrier to young people wanting to farm. This is also reflected in the high number of responses agreeing or strongly agreeing with the statement, 'the current system of land letting through conacre[8] can make it difficult to get into farming and also impact on future medium to long term investment decisions'. Respondents indicated that although it had always been hard to get into farming in your own right as a young person, the perception is that it is now much harder compared to previous generations and, in reality, inheriting a farm was the main way that a young person could get into farming. There was also a perception that core farming skills are in danger of being lost, as young people choose not to farm, or farm in such a way that they do not build up and retain their knowledge and skills.

In relation to the barriers to pursuing farming and maintaining a sustainable farming business, respondents indicated that broader economic and social factors (beyond the availability of capital from banks, working capital, cash flow issues and the cost and availability of land) were important when considering farming as a career. For example, the availability of good off-farm employment opportunities locally, and how well farming fits in around a spouse's/partner's off-farm employment, and the overall attractiveness of farming as a career were identified as being important.

Figure 3 shows the perception towards different support and policy measures, which may assist new entrants to become established in farming. Financial support directed specifically at young farmers wanting to farm in their own right is the highest ranking response, however, there are positive responses to other aspects of support, particularly in relation to advice to both retiring farmers and new entrants, mentoring and farming partnership schemes for young farmers, more flexible approaches to the terms and taxation issues around land letting and support mechanisms to remove perceived barriers to retirement.

Farm transfer issues

Respondents were then asked an open-ended question

''When a farm is being passed on within the family from one generation to the next, what would you say the main difficulties are in achieving a smooth handover?''

Four distinctive themes emerged in the responses to this question:

(i) The future financial viability of the farm;
(ii) Inter-generational issues (i.e. between generations for example, children, parents and grandparents);
(iii) Issues across the current generation;
(iv) Issues around planning (financial and administrative).

The future financial viability of the farm

In terms of the concerns raised around the future financial viability of the farm respondents highlighted that: ''*If the farm has to be split up then it is no use as a farm*''. Other respondents indicated that if a farm has been run down leading up to retirement then financing new enterprises can be difficult: ''*It can be difficult now to get the finance required to launch the inherited farm as a new business*''. The ability of farms to support two families was also raised as an issue. ''*If the farm is not big enough young farmers take off-farm employment and their priorities change and their focus changes to work, young family etc. .... so parents end up staying at the helm longer*''. Concerns were also raised around the level of farm investment and associated debts as well as the lack of available working capital when the farm is handed on, so it is difficult for the next generation to make further investments. Although the younger generation may have been working on the farm on a day to day basis, there was an acknowledgement that this did not necessarily translate to them having full knowledge of the financial position of the farm business: ''*Lack of*

[8] Farm land rental in NI is based around a system of short-term leasing over an eleven-month period called, conacre. This system of rental arose as a result of the Irish Lands Act introduced between 1870 and 1925 aimed at bringing an end the landlord–tenant system and prevented long-term leasing.

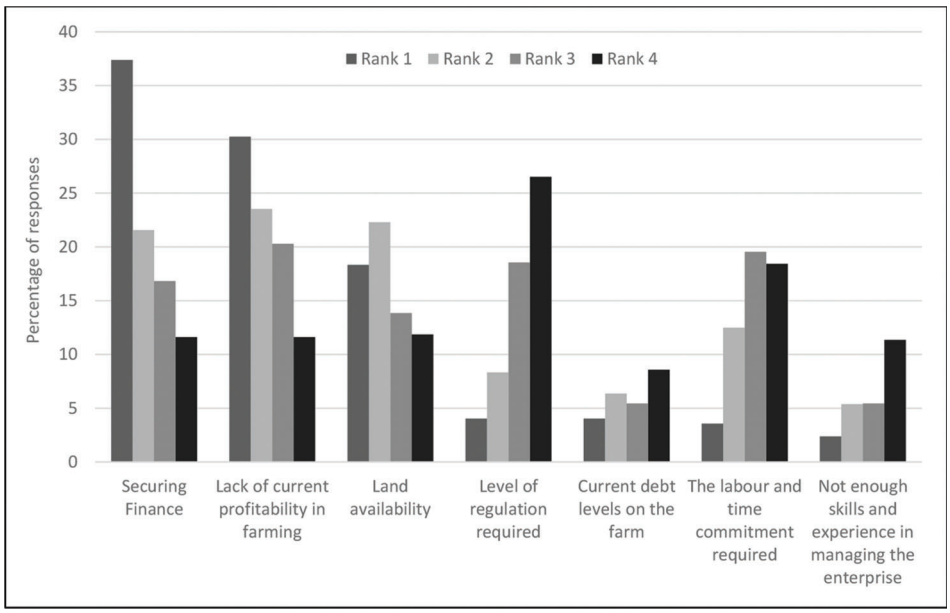

Figure 1: Perceived difficulties in establishing a new enterprise on an existing farm for new entrants

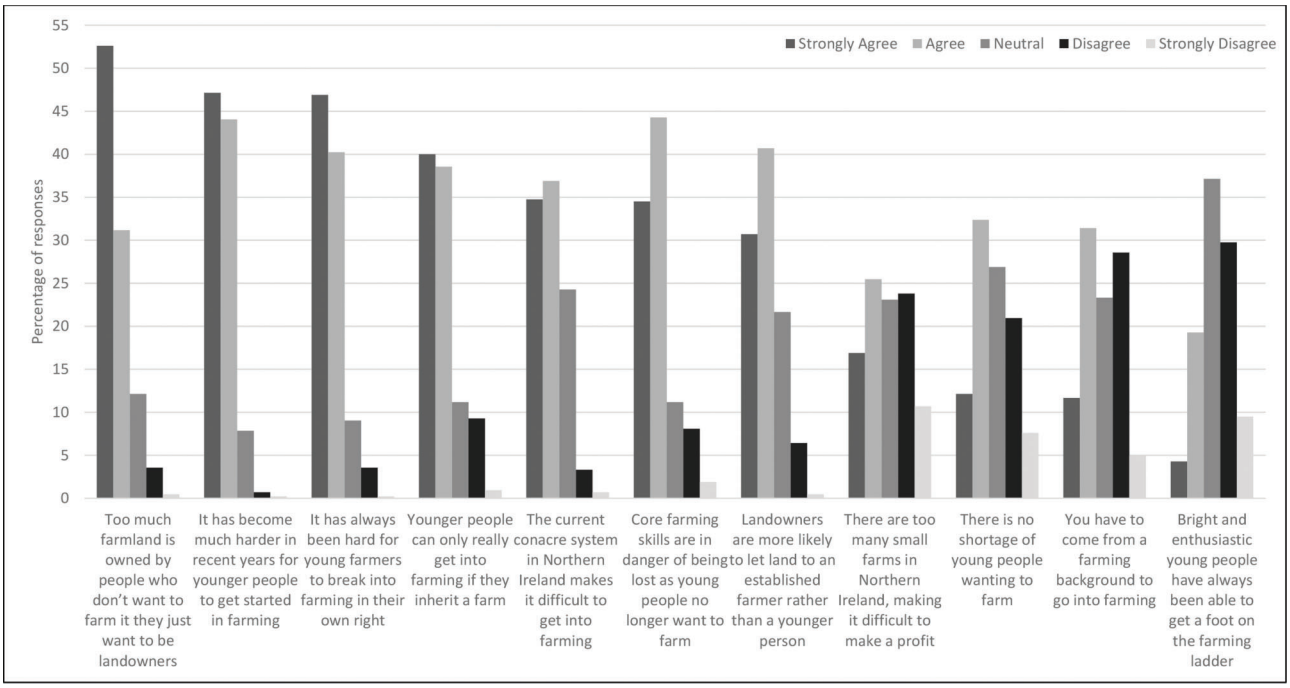

Figure 2: Attitudinal responses to 'percieved barriers/difficulties' for new entrants to farming

knowledge of the financial state of the business with creditors and in general....as information is not generally shared other than market prices on the day''. In addition, respondents highlighted that there may still be a need for the older generation to be provided with a retirement income from the farm business which can create additional pressure. The balance and difficulty of maintaining a smooth transition in the farm transfer process was also highlighted: ''*There is an overlap....retaining a level of financial security for the predecessor whilst ensuring that the new member is not overburdened with crippling debt*''.

Respondents highlighted that if a farmer chooses not to actively farm land that has been rented out in conacre over a number of years impacts on how the land has been maintained. These conacre rental agreements tend not to provide incentives for the renting farmer to make longer term decisions around land management and improvement compared to the land which they own themselves. Consequently, the respondents suggested that a higher level of investment would be needed to re-establish the land into production. This finding is supported by previous research undertaken in Ireland, (O'Donoghue *et al.*, 2015). A number of respondents highlighted that if the land is currently rented on conacre due to retirement it acts as a barrier for the next generation wanting to establish the farm again as a viable business: ''Getting entitlements, capital for farm improvement and sound

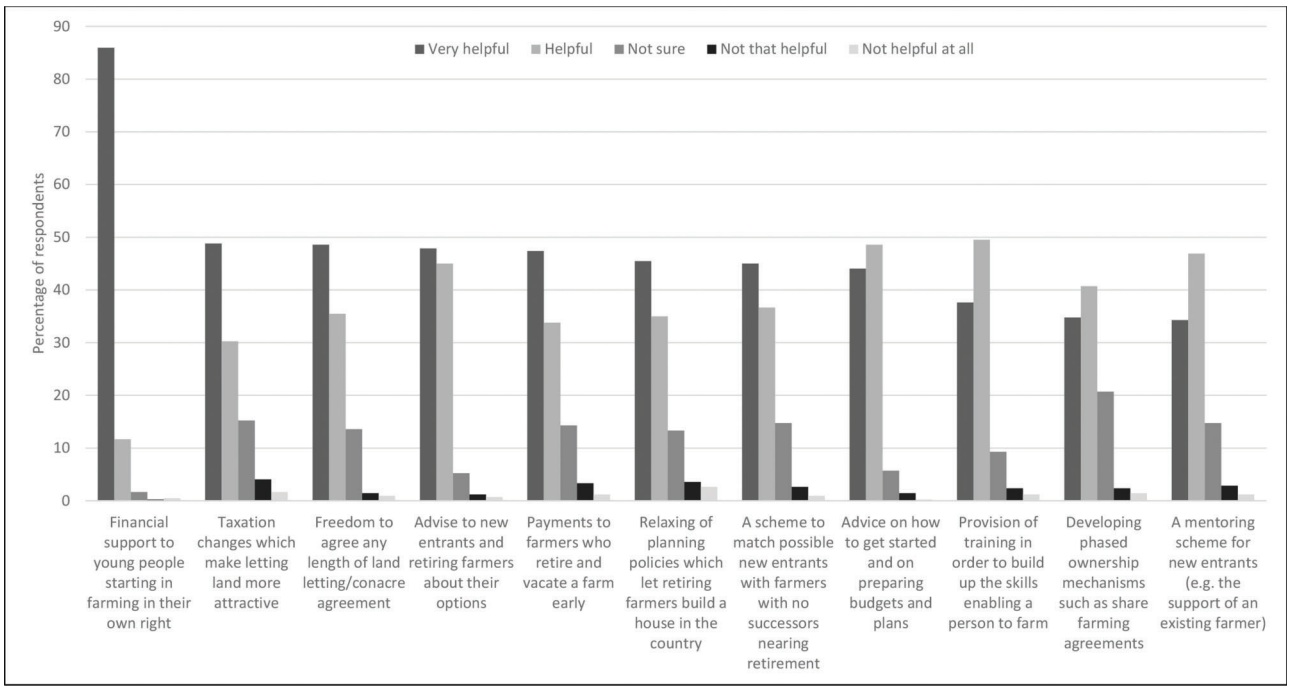

Figure 3: Helpfulness of measures to assist new entrants to become established in farming

advice are the biggest issues''. Finally, many respondents did feel that despite perhaps leading to: ''Awkward conversations which they would prefer to avoid,'' there needed to be more openness in communication between one generation and the next to discuss expectations and plans from all parties' perspectives.

Inter-generational issues

One of the main inter-generational issues was the timing around when the farm is handed over to a successor and this was viewed as crucial to the sustainability of the farm: ''*No point in receiving it (the farm) when you are in your forties or fifties you need it in your thirties to make good use of it*''. From the perspective of the person handing the farm on, respondents indicated that there can be concern around marital/partner break-ups and the financial impact that this could have on the future of the farm with the: ''*Farm having to be sold*''. The transfer of managerial control was also highlighted as an area of difficulty. A commonly occurring theme throughout the responses was the view that older generation farmers want to stay in control and make little changes to the way the farm business is run, while the younger generation want to take control and introduce new ways of doing things. ''*It is easier to let the farm be transferred on death as it avoids difficult situations,*'' and in contrast: ''*It is about getting complete control of the business at the right time....being able to bring new ideas and make your own decisions to enhance the business*''. However, it is evident this is an area where more discussion and guidance and perhaps facilitation by a third-party is required: ''*The person passing on the farm has to be comfortable and confident that the person taking over has the ability and maturity to take the farm on,*'' and: ''*In my opinion there needs to be more support and guidance offered on creating partnerships between father and son*''.

Issues across the current generation

The respondents to the survey did not indicate that there had been any difficulties or rivalry between other siblings in terms of the choice of the successor. This may be attributable to the fact that for those who responded to the survey, (their average age was 35 years), the decision on the farm around who would be the potential or actual successor had already been made. This would be in line with other research, which indicates that often, either directly or in directly, the choice of successor can happen at an early age (Schwartz, 2004).

However, issues arose across the current generation around who is family, when it comes to inheritance, how other siblings/in-laws may: ''*Want their cut,*'' or: ''*Need provided for,*'' and again the impact that this may have on the viability of the farm as a business. This was mainly perceived as disagreements amongst the siblings of those inheriting the farm and other: ''*Family disagreements about who gets what*''. Housing and the requirement for additional housing, or the provision of housing for other siblings, on the farm land was also identified as an issue. Furthermore, the relationship and tensions that may arise between farming and non-farming siblings was raised as an issue: ''*Family members with no interest in farming trying to sell it (land) to make a quick profit,*'' and: ''*Other members thinking that they must get a share from it, even if they have moved away and have no interest in farming*''.

Issues around planning (financial and administrative)

Timely and good financial planning and provision by the older generation makes handover much easier, (Wilkinson and Sykes, 2007; Winter and Lobley, 2016). In addition, difficulties were perceived in relation to business planning relating to, and around the area of, succession. For example: taxation issues (inheritance and

capital gains), the administrative burden around setting up a new farm business herd number, solicitors/accountants fees and land valuations. A number of respondents expressed difficulties around a lack of co-ordination amongst the various agencies when land is being transferred: "*When you inherit a farm the assumption amongst the agencies is that you know what to do and the rules*". Respondents indicated that the area of timely succession planning and advice around this is something where more guidance could be given and also that again impacts on both generations, i.e. the generation exiting farming and the new generation coming into farming, needed to be involved in that dialogue and advice.

4. Discussion

The majority of new entrants involved in this study were currently farming in some way, with their farming experience gained mainly from working on a family-farm. There was a general acknowledgement that farming has high start-up costs and outside of inherited or earned wealth, for someone wanting to go into farming, access is very difficult. Respondents predominately expressed that entry for them into farming will take place eventually through succession (where they take over the management of the family-farm business) and ultimately inheritance of some/or all of the family-farm business and assets. As with all businesses, the succession strategy, in terms of both the farm business and wider farm household priorities, will take account of the economic situation, family life cycle and preferences and attitudes of family members. Given this, the new entrants surveyed exhibited a range of strategies in relation to their farming activities and how they viewed the future potential of the farm business alongside other wider objectives. Examples of new entrant's strategies included: introducing new enterprises, intensifying production, diversifying into other enterprises or non-traditional farming enterprises or developing a pluri-active approach where farming is undertaken on a part-time basis as well as engaging in off-farm employment. Those respondents from smaller farms, particularly beef and sheep farms were more likely to be in and planned to remain in, off-farm employment.

For many of those surveyed, both the cost and availability of land was deemed a fundamental barrier to entering farming. In terms of land availability, the capitalisation of agricultural support payments into land values (under successive CAP reforms) has resulted in farmers being disinclined to sell land in the expectation of future gains (Jack *et al*., 2009). Even when land becomes available the current levels of farm profitability and capital constraints can impact on the ability to purchase land to allow for expansion (Hennessy and Rehman, 2007). Therefore, in a situation where a farmer wants to bring a potential successor into the farm business but needs to expand production/enterprises to allow for it to be profitable to do so, land availability is a limiting factor. The current conacre system was also raised as a concern in the current survey because it did not allow for longer-term strategies in relation to farm business planning. Furthermore, the authors also found concerns about both securing conacre land and the price of securing it as farmers remained uncertain about the impact of the implementation of current CAP reforms. In addition, new entrants in this survey indicated that farmers letting land took a: "*Better the devil you know,*" approach, that is they were more likely to continue to let it to existing established farmers rather than allow it to be taken up by a younger farmer who is a new entrant. The flexibility of land-letting agreements was raised as an important issue in the current survey in relation to the ability to expand farm enterprises or take on new enterprises. From a policy perspective, an assessment of the nature of and role of different types of land-letting agreements and support for the introduction and development of shared farming initiatives is something which should be explored. However, this should be viewed in the context that farmers may be reluctant to be seen as 'non-active'; or not involved directly in farming from the perspective of taxation regulations, particularly income, inheritance and capital gains tax relief, which may incentivise a farmer to remain active and in business (Hill and Cahill, 2007).

Historically, for rural areas in Northern Ireland, policymakers have tended to emphasise the need for employment generation and creation at a local level and rural development policies tended to focus on agriculture and agriculturally related industries, (Scott, 2004). However, the rural and the urban in terms of economic activity have shown a greater degree of integration and over recent years the rural economy has become more diversified, (Scott, 2004). This has brought significant change for indigenous rural families, and those surveyed did indicate the importance of the wider rural economy in terms of influencing their decision to farm.

Farm operator, spouse, or both face important decisions regarding maintaining the farm business, sourcing additional income and accessing off-farm employment. In 1997, for those farmers aged under 65 years of age, 30 percent had some other form of 'other gainful activity' and this had increased to 44 percent by 2016; an increase of almost a third, (DAERA, 2017). In the current survey, most respondents indicated that not only for themselves but for their spouse/partner, the ability to access good off-farm employment was important, this is reflected in DAERA (2017) which indicated that for all those farms were the farmer is under 65 years of age, 55 percent of households have either the farmer, the spouse or both engaged in off-farm employment. This trend towards a greater reliance on off-farm employment has broadened the context of farm household decisions, (Moss *et al*. 2004). Whilst farm businesses and households through their production and consumption activities on and off-farm contribute to the rural economy, a strong and diversified rural economy providing off-farm work as well as services is critical for the well-being of farm households for whom farming alone would not sustain an adequate household income (Jones *et al.*, 2009). Respondents indicated for succession to be successful on a farm, particularly those which may not be able to sustain two family households, off-farm sources of income and, in particular, income from off-farm employment is of vital importance in ensuring the sustainability of farms, particularly smaller farms. Household consumption demands and farm investment cannot be financed from the income generated by a small farm and off-farm income can remove the pressure of having to meet all family consumption needs from farming income and can have a smoothing out effect during periods of 'cash flow'

difficulties (Jack *et al*., 2009). These results support the idea that in terms of farm viability, family-farm households and farm business sustainability is intrinsically linked to the wider economic and social development of rural areas.

A key factor in the development of the family-farm business is planning farm succession. Researchers in the field of family businesses agree that the intergenerational transfer decision is one of the most important issues that family businesses can make (Brockhaus, 2004; Glover, 2011). A distinguishing feature of family-farm businesses is that farming is not just a job but a way of life, involving the wider family household so transferring management and subsequently ownership of a family-farm from one generation to the next is a crucial aspect of the sustainability of any farm business into the future. Projection of structural change in agriculture requires an understanding of the complex social and economic motives underlying household behaviour. Respondents indicated that one of the strong motivational factors for being in farming was to: ''*Keep the family name on the land*''. This response encapsulates the idea that the family-farm is not only a business but a family home (often incorporating a wider group of family members and siblings) and any transfer of resources can be difficult within this context. The responses within the survey reflected the difficulties of the very sensitive issue of succession and subsequent inheritance. A number of issues were raised around the provision for other siblings and whether or not the farm, in the short to medium term, could provide adequate financial resources to do this without compromising the long term viability and sustainability of the farm itself. This complexity of issues around farm succession was also found by Conway *et al*. (2017) who stated that a farmer's decision to retire can be affected by inter-generation conflict, the balance of power, the farmer's anxiety over their future security, a lack of confidence in their successor's ability or personal circumstances and reservations about the changes their successor would make.

Traditional gender roles in farming are reflected in the survey results; 12 percent of the respondents were women, the majority of which were farming part-time. In 2010, within the NI farming population 9 percent of farmers were women, (DAERA, 2018c) with 45 percent of the female farmers aged 65 or over compared with 35 percent of male farmers. Although primogeniture often characterises farm succession, increasingly as the nature of farming changes there is evidence that women are more involved in the farm decision-making processes. In the US, 62 percent of farm women who were of working age had off-farm jobs, providing an income that helps to support the household and indirectly farm investment. Findeis and Swaminathan 2002, identify that women who are involved in their own family farm are more likely to be involved in decision-making on the farm. In research undertaken in the UK by Glover (2014), using an ethnographic longitudinal case study, this identified the power struggle and gender issues in a small family-farm business, suggesting gender creates conflict not only in the business but also in the family. The case study focuses on the struggle of the single daughter position as a partner in the family-farm, in the context of her father's preference towards male farm employees. Gender stereotypes seems to hold in the agrarian context well into the 21st Century, males favoured over daughters. Shortall's research (2017) on gender roles in Irish farm households over a period of 25 years (1987 to 2012) argues that even though there are considerable changes in the gender relation with the farm household, farming as an occupation remains tied to gender and male farmer work identity. The focus group research suggested that women reinforce their husband's position as breadwinners, even when their off-farm employment income is the primary source of income in the farm household. The line of inheritance remains in place with both parents expressing concern for the future of the son in farming in the context of economic uncertainty around future viability of farms while their hope would be that the daughter, ''if she loves farming'' to ''marry into land'' (Shortall, 2017).

Succession planning within farm businesses involves a smooth financial transition from the older generation to the younger generation as well as considering factors such as, housing provision for a retiring farmer and adequate income provision in retirement, to ensure the long-term viability of the business. Poor succession planning can make it difficult to achieve a desirable level of income to provide for both households and young entrants can be often caught in a 'holding position' where they work off-farm with a view to taking over the management of the farm at a later date. However, rather than this being a short-term solution, this can continue indefinitely and as a number of respondents from this survey stated, this can lead to a change in objectives particularly in relation to the farm business and wider household objectives, which may make the probability of the farm being operated on a full-time basis less likely. Respondents indicated that the area of timely succession planning and advice around this was something where more guidance could be given with both generations involved in that dialogue and advice. Respondents showed support for this dialogue to be facilitated through the engagement of professional mediators with the involvement of other professionals (i.e. accountants and solicitors).

A key component of the EU agricultural policy agenda is to redress an ageing farm population by increasing the number of younger entrants to farming (European Commission, 2012). Younger farmers are deemed to be more innovative, better educated, and more open to adopting new technologies and innovations on the farm resulting at an overall aggregate level, in improved competiveness and productivity within the sector (Potter and Lobley, 1996; Lobley *et al*., 2010; Howley *et al*., 2012). However, an emerging issue is the understanding of the definition of young farmers, successors and/or new entrants to farming (Zagata and Sutherland, 2015). As the results of this survey show, for those who are successors and for those who are entering farming as new entrants there can be a range of ages and variety of circumstances under which succession can happen. Successors and/or new entrants can be farming on a part-time basis or they can be returning to farming after being away from farming for a number of years. They may have a high level of agricultural related training whilst others may have minimal agricultural training and/or experience. This is supported by Uchiyama (2014) who found that new entrants to farming can either be those who come 'back to home farms' from non-farming jobs (i.e. farmers' children or retired people); those who are 'new employees in farm businesses'; and those who 'create new farms'

(i.e. who do not succeed to farming through inheriting the management and ultimately the assets of the farm). There is no indication that a successor or a new entrant will necessarily be young as defined by the legislative framework of the CAP.

The wider demographic characteristics of new entrants including gender, age and educational achievement, alongside other key socio-economic variables, can have important influences on new entrants/young farmers' attitudes and behaviours around the future sustainability of the farm and at a broader level, how that impacts on the economic development of rural areas. Therefore, in the context of structural adjustment and informing the policy evidence base a better understanding is needed to explore the intentions of young farmers and new entrant farmers particularly in relation to their decisions to farm either full-time or part-time. Currently, Eurostat figures are limited in this area and do not provide the detail from which to explore who are the new entrants to farming. However, important decision-making processes and behaviours are on-going at the farm-level and there is merit from an evidence based policy perspective to investigating further how an individual's entry into farming comes about.

5. Conclusion

The results from this study, reflect the strong interaction which exists between 'family' and 'business' within the Northern Ireland farm sector and an appreciation of the difficulties which can be encountered in family-farm businesses, particularly in relation to the sustainability and viability of the farm as it moves from one generation to the next. There are a number of issues which can impact and influence new entrants to farming being successful. These issues include the profitability of the farm business, household factors, the age of the farmer when a successor is identified, the stage in the household lifecycle when a successor is identified, the dynamics of the family household and the role of the wider rural economy. All of these issues were raised within the context of the results of this survey, highlighting potential barriers to new entrants to farming in Northern Ireland and the influence this may have on the future trajectory of family-farms. In view of the undesirable structural rigidities that can arise due to the barriers to resource mobility identified in this study there is a public interest in facilitating positive structural change and an ongoing role for public policy to target some of the key constraints identified.

About the authors

Dr Claire Jack is a Principal Agricultural Economist at the Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland.

Dr Corina Miller is a Research Fellow at the Centre for Public Health, Queen's University Belfast, Belfast, BT12 6BJ, Northern Ireland.

Dr Austen Ashfield is an Agricultural Economist at the Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland.

Dr Duncan Anderson was formerly a Principal Agricultural Economist at the Agri-Food and Biosciences Institute (AFBI), Belfast, Northern Ireland.

Acknowledgement

The authors are grateful to the Department of Agriculture, Environment and Rural Affairs, who funded the research on which this article is based. The authors are grateful to the anonymous reviewers for their constructive comments on the original manuscript.

REFERENCES

ADAS (2004). Entry to and Exit from Farming in the United Kingdom. ADAS Consulting Ltd, Wolverhampton, UK.

Benavides-Velasco, C.A., Quintana-Garcia, C. and Guzman-Parra, V. (2013). Trends in family business research. *Small Business Economics*, 40, pp. 41-57. DOI: 10.1007/s11187-011-9362-3.

Bowman-Upton, N. (1991). Transferring Management in the Family-Owned Business, avaiable at: http://www.hispanicbic.org/docs/ManagementTransfer.pdf (accessed 15 August 2017).

Brockhaus, R.H. (2004). Family business succession: suggestions for future research. *Farm Business Review*, 17(3), pp. 165-177. DOI: 10.1111/j.1741-6248.2004.00011.

Caskie, P., Davis, J., Campbell, D. and Wallace, M. (2002). An economic study of farmer early retirement and new entrant schemes for Northern Ireland. Queen's University Belfast, Belfast, Northern Ireland.

Conway, S., McDonagh, J., Farrell, M. and Kinsella, A. (2017). Uncovering obstacles: The exercise of symbolic power in the complex arena of intergenerational family farm transfer. *Journal of Rural Studies*, 54, pp. 60-75. DOI: 10.1016/j.jrurstud.2017.06.007.

DAERA (2018a). Statistical review of Northern Ireland Agriculture 2017. Department of Agriculture and Rural Development, Dundonald House, Upper Newtownards Road, Belfast, Northern Ireland.

DAERA (2018b). The agricultural Census in Northern Irleand (Results for June 2018). Department of Agriculture and Rural Development, Dundonald House, Upper Newtownards Road, Belfast, Northern Ireland.

DAERA (2018c). Equality Indicators for Northern Ireland Farmers. Department of Agriculture and Rural Development, Dundonald House, Upper Newtownards Road, Belfast, Northern Ireland.

DAERA (2017). EU Farm Structure Survey 2016 Northern Ireland. Department of Agriculture and Rural Development, Dundonald House, Upper Newtownards Road, Belfast, Northern Ireland.

Davis, J., Caskie, P. and Wallace, M. (2013). Promoting structural adjustment in agriculture: The economics of New Entrant Schemes for farmers. *Food Policy*, 40, pp. 90–96. DOI: 10.1016/j.foodpol.2013.02.006.

Davis, P.S. and Harveston, P.D. (1998). The influence of family on business succession process: a multigenerational perspective. *Entrepreneurship Theory and Practice*, 22(3), pp. 31-53.

Dellapasqua, C., (2010). Young farmers and the EU's rural development policy. In *CEJA Conference on Multifunctional Agriculture*, 15 December 2010.

Deutskens, E., de Ruyter, K., Wetzels, M. and Oosterveld, P. (2004). Response Rate and Response Quality of Internet-Based Surveys: An Experimental Study. *Marketing Letters*, 15(1), pp. 21-36. DOI: 10.1023/B:MARK.0000021968.86465.00.

De Massis, A., Chua, J.H. and Chrisman, J.J. (2008). Factors preventing intra-family succession. *Family Business Review* 21(2), pp. 183-199. DOI: 10.1111/j.1741-6248.2008.00118.

European Commission (2012). EU Agricultural Economic Briefs. Generational Renewal In EU Agriculture: Statistical Background, Brief No 6. European Commission, DG Agriculture and Rural Development, Brussels, Belgium.

Eurostat Yearbook (2016). Europe in figures, Eurostat yearbook 2016. Eurostat, Luxemberg city, Luxemberg.

Findeis, J.L. and Swaminathan, H. (2002). Multiple job-holding among farm women: Off-farm work and on-farm work decison making using a bargaining approach. In *Annual Meetings of the American Agricultural Economics Association*, Long Beach, USA.

Glover, J.L. (2011). Resilient family firms in the rural landscape: the role of symbolic capital. In *34th Institute for Small Business and Enterprise Conference*, Sheffield, UK.

Glover, J.L. (2014). Gender, power and succesion in family farm business. *International journal of gender and entrepreneurship*, 6 (3), pp. 276-295. DOI: 10.1108/IJGE-01-2012-0006.

Hennessy, T.C. and Rehman, T. (2007). An investigation into factors affecting the occupational choices of nominated farm heirs in Ireland. *Journal of Agricultural Economics*, 58(1), pp. 61-75. DOI: 10.1111/j.1477-9552.2007.00078.

Hennessy, T. (2014). CAP 2014–2020 tools to enhance family farming: opportunities and limits. Prepared for the European Parliament's Committee on Agriculture and Rural Development, European Parliament, Brussels, Belgium.

Hill, B. and Cahill, C. (2007). Taxation of European Farmers. *Eurochoices*, 6, pp. 44-49. DOI: 10.1111/j.1746-692X.2007.00052.

Howley, P., O'Donoghue, C. and Heanue, K. (2012). Factors affecting farmers adoption of agricultural innovations: a panel data analysis of the use of artificial insemination among dairy farmers in Ireland. *Journal of Agricultural Science*, 4(6), pp. 171–179. DOI: 10.5539/jas.v4n6p171.

Jack, C.G., Moss, J.E. and Wallace, M.T. (2009). Is Growth in Land-based Wealth Sustaining Part-time Farming. *EuroChoices*, 8(3), pp. 29-36. DOI: 10.1111/j.1746-692X.2009.00143.

Jones, D., Moreddu, C. and Kumagai, T. (2009). The Role of Agriculture and Farm Household Diversification in the Rural Economy: Evidence and Initial Policy Implications. OECD Report, OECD, Paris.

Jordan, A. (2019). *Steady Prices High Uncertainty. Agricultural Land Price Report*. Irish Farmers Journal, March 2019.

Lobley, M., Baker, J.R. and Whitehead, I. (2010). Farm succession and retirement: Some international comparisons. *Journal of Agriculture, Food Systems, and Community Development*, 1(1), pp. 49–64. DOI: 10.5304/jafscd.2010.011.009.

Lockamy III, A., Carson, C.M. and Lohrke, F.T. (2016). An evaluation of key determinants preventing intra-family business succession. *Journal of Family Business Management*, 6(1), pp. 64-80. DOI: 10.1108/JFBM-01-2015-0002.

Matthews, A. (2014). *The agri-food sector*. In O'Hagan, J., Newman, C. (Eds.), The Economy of Ireland: National and Sectoral Policy Issues, 12th Edition. Gill and Macmillan, Dublin.

Milne, C. and Butler, A. (2014). Young Entrants to Farming: Explaining the Issues. Rural Policy Centre Policy Breifing. SRUC, Edinburgh, Scotland.

Moss, J.E., Jack, C.G. and Wallace, M. (2004). Employment location and associated commuting patterns for individuals in disadvantaged rural areas in Northern Ireland. *Regional Studies*, 38, pp. 121-136. DOI: 10.1080/00343400420001 90118.

Potter, C. and Lobley, M. (1996). Unbroken threads? succession and its effects on familyfarms in Britain. *Sociologia Ruralis*, 36(3), pp. 286–306. DOI: 10.1111/j.1467-9523.1996.tb00023.

O'Donoghue, C., Creamer, R., Crosson, P., Curran, T., Donnellan, T., Farrelly, N., Fealy, R., French, F., Geoghegan, C., Green, S., Hanrahan, K., Henchion, K., Kinsella, A., Magnan, A., Meredith, D., Murphy, P., Ní Fhlatharta, N., O'Donovan, M., O'Huallachain, D., Phelan, F., Richards, K., Ryan, M., Schulte, R., O'Sullivan, L., Spink, J. and Thorne, F. (2015). Drivers of Agricultural Land Use Changes in Ireland to 2025. Teagasc. 19 Sandymount Avenue, Dublin 4, Ireland.

Schwartz, U. (2004). '*To farm or not to farm*' Gendered paths to succession and inheritance. Transcations Publications, London.

Scott, M. (2004). Building institutional capacity in rural Northern Ireland: the role of partnership governance in the LEADER II programme. *Journal of Rural Studies*, 20(1), pp. 49-59. DOI: 10.1016/S0743-0167(03)00042-1.

Shortall, S. (2017). Changing Gender Roles in Irish Farm Households: Continuity and Change. *Irish Geography*, 50(2), pp. 175–191, DOI: 10.2014/igj.v50i1.1321.

Taylor, J.E. and Norris, J.E. (2000). Sibling relationships, fairness, and conflict over transfer of the farm. *Family Relations*, 49, pp. 277-283. DOI: 10.1111/j.1741-3729.2000.00277.

Tobin, D., Thomson, J., Radhakrishna, R. and LaBorde, L. (2012). Mixed-Mode Surveys: A Strategy to Reduce Costs and Enhance Response Rates. *Journal of Extension*, 50(6), pp. 1-6.

Uchiyama, T. (2014). Recent trends in Young People's Entry into Farming in Japan: An International Perspective. In the FFTC-RDA International Seminar on Enhanced Entry of Young Generation into Farming, Jeonju, Korea.

Venter, E., Boshoff, C. and Maas, G. (2005). The influence of successor-related factors on the succession process in small and medium-sized family businesses. *Family Business Review*, 18, pp. 283-303. DOI: 10.1111/j.1741-6248.2005.00049.

Ward, J.L. (2004). Perpetuating the Family Business. 50 Lessons Learned from Long-Lasting, Successful Families in Business. Palgrave Macmillan, New York.

Ward, J.L. (1997). Keeping the Family Business Healthy: How to Plan for Continuity Growth, Profitability and Family Leadership, Business Owner Resources. Marietta, Georgia.

Wilkinson, J. and Sykes L. (2007). A guide to Succession. Sustaining Families and Farms. Grain Research and Developmnt Cooperation, Cranberra, Australia.

Wilson, S., Marotz-Baden, R. and Holloway, D.P. (1991). Stress in two-generation farm and ranch families. *Lifestyles: Family and Economic Issues*, 12, pp. 199-216. DOI: 10.1007/BF00988670.

Winter, M. and Lobley, M. (2016). Is there a future for the small family farm in the UK? Report to The Prince's Countryside Fund, London: Prince's Countryside Fund. ISBN 978-902746-36-7.

Zagata, L. and Sutherland, L.A. (2015). Deconstructing the 'young farmer problem in Europe': towards a research agenda. *Journal of Rural Studies*, 2, pp. 39-51. DOI: 10.1016/j.jrurstud.2015.01.003.

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-65

How can dairy farmers become more revenue efficient? Efficiency drivers on dairy farms

BJØRN GUNNAR HANSEN[1], KATHRINE MOLAND[2] and MONICA ILSTAD LENNING[3]

ABSTRACT

The aim of this article is to identify a set of efficiency drivers which can explain differences in revenue efficiency between dairy farms. To explore farm efficiency, we apply stochastic frontier analysis on a balanced panel of 212 Norwegian dairy farms. The results show that on average the farms can increase the revenue from dairy by 28 percentage points. The article identifies important drivers of revenue efficiency which the farmer can change in the short or medium run to increase efficiency. Automatic milking systems, high beef production per cow, low age at first calving and organic farming are among drivers which can explain differences in revenue efficiency between farms. Our findings have implications for both management scholars, practitioners and policy makers.

KEYWORDS: farm efficiency; stochastic frontier function; farm management; panel data; automatic milking systems; beef production

Introduction

Efficient dairy farms are important not only to the farmer, but also to the society as such, because farms contribute to work opportunities, food security, rural viability and biodiversity in the countryside. Comparing farming literature shows that technical inefficiency is present in dairy farming (Zhu *et al*., 2012; Manevska-Tasevska *et al*., 2013; Areal *et al*., 2012; Barnes *et al*. 2011; Lawson *et al*. 2004; Heshmati and Kumbhakar 1994). The average efficiency and consequently profits can increase significantly if production is conducted with more intense use of inputs, or with combinations of inputs and outputs closer to optimum (see e.g. Lawson *et al*., 2004; Heshmati and Kumbhakar, 1994). Less is known about what the causes of inefficiency at the farm level are. Profitable and efficient farming can be said to depend on the so-called managerial factor (Rougoor *et al*., 1998) or the farmers' human and social capital (Hansen and Greve, 2015). Differences in operational and managerial practices of the farmer are particularly interesting because these actions are possible to change over a relatively short run. Consequently, identifying how differences in the operational work contribute to increased farm level efficiency is interesting, because it helps us understand how the inefficient farms can improve.

Norwegian dairy farmers participate in a program to monitor their economic performance, with Tine cooperative dairy company keeping a database of biological and financial data that indicates substantial differences exist among farmers. The data are collected for farm management, advisory and research purposes. The present research accessed Tine's database to see what may explain differences in farmers' revenue efficiency. The remainder of the paper is structured as follows: First, relevant literature data and methods are presented, then follows presentation of results, discussion and conclusion.

Literature review

The relationships between economic consequences and managerial practices on dairy farms have attracted attention in previous literature. Danish dairy farmers reporting higher frequencies of lameness, ketosis and digestive disorders were more technically efficient, while farmers reporting higher frequencies of milk fever were less efficient (Lawson *et al*., 2004). Technical inefficiency increases and allocative inefficiency decreases as the proportion of purchased feed rises (Hansen *et al*., 2005; Cabrera *et al*., 2010). The actual effects of subsidies on a producer's performance are complex and vary e.g. with production (Zhu *et al*., 2012). Similarly, while Kelly *et al*. (2013) found a positive contribution from specialization in dairy on technical efficiency, Brümmer (2001), Hadley (2006) and Hansson (2007b) found a negative effect. Technical efficiency is also positively related to the stocking rate (Kelly *et al*., 2013), the contribution of family labor, the use of a total mixed ration feeding

Original submitted February 2018; revision received April 2019; accepted May 2019.

[1] Corresponding author: Tine advisory service, Langbakken 20, Norway. Email: bjorn.gunnar.hansen@tine.no

[2] Email: kathrinemoland@gmail.com

[3] Email: monica.lenning@gmail.com

system, a low share of purchase feed and milking frequency (Cabrera *et al*., 2010). Further, technical efficiency is negatively related to farmer age and farm size (Rasmussen, 2010).

Milk yield has a positive effect on farm economic and technical efficiency (Hansen *et al*., 2005; Hansson, 2007b). However, the positive effect might be diminishing (Sipiläinen *et al*., 2009). Kumbhakar *et al*. (2009), Sipiläinen and Oude Lansink (2005), and Tiedemann and Latacz-Lohmann (2011) report lower technical efficiency on organic dairy farms than on conventional farms. However, Mayen *et al*. (2010) and Lansink and Pietola (2002) find no difference when they correct for the different technologies used. Finally, Haga and Lindblad (2018) find that organic farmers are more revenue efficient than conventional farmers. Farmer education, experience in farming and specialization contribute to efficiency on organic farms (Lakner and Breustedt 2015). Jiang and Sharpe (2014) report a significant negative relationship between capital intensity, livestock quality and cost efficiency. According to Allendorf and Wettemann (2015) a high percentage of losses, a high replacement rate and a long calving interval decreases technical efficiency, while a low age at first calving, high milk yield and high somatic cell count increases efficiency. Hansen *et al*. (2005) found that a low age at first calving, low forage-, insemination- and veterinary costs, a high fertility, milk quota filling and milk yield, and a high amount of beef produced per cow were hallmarks of economically efficient Norwegian farms. Similarly, Inchaisri *et al*. (2010) found a negative correlation between dairy farm profits and low reproductive efficiency. Finally, Steeneveld *et al*. 2012 found that automatic milking systems (AMS) do not affect technical efficiency as compared to conventional milking systems (CMS), while Hansen *et al*. (2019) find that AMS farms are more revenue efficient than CMS farms beyond 35-40 cows, but only after a transition period of four years.

Previous literature has focused little on factors that the farmer can easily change in the short-run to increase efficiency in the dairy farm operations. We denote these factors efficiency drivers. Further, except from Hansson (2007b) and Jiang and Sharp (2014), literature focusing on managerial practices and efficiency on dairy farms have focused mainly on technical efficiency, and not considered allocative and economic efficiencies. This is somewhat paradoxically, since cost efficiency and particularly allocative efficiency is considered the more problematic part of the profitability process (Hansson 2007b). Revenue efficiency is output oriented and considers both technical and allocative efficiency. Revenue efficient farmers maximize the output given the input factors available, and combine the outputs to maximize the revenue. Consequently, revenue efficiency gives us a better view of farm efficiency and how it is affected by the operational managerial practices than just technical efficiency. The aim of this paper is to identify a set of efficiency drivers which the dairy farmer can affect through managing the farm.

Material and methods

There are several approaches to analyze efficiency, both nonparametric and parametric ones. Within these categories, Data Envelopment Aanalysis (DEA) (Farrell, 1957; Charnes *et al*., 1978) and Stochastic Frontier Analysis (SFA) (Aigner, Lovell and Schmidt, 1977; Meeusen and van den Broeck, 1977) are the most common. According to Coelli *et al*. (2005) both DEA and SFA have their advantages and disadvantages, and there is no clear winner. As compared to DEA SFA allows for both unobserved variation in output due to shocks and measurement error as well as inefficiency, and according to Coelli (1995) shocks and errors can be a challenge in analyzing agricultural data. Therefore, we chose SFA in this study. Differences in efficiency can be explained by either a one-step SFA approach, or a two-step approach. However, the two-step approach has been criticized due to statistical inconsistencies (Kumbhakar and Lovell, 2000; Wang and Schmidt, 2002), and therefore we decided to use the one-step SFA approach.

SFA is a parametric method that makes use of econometric techniques to estimate the production frontier. The frontier in our setting characterizes the maximum output with various input combinations given a technology. Producers do not always optimize their production functions. Producers operating above the frontier are considered efficient, while those who operate under the frontier are considered inefficient. However, observations at the frontier does not necessarily have to be real producers, which means that even the most efficient ones can end up with an efficiency index below one. Because our main interest is the efficiency drivers, we want an output variable which reflects the value created in the dairy production. The Norwegian red breed is a combined breed, and thus it is important to include revenue from both beef and livestock in the output. Norwegian dairy farmers receive coupled subsidies which may constitute a significant part of farm revenue, particularly on small and medium sized farms. In the present study, we include the total subsidy amount received by the farmer related to dairy in the farm revenue or output, following Barnes (2008), Rasmussen (2011) and Manevska-Tasevska *et al*. (2016). Our choice to use total revenue from milk and beef production includes subsidies as output variable aligns with Kompas and Che (2006) and Allendorf and Wettemann (2015). The SFA estimates farm revenue efficiency by measuring the distance between the observed and the highest possible amount of output/ revenue that can be obtained, while keeping the amount of inputs fixed. Basically, the structure of our estimated model is equivalent to a production function, since price differences between farms are partly due to product quality differences. Regionally differentiated subsidies per liter milk also contribute to price differences.

To choose between fixed effects or random effects models a Hausman test was applied. The test showed no significant differences between the fixed and random coefficients ($p=0.275$), and thus the random effects model yields the most efficient estimates. Using a random effects model also has the advantage that the analysis can be performed in one step, as compared to the fixed effects model. Estimation of the stochastic frontier panel data under the random effects framework can be done by imposing distributional assumptions on the random components, and estimate the parameters by maximum likelihood. Thus, the inefficiency term u_i is truncated normally distributed from 0 and downwards. This ensures

that $u_i \geqslant 0$. Further we assume that the production frontier follows a Cobb- Douglas (CD) product function, which is commonly applied in agriculture (see e.g. Battese and Coelli, 1995; Pitt and Lee, 1981). In case of SFA it is possible to choose between several production function models: CD, CES, translog, generalised Leontief, normalized quadratic and its variants. The translog and the CD production functions are the two most common functional forms used in empirical studies of production, including frontier analyses (Battese and Broca 1997).

Compared to e.g. a translog production function, the CD is restrictive in the properties it imposes upon the production structure, such as an elasticity of substitution equal to unity. The translog also opens up for interaction effects between input variables and second order effects. On the other hand, the CD functional form is relatively easy to estimate and interpret. The wrong choice of production function may influence the results. However, while the absolute level of the technical efficiency is quite sensitive to distributional assumptions, rankings are less sensitive (Battese and Broca, 1997). In this study ease of estimation is important because we included up to 22 efficiency drivers in addition to the five input variables. Even with this relatively simple functional form we sometimes had trouble getting the model to converge. Further, ease of interpretation is important because our main interest is to explore the efficiency drivers, not the efficiency level per se.

Our one-step parametric SFA model with farms indexed i, and two periods 2012 and 2013, indexed t=1,2, is defined as

$$\begin{aligned}\ln(\text{total dairy revenues}_{it}) &= \beta_0 + \beta_1 \ln(\text{working hours}_{it}) \\ &+ \beta_2 \ln(\text{milk quota}_{it}) + \beta_3 \ln(\text{cowshed capacity}_{it}) \\ &+ \beta_4 \ln(\text{forage acreage}_{it}) + \beta_5 \ln(\text{variable costs}_{it}) \\ &+ \delta \text{year2013} + (v_{it} - u_i),\end{aligned} \tag{1}$$

where v_{it} is the error term, $v_{it} \sim N(0, \sigma_v^2)$ and $u_i \sim N^+(\mu, \sigma_u^2)$. We assume that the expected value of the inefficiency term μ is a function of the vector of the efficiency drivers $\mathbf{z}_m$ (m=1,…,22), and a vector of unknown coefficients γ_m

$$\mu = \gamma_0 + \sum_{m=1}^{M} \gamma_m z_m \tag{2}$$

In a SFA model with output- oriented specification, the inefficiency term u_i represents the log difference between the maximum attainable output and the actual output (Kumbhakar *et al*. 2015). After estimating the model, the JLMS estimator of inefficiency $E(u_i|\epsilon_i)$ (Jondrow *et al*. 1982; Kumbhakar and Lovell, 2000) is applied to estimate the inefficiency of each farm. Finally, each farm is assigned a revenue efficiency index based on the estimated value of u_i.

$$\text{Revenue efficiency} = e^{-E(u_i|\epsilon_i)} \tag{3}$$

The model (1) has a log- log form, and the estimated coefficients (β_1,…,β_5) can therefore be interpreted as elasticities, or the percentage change in total revenue as the corresponding input factor changes by one percent. By summing the estimated coefficients of the input factors one obtains the return to scale, or the percentage increase in total revenue as all input factors increase proportionally. Bayes Information Criteria (BIC) is used to choose between different models, and the model is estimated using STATA.

According to Statistics Norway (2013) the inflation rate was moderate, 1.6 percent from 2012 to 2013, and therefore we do not deflate the monetary values. Further, since the analysis comprises two years only, it is reasonable to assume time- invariant revenue inefficiency. Possible heteroscedasticity in SFA models is usually reduced when taking logs of the dependent variable. Thus, plots of the predicted variable against the residuals show no patterns indicating heteroscedasticity. When the distribution of inefficiency depends upon a set of efficiency drivers, it is important to check for possible correlation between the inputs and these drivers (Parmeter and Kumbhakar, 2014). For example, it could be that the inefficiency term is correlated with farm specific variables in terms of capital, land etc. A preliminary analysis shows a mean absolute value of the Pearson correlation coefficient of 0.137. This level is slightly above the limit of low correlation, and well below the limit of moderate correlation (Cohen, 1988). The absolute values range from 0.017 to 0.242, still well below the limit of moderate correlation (Cohen, 1988).

To aid the interpretation of the results and to identify the best practice in dairy farming, we apply the method used in Kompas and Che (2006) and Lien *et al*. (2007). First, we rank the farms according to their efficiency index. Then we define the lowest 25th percentile as the low efficient group (L), and the highest 25th percentile as the highly efficient group (H). The rest are in the medium efficient group (M). This classification yields three groups of 53, 53 and 106 farms respectively. We use t- tests and chi square tests to detect possible significant differences between the three groups.

Our data set is a balanced panel of 212 Norwegian dairy farmers in 2012 and 2013. Panel data have advantages over cross sectional data as it allows to control for unobservable heterogeneity (Schmidt and Sickles, 1984). Further, repeated measurement of each farm reduces the estimated standard errors of the estimates, which results in more reliable estimates. Farms with obvious irretrievable erroneous recordings, of a kind that might affect the results, were excluded. The study population covers most of Norway, with most farmers located in Eastern- Norway, Western- Norway and Mid-Norway. Altogether 22 percent of the farms are joint operations. A comparison of the study population and the average Norwegian dairy farms in 2012/2013 showed that while the farms in our panel have 31 cows and deliver 218770 liters of milk, the average Norwegian farm had 24 cows and delivered 148763 litres of milk. Thus, the farms in our study are slightly larger than the average Norwegian dairy farm.

Altogether five inputs are considered: labour, cowshed capacity, forage acreage, milk quota and total variable costs. Coelli *et al*. (2005) claim that labour and capital are the most important inputs in analyses of efficiency. Labour includes all hours worked by both family members and hired staff. Capital includes farm land, buildings, machinery and other manufacturing equipment. However, in the farm accountancy these assets are most often assessed for tax purposes, and therefore the

figures do not necessarily reflect their operational values. For example, choice of depreciation rate is often a result of adaptation to the tax scheme, and asset values and depreciation rest on historic costs. To deal with such problems Coelli *et al*. (2005) recommends use of proxies for capital. Thus, we use cowshed capacity, forage acreage and milk quota as proxies for capital. Following Hansen *et al*. (2005) cowshed capacity is used as a proxy for capital allocated to cowsheds. It is calculated based on the average number of animals in each age category in each year, multiplied by the space recommended for each animal relative to the space of a cow. It is expressed in cow units. A potential disadvantage of using this measure is that building capital and machinery capital are not necessarily fully proportional to the number of cows. However, we think it is at least as good as tax values. Forage is an important input factor in dairy farming, thus acreage of grassland included pasture is used as a proxy for capital. Acreage used for grain, vegetables etc. is left out because revenues and costs related to arable crops is not considered in this study. Further, milk quotas are important for determining farm revenues in Norway. Previous research has shown that some farmers do not manage to fill the milk quota, and this reduces their efficiency (Hansen *et al*., 2005). Quotas also represent a significant capital on dairy farms. Following Areal and Balcombe (2012) the farms' milk quota is used as a proxy for capital. Finally, total variable costs are included as an input. Variable costs include purchased concentrate, fertilizers, seeds, dairy consumables and veterinary and insemination costs. A possible limitation of our study is that we omit some fixed costs such as e.g. costs related to administration, book keeping, electricity, fuel, insurances, freight, maintenance of buildings and so on. We chose to do so because our main interest is to identify efficiency drivers related to the production of milk and beef itself. In that respect we think the most relevant fixed costs are represented in our study.

Based on our professional knowledge and literature findings we explore the following efficiency drivers: age of cows at first calving, insemination costs per litre milk delivered to dairy, percentage of milk quota delivered to dairy (quota filling), milk yield in kilogram energy corrected milk (ECM), milk quality payment, purchased concentrate in percentage of all feed, and kilogram beef produced per cow per year included fattening of bull calves. A high age at first calving increases total forage consumption, and if we assume that the milk yield does not increase beyond e.g.24 months, this reduces farm efficiency. High insemination costs might indicate problems with detecting cows in heat, and thus reduced efficiency. A low milk yield or bad milk quality payment may indicate e.g. bad forage quality or bad management, which also reduces efficiency. Contrary, a low share of concentrate may signal a good forage quality and good management, which increases efficiency. A high beef production per cow indicates that the farmer utilizes the opportunity to increase revenues by producing beef on male calves. A preliminary analysis showed a low correlation coefficient between kilogram milk per cow and kilogram beef produced per cow (r=0.08). We include dummy variables for farms that had an AMS before 2012, and for those who installed AMS during 2012 or 2013. Similarly, we include dummy variables for the twenty organic farms included and for district subsidy. The subsidy zones F to J include most parts of Northern Norway. Although the climatic conditions for dairy farming and zone subsidy vary within Northern Norway, we decided to merge the farms in these zones to obtain enough farms in each group for the statistical analysis. In a preliminary analysis, we compared the organic farms and the conventional farms using one-way analysis of variance. The analysis showed that the organic farms have significantly larger acreage and milk quota, lower beef production per cow and lower variable forage costs, as compared to the conventional farms. All differences were significant ($p < 0.05$). Descriptive statistics of the output variable, the input variables and the efficiency drivers are given in Table 1.

Results

In Table 2 we can see that the average JMLS-estimator $E(u_i|\epsilon_i)$ is estimated to 0.33, with a minimum of 0.09. Similarly, the average revenue efficiency (e^{-JLMS}) is estimated to 0.72, with a minimum of 0.56 and a maximum of 0.91. Approximately five percent of the farms have an index below 64 percent, while approximately five percent of the farms are relatively efficient, with an index above 80 percent. In Table 2 we present the result of the stochastic frontier analysis, and in Table 3 the averages of the efficiency drivers are given.

The variance parameters reported are only used in estimating the efficiency. All output elasticities of the input factors are significantly greater than 0, which means that they are positively correlated with total revenue (Table 2). However, we notice that most elasticities are rather low. The calculated return to scale implies that one percent increase in all input factors increase total revenue by 0.9 percent. A one- sided Wald test rejected the null hypothesis of constant returns to scale. Thus, there is decreasing returns to scale in Norwegian dairy farming. Inspecting the coefficients of the inputs we notice that milk quota has the largest output elasticity, followed by cowshed capacity, variable costs, forage acreage and working hours. Therefore, an increase in milk quota will affect total revenue the most. We also tried to include machinery costs related to forage production as an input in the model, but the coefficient for this variable was not significantly different from zero. In Table 2 we also include the efficiency drivers which have a significant impact on the efficiency indexes. A negative coefficient indicates that an increase in the variable has a positive impact on efficiency, it reduces farm inefficiency. Increasing age at first calving, share of purchased concentrate of all feed and increasing insemination costs reduce efficiency. Contrary, an increase in milk yield, percentage of quota delivered to dairy and quality payment increases efficiency. A similar effect can be observed from increasing beef production per cow. Our results also indicate that farmers who invested in an AMS before 2012 are more efficient than farmers who installed AMS during 2012 or 2013, and farmers with CMS. Further, our findings suggest that organic farms and farms in the district subsidy zones F, G, I and J are more revenue efficient than the others. In addition to the variables mentioned, we also tried other variables which did not have a significant effect on efficiency. These variables were: herd fertility status, forage yield per 0.1 ha, calf mortality, no of veterinary

Table 1: Descriptive statistics of the output variable, the input variables and the efficiency drivers

Variable	Unit	Mean	Std. dev.	Min.	Max
Total farm revenue	NOK[1]	1 996 459	1 074 887	447 122	7 215 143
Labour	Hours	3 242	1 114	1 166	8 683
Cowshed capacity	Cow units	55.4	32.4	10.6	197.4
Forage acreage	Hectares	37.3	23.7	9.6	190.6
Milk quota	Litres	234 949	144 183	43 910	773 000
Variable costs	NOK	660 928	374 753	110 427	2 283 000
Efficiency drivers					
Age at first calving	Months	25.8	2.1	20.8	42.9
Insemination costs	NOK/litre	0.14	0.04	0.01	0.30
Quota filling	%	93.8	10.6	39.1	124.9
ECM per cow	Kg	7 750	880	5 084	10 006
Quality payment	NOK/litre	0.60	0.14	0.19	1.01
Beef produced per cow	Kg	259	123	21	935
Concentrate of total feed	%	41	7	17	63
Dummy variables	No of farms and share of total				
AMS installed before 2012	36 (0.17)				
AMS installed 2012/2013	19 (0.09)				
Organic farming	20 (0.09)				
District subsidy zone					
A and B	80 (0.38)				
C	45 (0.21)				
D	34 (0.16)				
E	27 (0.13)				
F, G, I and J	26 (0.12)				

[1] 1 NOK corresponds to 0.11 €.

treatments per calf, veterinary costs, amount spent on advisory services and joint farming operations.

In Table 3 we compare the estimated average values of the efficiency drivers for each of the three groups of farms ranked after efficiency. In group L, the efficiency index is below 68 percent, in group M between 68 and 75 percent, and in group H beyond 75 percent. In Table 3 one can see that quota filling, kg ECM per cow and beef produced per cow are significantly higher in the H group, as compared to the two other groups. For an average farm in the sample, the difference in quota filling between the H group and the L group amounts to 84370 NOK per year, given the mean milk revenue minus feed costs in the sample. Similarly, the difference in kg beef produced per herd between the two groups amounts to 3131 kg per year on an average farm. Given the sample mean of beef revenue minus variable feed costs this difference amounts to 77 962 NOK per year.

The average age at first calving is significantly lower in the H group as compared to the L group. Group H also tends to have lower age at first calving as compared to the M group, but the difference is smaller. Further, the H group has lower insemination costs as compared to the L group. The farms in the L group achieve significantly lower quality payment as compared to the two other groups. For an average farm the differences between the L group and the H group amounts to 12 032 NOK per year. However, the average share of concentrate of total feed does not differ significantly between the groups. The frequency of automatic milking systems (AMS) installed prior to 2012, and the frequency of organic farms are higher in the H group, as compared to the two other groups. Finally, there are more farms in the district zones E, F, G, I and J in the H group, than in the L group.

Discussion

The findings reported here indicate that there are diminishing returns to scale in Norwegian combined milk and beef production, and the return to scale in our study is in line with the findings in Haga and Lindblad (2018). In our sample, total subsidies received is negatively correlated with no of cows per farm, and this can explain why our study differs from studies reporting constant returns to scale (Lawson *et al.*, 2004; Kompas and Che, 2006, and Cabrera *et al.*, 2010). Our finding is as expected since subsidies are included in the revenue and some of the rates in the subsidy scheme decrease with increasing number of cows and acreage. The relationship between the sizes of the output elasticities reported in this study is comparable to the findings in Lawson *et al.* (2004). On average, each farm in our sample can increase the total revenue by 28 percentage points, given the input factors. Thus, many farms have a potential to increase their revenue efficiency. However, to become 100 percent efficient, the farmer must apply best practice on all the efficiency drivers, which is demanding. Further, we agree with Lawson *et al.* (2004) that an average efficiency index in one study cannot easily be compared to other studies. Our finding that the output elasticity for milk quota is the highest relates to that since 2012/2013 many farms have increased their milk production by buying or renting milk quota. Much of the increased production needed to expand milk production has been possible due to increased milk yield per cow, from 7 509 kilogram to 8 374 kilogram per cow (Tine, 2018). In the same period the number of cows has increased by 4.2 (ibid.).

Table 2: Results from the stochastic frontier analysis

	Coefficients		Std. error
Input factors[1,2]			
ln(working hours)	0.029**		0.012
ln(cowshed capacity)	0.240***		0.028
ln(forage acreage)	0.073***		0.011
ln(milk quota)	0.353***		0.032
ln(variable costs)	0.209***		0.022
Efficiency drivers			
Age at first calving	0.007***		0.002
Insemination costs	0.256***		0.077
Quota filling	-0.005***		0.001
Kg ECM per cow (in 1000)	-0.009*		0.005
Quality payment	-0.089***		0.026
Kg beef produced per cow (in 100)	-0.026***		0.005
Concentrate, share of total feed	0.158**		0.062
AMS before 2012	-0.030***		0.011
Organic farming	-0.132***		0.011
District zones A and B	0.126***		0.011
District zone C	0.102***		0.011
District zone D	0.068***		0.011
District zone E	0.064***		0.012
Log- likelihood value[3]	675.3		
Variance parameters			
ln σ_u^2	-7.233***		0.263
ln σ_v^2	-6.317***		0.100
	Mean	**Max.**	**Min.**
JMLS- estimator ($E(u_i\|\epsilon_i)$)	0.33		
Income efficiency (e^{-JLMS})	0.72	0.91	0.56

*p ⩽ 0.10, **p ⩽ 0.05, ***p ⩽ 0.01.

[1] Interpretation of the constant term is not meaningful when we estimate the efficiency drivers in the same model, and therefore we do not show it. As a robustness check, we also estimated the model without an intercept. The results of this check is not reported as the coefficients are at the same order of magnitude as the ones reported in Table 2. The results are however, available from the authors on request.

[2] The model also includes a time dummy variable to capture changing climate conditions and other factors which affects each farm equally. The time dummy is significantly greater than one (p⩽0.05).

[3] The log- likelihood value and number of parameters are used in BIC-tests to find the optimal model.

The drivers identified and the figures for the H- group can be interpreted as the best practice in dairy farming (Table 3). High age at first calving implies a high feed consumption during the rearing period, and postponed milk revenue, which reduces farm efficiency. Our finding that the H group has lower age at first calving is in line with the findings of Lawson *et al.* (2004), Hansen *et al.* (2005) and Allendorf and Wettemann (2015). High insemination costs reduce revenue efficiency, in line with the findings of Hansen *et al.* (2005). This can indicate bad reproductive performance in the herd, leading to e.g. involuntary culling of cows, long calving intervals and fewer calves for beef production. The findings reported here support the findings of Hansen *et al.* (2005) and Allendorf and Wettemann (2015).

The milk yield in group H is approximately 600 kg lower as compared to the L group. Given a fixed milk quota, a high milk yield requires fewer cows, and thus fewer hours of work and less space needed in the cowshed. Our finding is in line with the findings of Hansen *et al.* (2005), Hansson (2007), Sipiläinen *et al.* (2009) and Allendorf and Wettemann (2015). However, when interpreting the positive effect of milk yield on efficiency, one should keep in mind that the coefficient for milk yield in Table 2 is significant at the ten percent level only.

The H- group achieves 0.055 NOK lower quality payment per liter milk as compared to the L- group. Under the Norwegian milk payment scheme farmers get extra paid for low bacteria and somatic cell counts, and for contents of protein and fat above average. Thus, it is important for farmers to adapt to the payment scheme to be revenue efficient. Our finding is in line with the finding of Hansen *et al.* (2005). A high quota filling also increases revenue efficiency. The quota filling in the L group is remarkably low. The low quota filling relates to the low milk yield in the L group as compared to the H group.

Farms in group H have significantly higher revenue from beef production than farms in the L group. Beef production requires relatively few hours of labour and little forage as compared to milk production, and the farmer can use the same cowshed and the same forage machinery as for the dairy cows. Our findings are in line with the findings of Hansen *et al.* (2005), and studies reporting negative effects on efficiency from specialization in dairy (Brümmer, 2001; Hadley, 2006; Hansson, 2007a).

Table 3: Average values of the farm efficiency drivers in each efficiency group

Efficiency drivers	Unit	Efficiency index group			Significant differences		
		Low (L) < 68 %	Medium (M) 68-75 %	High (H) > 75 %	L-M	L-H	M-H
Age at first calving	Months	26.6	25.7	25.4	***	***	*
Insemination costs	NOK/l	0.149	0.145	0.139	-	*	-
Quota filling	%	86.3	95.5	97.7	***	***	**
ECM per cow	Kg	7394	7802	8003	***	***	**
Quality payment	NOK/l	0.568	0.608	0.623	***	***	-
Beef produced per cow	Kg	205	261	306	***	***	***
Concentrate of total feed	%	40.3	40.9	40.2	-	-	-
AMS before 2012	%	15.1	13.2	26.4	-	***	***
Organic farming	%	1.9	5.7	24.5	*	***	***
District zones A and B	%	52.8	35.8	26.4	***	***	**
District zone C	%	20.8	26.4	11.3	-	**	***
District zone D	%	11.3	17.9	17.0	*	-	-
District zone E	%	11.3	10.4	18.9	-	*	**
District zones F, G, I, J	%	3.8	9.4	26.4	**	***	***

*p ⩽ 0.10, **p ⩽ 0.05, ***p ⩽ 0.01.

Similar to the findings of Mishra and Lovell (2007) and Hansen *et al.* (2005) we find that a low share of concentrate improves farm efficiency. The H group produces approximately 600 kilogram more milk per cow on the same share of concentrate. This indicates a better management and a significantly better forage quality in the H group as compared to the L group. Under Norwegian conditions, variable roughage costs per energy unit feed are significant lower than the concentrate costs. Normally substitution is therefore profitable, but the degree of substitution depends on the roughage quality. Thus, good quality roughage in sufficient amounts appears to be an important strategy to maintain efficient dairy farm production, in line with the findings of Charbonneau *et al.* (2011).

Our findings show that farmers who invested in AMS before 2012 are more efficient than others. It might take some time before farmers with AMS utilize the efficiency potential. Thus, our finding indicates that there are learning costs involved, similar to the findings reported by Sauer and Latacz- Lohmann (2015), Hansen (2015), Hansen and Jervell (2014) and Hansen *et al.* (2019). However, neither the specific capital costs, nor the operating costs related to the AMS was available in this study. Therefore, one cannot conclude that farms with AMS are more revenue efficient as compared to farms with CMS based on this study only. The study of economic efficiency of AMS merits careful consideration and is a topic for a special study, see e.g. Hansen *et al.* (2019) for an example.

Almost one quarter of the farms in the H group are run organic. Our finding relates to the findings reported by NIBIO (2013), that organic farms achieve a higher return to labour as compared to conventional farms due to higher milk price, higher subsidies and lower costs. In 2012 and 2013 the organic farms were paid 0.75 NOK extra per litre milk. Low variable forage costs also contribute to efficiency. They also received slightly more subsidies, although this difference alone cannot explain the difference in efficiency. On the other hand, the organic concentrate is more expensive than the conventional. The findings reported here support the finding of Lansink *et al.* (2002), but are contrary to those reported by Kumbhakar *et al.* (2009), Sipiläinen and Oude Lansink (2005) and Mayen *et al.* (2009). The reason might be that these studies focus on technical efficiency, and do not take revenue efficiency into account. Future studies could also consider other possible explanatory variables such as differences in education (Koesling *et al.*, 2008; Latruffe and Nauges, 2013) and intrinsic motivation (Rigby *et al.*, 2001) between organic and conventional farmers.

The findings in this study indicate that farms in less favorable areas (district zones F, G, I and J) are more revenue efficient. District subsidy is intended to even out differences in climatic conditions and higher prices of input factors due to e.g. transportation costs. Our analysis does not cover all costs the subsidy scheme is supposed to compensate for, thus one cannot conclude whether farms in these zones are over- compensated for their disadvantages or not.

One can draw some policy implications based on our results. First, our results indicate that for dairy farmers it is profitable to combine production of milk and beef. The bull calves are already in place and feeding them requires relatively little extra work. Further, little extra equipment and machinery is needed, neither in the cowshed nor on the fields. In recent years, the number of dairy cows in Norway has decreased, and this decline has not been compensated by an equivalent increase in the number of suckler cows (Hegrenes *et al.*, 2009). Manevska-Tasevska *et al.* (2013) describe similar challenges with keeping up beef production in Sweden, thus our results are relevant also for other Nordic countries. Taken together our findings suggest that the government should consider a policy which better facilitates farm expansion for production of both milk and beef together. Further, our results indicate that organic farmers are more efficient than conventional ones, a topic more thoroughly treated in Haga and Lindblad (2018). Their findings also suggest that organic farmers are more revenue efficient than conventional farmers.

The data in this study are from 2012 and 2013. Meanwhile the differentiation of headage and acreage payment has been changed, and this might have influenced how revenue varies with inputs as measured in this paper. For example, the headage payment for youngstock is no longer limited to the first 250 animals, and the rate for acreage payment for forage is no longer differentiated by the number of 0.1 ha. These changes may have influenced the results of this study, in favor of larger farms. Finally, a new headage payment favoring small and medium sized farms was introduced from 2019 on, and this may somewhat dampen this effect.

Conclusion

Norwegian dairy farms above average size can increase their total revenue by 28 percentage points, given their input factors. There are diminishing returns to scale in Norwegian dairy farming due to the structure of the subsidy scheme. The most important efficiency drivers are: A low age at first calving, low insemination costs, a low share of concentrate out of total feed, a high quota filling and beef production per cow, a high milk yield and quality payment, and organic farming. The comparison of different milking systems suggests that farms with AMS are more efficient than farms with CMS, and that there are learning costs involved in the transition from CMS to AMS. Our findings that combined milk and beef production, and organic farming increases revenue efficiency have implications for policy makers.

About the authors

Bjørn Gunnar Hansen works as a researcher at Tine SA. He holds master degrees in agricultural science and economics and a PhD in economics.

Kathrine Moland holds a master's degree in Norwegian School of Economics.

Monica Ilstad Lenning holds a master's degree in Norwegian School of Economics.

Acknowledgement

The authors want to thank Øivind Anti Nilsen at Norwegian School of Economics for valuable discussions and comments, and Andrè Brockstedt Myrseth at Tine for help with facilitating the data set.

REFERENCES

Aigner, D., Lovell, C.A.K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6:21–37.

Allendorf, J.J. and Wettemann, P.J.C. (2015). Does animal welfare influence dairy farm efficiency? A two-stage approach. *Journal of Dairy Science*, 98:7730–7740. https://doi.org/10.3168/jds.2015-9390

Areal, F.J., R. Tiffin, R. and Balcombe, K. (2012). Farm technical efficiency under a tradable milk quota system. *Journal of Dairy Science*, 95:50–62. https://doi.org/10.3168/jds.2011-4638

Balcombe, K., Fraser, I. and Kim, J.H. (2006). Estimating technical efficiency of Australian dairy farms using alternative frontier methodologies. *Applied Economics*, 38:2221–2236. https://doi.org/10.1080/00036840500427445

Barnes, A.P., Revoredo-Giha, C. and Sauer, J. (2011). A meta-frontier approach to measuring technical efficiencies across the UK dairy sector. Paper prepared for the 122nd EAAE Seminar "Evidence- based Agricultural and Rural Policy making: Methodological and empiral challenges of policy evaluation, Ancona, February 17–18, 2011. http://ec.europa.eu/agriculture/rica/pdf/EU_FEO_FADN_2011_web.pdf

Battese, G.E. and Coelli, T. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20:325–332.

Battese, G.E. and Broca, S.S. (1997). Functional Forms of Stochastic Frontier Production Functions and Models for Technical Inefficiency Effects: A Comparative Study for Wheat Farmers in Pakistan. *Journal of Productivity Analysis*, 8:395–414.

Brümmer, B. (2001). Estimating confidence intervals for technical efficiency: The case of private farms in Slovenia. *European Review of Agricultural Economics*, 28:285–306. https://doi.org/10.1093/erae/28.3.285

Cabrera, V.E., Solís, D. and del Corral, J. (2010). Determinants of technical efficiency among dairy farms in Wisconsin. *Journal of Dairy Science*, 93:387–393. https://doi.org/10.3168/jds.2009-2307

Charbonneau, É., Oba, M. and Pellerin, D. (2011). The Impact of Forage Use and Quality on Economic Returns of Canadian Dairy Farms. *WCDS Advances in Dairy Technology*, 23:349–359

Charnes, A., Cooper, W. and Rhodes, E. (1978). Measuring the Efficiency of Decision Making Units. *European Journal of Operational Research*, 2:429–444.

Coelli, T.J. (1995). Recent Developments in Frontier Modelling and Efficiency Measurement. *Australian Journal of Agricultural Economics*, 39:219–245.

Coelli, T.J., Rao, D.S.P., O'Donnell, C.J. and Battese, G.E. (2005). *An Introduction to efficiency and productivity analysis*, (2nd ed.). Springer, New York, USA. https://doi.org/10.1007/b136381

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences, 2nd Edition, Hillsdale, Lawrence Erlbaum, USA*

Farrell, M.J. (1957). The Measurement of Productive Efficiency. *Journal of the Royal Statistical Society. Series A (General)*, 120:253–290.

Haga, H. and Lindblad, K. (2018). Profitability in organic and conventional farming. Master thesis. *Norwegian School of Economics*

Hansen, B.G. (2015). Robotic milking-farmer experiences and adoption rate in Jæren, Norway. *Journal of Rural Studies*, 41:109–117. https://doi.org/10.1016/j.jrurstud.2015.08.004

Hansen, B.G. and Greve, A. (2015). The role of human and social capital in dairy farming. *Rural Society*, 24:154–176. https://doi.org/10.1080/10371656.2015.1060718

Hansen, B.G. and Jervell, A.M. (2014). Change Management in Dairy Farming. *International Journal of Sociology of Agriculture and Food*, 22:23–40.

Hansen, B.G., G. Stokstad, A. Hegrenes, Sehested, E. and Larsen, S. (2005). Key Performance Indicators on Dairy Farms. *Journal of International Farm Management*, 3:1–15.

Hansen, B.G., Herje, H.O. and Höva, J. (2019). Profitability on dairy farms with automatic milking systems compared to farms with conventional milking systems. *International Food and Agribusiness Management Review*, 22:215–228.

Hansson, H. (2007a). Strategy factors as drivers and restraints on dairy farm performance: Evidence from Sweden. *Agricultural Systems*, 94:726–737. https://doi.org/10.1016/j.agsy.2007.03.002

Hansson, H. (2007b). The links between management's critical success factors and farm level economic performance on dairy farms in Sweden. *Acta Agriculturae Scandinavica. Section C, Food Economics*, 4:77–88. https://doi.org/10.1080/16507540701415019

Hansson, H. (2008). How can farmer managerial capacity contribute to improved farm performance? A study of dairy farms in Sweden. *Acta Agriculturae Scandinavica Section C*, 5:44–61. https://doi.org/10.1080/16507540802172808

Hansson, H., Larsén, K. K. and Öhlmér, B. (2010). *Drivers and Restraints for Economically Efficient Farm Production*. *Nova Science Publishers, Inc., New York, USA*

Hegrenes, A., Hansen, B.G. and Mittenzwei, K. (2009). Production changes on dairy farms- consequences for beef production and resource use. Report no 2 Oslo: Norwegian Institute of Bioeconomic Research.

Heshmati, A. and Kumbhakar, S.C. (1994). Farm heterogeneity and technical efficiency: Some results from Swedish dairy farms. *The Journal of Productivity Analysis*, 5:45–61.

Inchaisri, C., R. Jorritsma and H. Hoegveen. 2010. Economic consequences of reproductive performance in dairy cattle. *Theriogenology*, 74:835–846. https://doi.org/10.1016/j.theriogenology.2010.04.008

Jiang, N. and Sharpe, B. (2014). Cost efficiency of dairy farming in New Zealand: A stochastic frontier analysis. *Agricultural and Resource Economics Review*, 43:406–418. https://doi.org/10.1017/s1068280500005517

Kelly, E., Shalloo, L.U. Geary, A. Kinsella, F. Thorne and Wallace, M. (2013). An analysis of the factors associated with technical and scale efficiency of Irish dairy farms. *International Journal of Agricultural Management*, 2:149–159. https://doi.org/10.5836/ijam/2013-03-04

Koesling, M., Flaten, O. and Lien, G. (2008). Factors influencing conversion to organic farming in Norway. *International Journal of Agricultural Resources, Governance and Ecology*, 7:78–95. https://doi.org/10.1504/ijarge.2008.016981

Kompas, T. and Che, T.N. (2006). Technology choice and efficiency on Australian dairy farms. *The Australian Journal of Agricultural and Resource Economics*, 55:65–83. https://doi.org/10.1111/j.1467-8489.2006.00314.x

Kumbhakar, S.C. and Lovell, C.A.K. (2000). *Stochastic Frontier Analysis* Cambridge University Press, New York, USA. https://doi.org/10.1017/cbo9781139174411

Kumbhakar, S.C., Efthymios, T. and Sipiläinen, T. 2009. Joint estimation of technology choice and technical efficiency: An application to organic and conventional dairy farming. *Journal of Productivity Analysis*, 31:151–161. https://doi.org/10.1007/s11123-008-0081-y

Kumbhakar, S.C., Wang, H.J. and Horncastle, A.P. (2015). *A practitioner's Guide to Stochastic Frontier Analysis using Stata* Cambridge University Press, New York, USA. https://doi.org/10.1017/cbo9781139342070

Lakner, S. and Breustedt, G. (2015). Efficiency analysis of organic farming systems- a review of methods, topics, results and conclusions Paper presented at the International Conference of Agricultural Economists in Milan, July 2015.

Latruffe, L. and Nauges, C. (2013). Technical efficiency and conversion to organic farming: the case of France. *European Review of Agricultural Economics*, 41:227–253. https://doi.org/10.1093/erae/jbt024

Lawson, L.G., Agger, J.F. M. L. u. n. d. and Coelli, T.J. (2004). Lameness, metabolic and digestive disorders, and technical efficiency in Danish dairy herds: A stochastic frontier production function approach. *Livestock Production Science*, 91:157–172. https://doi.org/10.1016/j.livprodsci.2004.07.016

Lien, G., Størdal, S. and Baardsen, S. (2007). Technical efficiency in timber production and effects of other revenue

sources. *Small-scale Forestry*, 6:65–78. https://doi.org/10.1007/s11842-007-9005-3

Manevska-Tasevska, G., Rabinowicz, E. and Surry, Y. (2013). Policy impact on farm level efficiency in Sweden 1998–2008 Working Paper, 2013: 6, AgriFood economics centre. Swedish University of Agricultural Sciences. Sweden.

Manevska-Tasevska, G., Rabinowicz, E. and Surry, Y. (2016) Pure and compensated technical efficiency of Swedish dairy farms. *Agricultural and Food Science*, 25:111–123.

Manevska-Tasevska, G., Hansson, H. and Rabinowicz, E. (2014). Input saving possibilities and practices contributing to more efficient beef production in Sweden. *Agricultural and Food Science*, 23:118–134.

Mayen, C., Balagtas, J. and Alexander, C.E. (2010). Technology adoption and technical efficiency: Organic and conventional dairy farms in the United States. *American Journal of Agricultural Economics*, 92:181–195. https://doi.org/10.1093/ajae/aap018

NIBIO. (2013). Better results on organic farms than on conventional farms. *Available at*, http://www.nilf.no/publikasjoner/artikler/2013/bedre_resultater_for_okologisk_enn_konvensjonell_drift.

Meeusen, W. and Van Den Broeck, J. (1977). Efficiency Estimation from Cobb-Douglas Production Functions with Composed Error. *International Economic Review*, 18:435–444.

Oude Lansink, A. and Pietola, K. (2002). Efficiency and productivity of conventional and organic farms in Finland 1994–1997. *European Review of Agricultural Economics*, 29:51–66. https://doi.org/10.1093/erae/29.1.51

Parmeter, C.F. and Kumbhakar, S.C. (2014). Efficiency Analysis: A primer on recent advances. *Foundations and Trends in Econometrics*, 7:191–385. https://doi.org/10.1561/0800000023

Pitt, M.M. and Lee, L.F. (1981). The measurement and sources of technical inefficiency in the Indonesian weaving industry. *Journal of Development Economics*, 9:43–64.

Rasmussen, S. (2011). *Data for analyzing productivity change in Danish Agriculture 1990- 2007*. *Institute of Food and Resource Economics, University of Copenhagen*,, 9:47 p. Copenhagen, Denmark.

Rasmussen, S. (2010). Scale efficiency in Danish agriculture. *European Review of Agricultural Economics*, 37:335–367. https://doi.org/10.1093/erae/jbq023

Rigby, D., Young, T. and Burton, M. (2001). The development of and prospects for organic farming in the UK. *Food Policy*, 26:599–613. https://doi.org/10.1016/s0306-9192(01)00023-9

Rougoor, C. W., Trip, G., Huirne, R.M.B. and Renkema, J.A. (1998). How to define and study farmers' management capacity: theory and use in agricultural economics. *Agricultural Economics*, 18:261–272.

Sauer, J. and Latacz–Lohmann, U. (2015). Investment, technical change and efficiency: empirical evidence from German dairy production. *European Review of Agricultural Economics*, 42:151–175. https://doi.org/10.1093/erae/jbu015

Sipilainen, T. and Oude Lansink, A. (2005). Learning in Organic Farming –An Application of Finnish Dairy Farms Paper presented at the EAAE Congress, 24–27 August, Copenhagen, Denmark. https://doi.org/10.1080/16507541.2010.481901

Sipiläinen, T., Kortelainen, M., Ovaska, S. and Ryhänen, M. (2009). Performance of Finnish dairy farms and its determinants: A comparison of parametric, semiparametric and nonparametric methods. *Food Economics- Acta Agriculture Scandinavia C*, 6:173–184.

Schmidt, P. and Sickles, R.C. (1984). Production frontiers and panel data. *Journal of Business & Economic Statistics*, 2:367–374.

Statistics Norway (2013). Available at https://www.ssb.no/kpi

Steeneveld, W., Tauer, L.W., Hogeveen, H. and Oude Lansink, A. (2012). Comparing technical efficiency of farms with an automatic milking system and a conventional milking system. *Journal of Dairy Science*, 95:7391–7398. https://doi.org/10.3168/jds.2012-5482

Tine 2018. Statistics collection. Available at: https://medlem.tine.no/aktuelt/nyheter/hk-statistikker

Wang, H.J. and Schmidt, P. (2002). One- Step and Two- Step Estimation of the Effects of Exogenous Variables on Technical Efficiency Levels. *Journal of Productivity Analysis*, 18:129–144. https://doi.org/10.1023/A:1016565719882

Zhu, X., Demeter, R.M. and Oude Lansink, A. (2012). Technical efficiency and productivity differentials of dairy farms in three EU countries: the role of CAP subsidies. *Agricultural Economics Review*, 13:66–92.

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-74

Farmer productivity by age in the United States

LOREN TAUER[1]

ABSTRACT

The productivities of farmers by age group for each of the previous eight U.S. agricultural census years were estimated by Tornqvist productivity indices. Productivity increases with age, peaks at mid-life and then decreases by age for each census year. This concave productivity pattern appears to be muted in the last census years of 2007 and 2012, such that the productivity increase and then decrease is not as large as in previous census years. If older farmers had not experienced decreases in productivity, U.S. agricultural output in 2012 would have been 5.66 percent greater.

KEYWORDS: farmer age; farmer productivity

Introduction

The average age of the U.S. farmer is increasing. In the U.S. Agricultural Census of 2012, the average age of the U.S. farmer was 58.3 years of age compared to an average age of 50.5 years reported in the 1982 agricultural census. As expressed by U.S. Agricultural Secretary Vilsack at Opening Comments to the Drake Forum on America's New Farmers, August 12, 2014, "We have an aging farming population. If left unchecked, this could threaten our ability to produce the food we need – and also result in the loss of tens of thousands of acres of working lands that we rely on to clean our air and water." As Figure 1 illustrates, average farmer age has increased each census year. But does that mean we might have a reduced ability to produce the food we need if the average farmer age continues to increase? That of course depends upon whether the productivity of the older farmer is lower than the productivity of younger farmers. Farm productivity depends upon efficient use of inputs, and this may depend upon farm size as well as the application of best practices and other factors. Those factors may be correlated with age, and thus would be reflected in differences in measured productivity by age. Beginning farmers may have limited resources and thus not able to capture any economies of size until they accumulate assets in middle age. Older farmers may not keep current with new technology, suffering a decrease in productivity.

Past research by Tauer (1984, 1995), and Tauer and Lordkipanidze (2000) have shown using previous census data that there does appear to be a life cycle phenomenon in production agriculture, such that farmers increase their productivity to mid-life, but then experience a decrease in productivity as they age. Those studies used various methods to estimate productivity and data from different production years. The purpose of this current paper is to use a consistent method on each of the last 8 census years and estimate the life-cycle pattern over those years to further test whether the life cycle pattern by age exits in U.S. farming and then determine if this pattern has changed over time. I find that the life-cycle exists but may have been muted in recent census years. The reduction in productivity as a farmer ages appears to be not as significant as in the past.

Loomis (1936) introduced the concept of the life cycle of the farm and found a cyclical relationship between the age of farmers and the size of the farm, use of inputs and output. This became received theory and Harl (1982) included a life cycle diagram in his popular farm estate planning book. Gale (1994) studied farms over age and time using census data from the years 1978, 1982, and 1987 and found that mean growth rates are greatest for younger farms, although he did not estimate productivity by age. Likewise, recently Katchova and Ahearn (2015) examined farm expansion by age and also found that younger farmers tend to expand over time in contrast to older farmers. Expansion permits adoption of new technology and practices which may be conducive for increases in productivity with age.

There is empirical evidence on the productivity of farmers of various ages, because many have included farmer age in estimating the efficiency or productivity of specific farms types. In exploring multiple job holdings for instance, Goodwin and Mishra (2004) find that farm efficiency decreases with farmer age. That pattern is almost universal in the myriad of articles estimating farm level productivity and efficiency summarized by Bravo-Ureta, *et al*. 2007, in a meta-regression of farm efficiency studies.

The limited research in agriculture exclusively looking at the role of age in farmer productivity is perplexing

Original submitted October 2017; revision received August 2018; accepted May 2019.

[1] Corresponding author: Cornell University, Charles H. Dyson School of Applied Economics and Management, Ithaca, New Yoik, US. Email: lwt1@cornell.edu

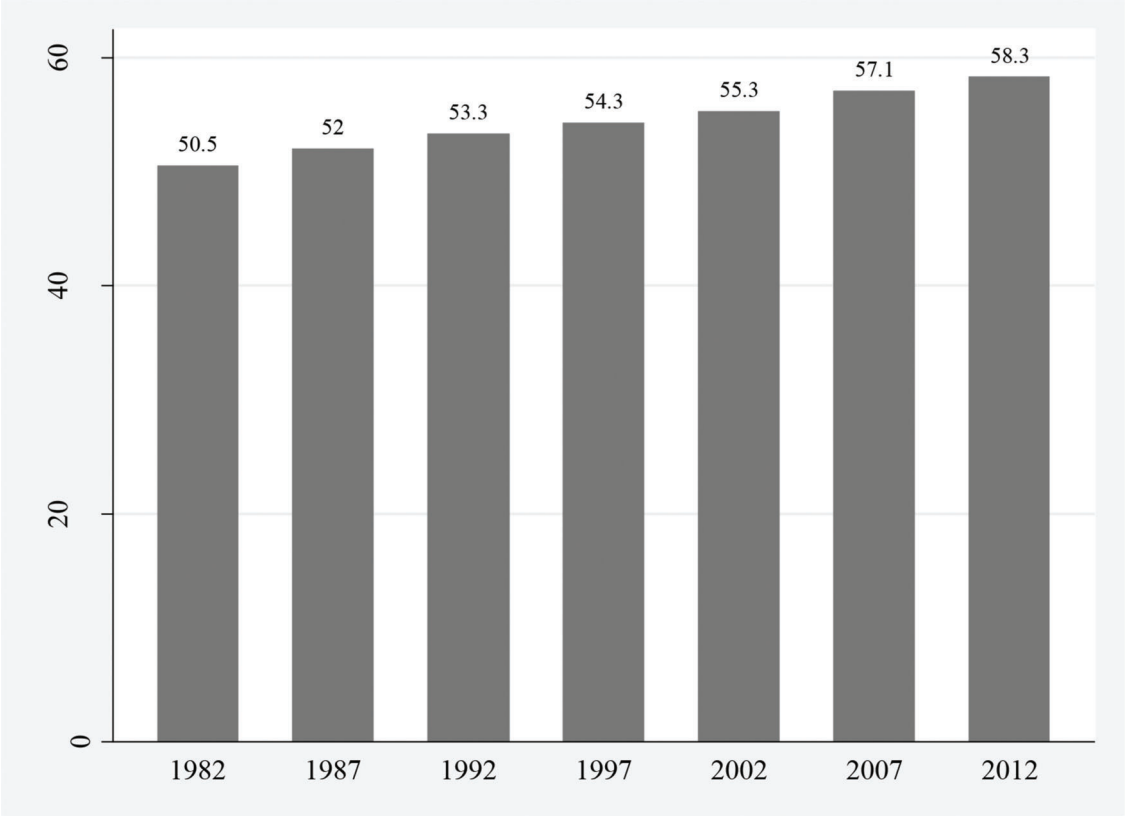

Figure 1: Average age of the principal farm operator, census years 1982-2012. Data: USDA NASS, census of agriculture

given the vast literature in labor economics estimating this relationship. The workforce in most countries and industries is getting older. A recent review of the literature by Frosch (2011), and a special section in *Labour Economics* (Bloom and Sousa-Poza, 2013), summarizes and explores some of the empirical results. Those results provide evidence of a concave relationship between productivity and age in a vast range of economic sectors.

Articles concentrating on farmer age and productivity include Tauer (1984), who estimated a production function using 1978 Census of Agriculture state level data by age group and derived marginal products of various inputs by age. He concluded that the overall productivity of the U.S. farmer was greatest at the age group of 35 to 45 years old. Tauer (1995) further estimated Tornqvist indices by age group and by U.S. region using 1987 Census of Agriculture data, after acknowledging and finding that the production function may differ by region. He likewise found a concave life cycle with a peak in efficiency, again in the middle age group of 35 to 45 years of age. Tauer and Lordkipanidze (2000) using 1992 U.S. Agricultural Census data, decomposed productivity into technology differences and efficiency indices using Data Envelopment Analysis methods. They found a life cycle pattern which varied by region, but most of that was due to differences in technology by age and less from efficiency differences by age. This implies that ageing farmers were not keeping up with technological change, but were still rather efficient in using the technology they had installed on the farm. Recently Fried and Tauer (2016) revisited age productivity using year 2012 U.S. Agricultural Census data and found that the life cycle may have become muted such that the older farmers are almost as productive as the younger farmers. They experienced a data limitation due to disclosure restriction on some inputs items in some states, mostly for the youngest age groups. This precluded them from using data from those age groups in those states, potentially biasing the empirical results. Data restriction by age at the state level has become more prevalent in recent census years as farm numbers have fallen, in order to prevent disclosure of data from any farming operation.

In this paper Tornqvist indices similar to Tauer (1995) are computed, but aggregate U.S. data by age group is used rather than state level data by age group given the large number of expense category items missing in many states due to nondisclosure rules. This allowed data from all age groups to be included in the U.S. aggregate analysis, including data that would be missing if state level data were used. The tradeoff is that state level results could not be derived, and technology may different across states. Aggregate productivity by age group is calculated for every U.S. Agricultural Census since the year 1978. All reported income and expense items were available and aggregated into productivity indices by age group. The estimated results support a concave productivity relationship over age, but the effect appears to be muted in recent census years.

Method and Data

Although there are alternative approaches to measure the productivity of farmers of various ages, such as econometrically estimating a production function or a dual function such as a cost function, or using Data Envelopment Analysis (DEA), I elect to calculate the productivity of farmers by age using the Tornqvist index of aggregated outputs divided by aggregated

inputs. Diewert (1979) defined the Tornqvist total factor productivity index as exact and superlative because the index can be derived from an underlying translog production function (exact), which is a second order local approximation to any arbitrary functional form (superlative). That means that the estimates are flexible in measuring substitution between inputs and allows non-linear responses to input increases. Like any approach, the Tornqvist index is not without limitation, the major being that economic optimization (profit, revenue, or cost) must be assumed to use first order conditions from those optimizations to aggregate outputs and inputs (Good, Nadir, Sickles, 1996).

The Tornqvist is defined as:

$$T_{j,j-1} = \frac{1}{2}\sum_{i=1}^{M}\left(\frac{q_{i,j}}{rev_j} + \frac{q_{i,j-1}}{rev_{j-1}}\right) ln\left(q_{i,j}/q_{i,j-1}\right)$$

$$- \frac{1}{2}\sum_{k=1}^{N}\left(\frac{x_{kj}}{exp_j} + \frac{x_{k,j-1}}{exp_{j-1}}\right) ln\left(x_{k,j}/x_{k,j-1}\right)$$

where $q_{i,j}$ is revenue of output i for age group j and age group j-1 and rev is total output revenue, $x_{k,j}$ is expense of input k for age group j and age group j-1 and exp is total expenses. Typically, the terms $ln(q_{i,j}/q_{i,j-1})$ and $ln(x_{k,j}/x_{k,j-1})$ are quantities of outputs and inputs rather than output revenues and input expenditures. Quantities or prices are not collected or reported in the Census reports; outputs are reported as revenues and inputs as expenditures. Thus it was not possible to use quantities unless prices are further collected to convert revenues and expenditures into quantities. However, it not unreasonable to assume that in any given Census year, the output prices and input prices faced by each age group were identical. An individual younger farmer may have sold a crop at a higher price than an individual older farmer, but there is no reason to expect that all young farmers sold their crops at a higher price than all old farmers. The same would be true in the purchase of inputs. If these identical prices were collected and used to convert revenue or expenditure into quantities, the output or input quantity ratio would be identical to the revenue and expenditure ratios, respectively, resulting in no change in the computed Tornqvist index. As a consequence, revenues and expenditures are used rather than quantities in the output and input ratios, with identical prices assumed across age groups.

However, if the assumption of identical prices across ages is not valid, then the results would reflect differences in productivity due to price differences as well as quantity differences. If young farmers in the earlier year census years as a group where better marketers, from say a use of cells phones to keep abreast and react to market prices, then those younger farmers as a group would have higher receipts because of prices in addition to output differences, and that would be correctly reflected in higher productivity. The same would occur if they paid less for inputs.

The index can be computed between any adjacent age groups by using the output and input quantities of the two age groups. Unlike comparing Tornqvist indices across regions or countries, this index is transitive between age groups similar to an index between time periods, so the index can be chained to the youngest age group to determine the productivity of each age group relative to the youngest age group.

There have been advances in the decomposition of productivity indices into components dealing with various types of economic efficiencies as well as scale effects (O'Donnell, 2010; O'Donnell, 2012). I elect not to implement these decompositions given the aggregate nature of Census data used, which are U.S. state farm averages by age group.

The U.S. Federal Government completes an agricultural census of all farmers every 5 years. The last agricultural census was completed for the production year of 2012. Previous to that year census data were collected for the years 2007, 2002, 1997, 1992, 1987, 1982 and 1978. Individual farm data are not reported; rather data are summarized and reported by state and for the U.S., with some data reported at the county level. Of interest for this research are the data summarized by decimal age group for farmers who indicated that farming was their principal occupation. Although those data are summarized at the state level, to protect the confidentiality of farmers, some receipt and expense items are not disclosed for some age groups in some states, precluding complete state level analysis. As the number of especially younger farmers have declined over succeeding census years, comprehensive analysis at the state level was not plausible. Instead, data summarized for the entire U.S. by age group of operators whose principal occupation was farming were used.

The six age groups are farmers under the age of 25, farmers from the age of 25 to 34, farmers from the age of 35 to 44, farmers from the age 45 to 54, farmers from the age of 55 to 64, and farmers over the age of 65. Only data of farmers indicating that farming was their principal occupation were used. However, many of these operations are multiple operator farms, with many of those being multiple generational farms where children are farming with their parents, and in some cases also with grandparents. As shown in Figure 2, a smaller ratio of farmers under the age of 25 are the principal operator of multiple operator farms, which might be expected since an older parent might be the principal operator. Also a smaller ratio of the farmers over the age of 65 are the principal operator of a multiple operator farm, because they may have already turned the reigns over to a younger child. Unfortunately, multiple operated farms are not separated from sole operated farms in the published census data by age group, and therefore it was not possible to look only at the sole managed farms over the various age groups. The question is whether the recorded principal operator is indeed the principal operator making the major or final decision in a multiple operated farm. It may be that in some instances a true young principal operator may be deferring to his elder, and listing the elder as the principal operator, when in fact the young operator may be the principal operator. It may also be possible that a true older principal operator may decide that the younger operator should be listed as the principal operator. The reporting situation is simply not known, so we assume that the correct principal operator is identified correctly on the census survey.

Also shown in Figure 2 are the number of principal operators who are women by age group in the year 2012.

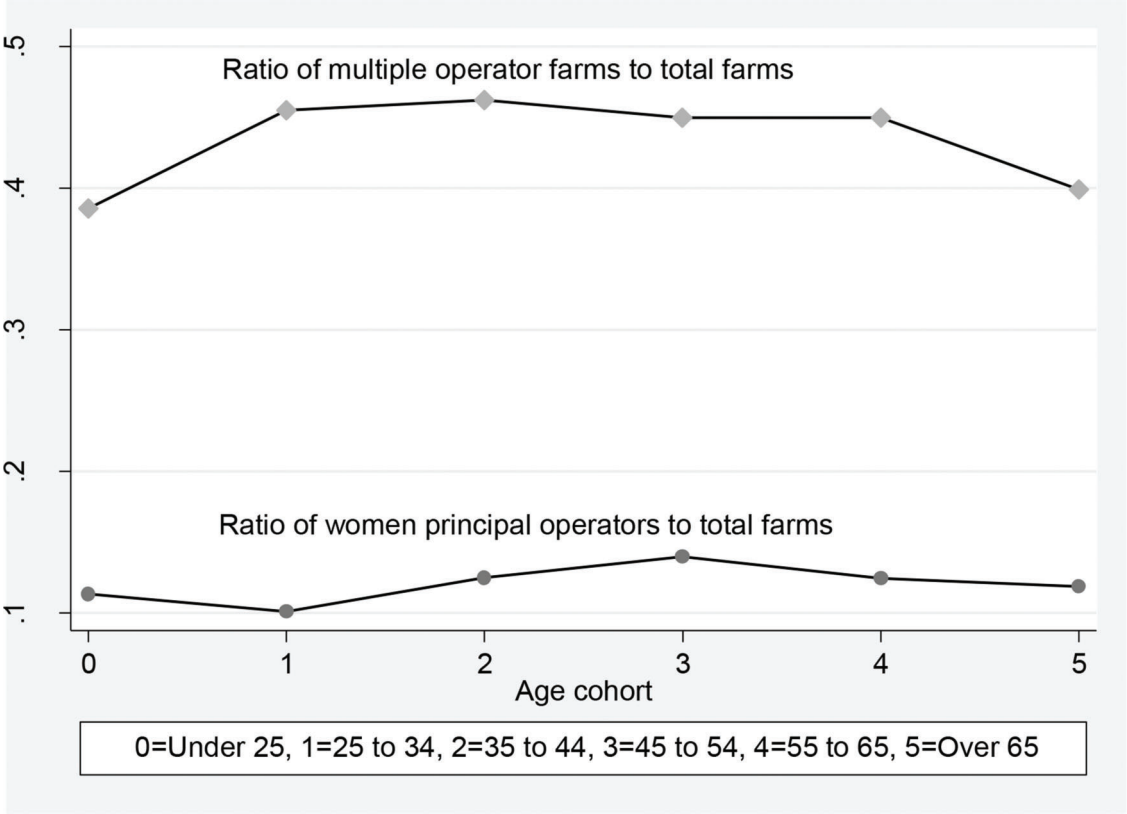

Figure 2: Ratio of multiple operated farms to total farms and ratio of women principal operated farms to total farms

The number of farms operated by women ranged from a low of 10 percent in the age group age of 25 to 34, to a high of 14 percent in the age group of 45 to 54. Eleven percent of the farm operators in the youngest age group were women. Women constituted 12 percent of the farm operators over the age of 65.

The various crop and livestock categories as shown in Table 1 are the major revenue and expense categories reported in census publications. These were actual sales and expenses that occurred during the production year of the census year rather than production and input use. For individual farms, production and sales in any year may be significantly different given inventory change decisions, but differences in production and sales should be muted over the entire population of U.S. farmers in any census year. Even if some age group consistently sold output after fall harvest rather than store the crop for sale into the following year, for instance, that event would still record consistent crop sales in any year, subject to aggregate weather effects.

Over the eight census years some slight changes were made in the reporting of some revenue and expense items. Examples include listing aquaculture as a separate revenue item in later census years when in the earlier census years aquaculture was embedded in the category of other livestock. Another change was separately listing hay as a commodity in the early years but later combining hay with other crops in later census years. These changes are noted in Table 1. Regardless, all commodity sales and farm income sources are included as output, including government payments. Government payments were included under the assumption that often production changes were required to receive these payments, and without those changes the payments would not have been received. Producers also had to meet the definition of a farmer to receive agriculture transfer payments.

Some expenses listed in the census, such as rent and depreciation, were not directly included as inputs, but rather indirectly included as a charge to the market value of real estate and machinery. Rent expenses only occur if land is rented rather than owned, and the proportion of land rented may vary by age group. As an alternative, a fixed interest rate was assessed to the market value of the real estate, both owned and rented by the farmer. Depreciation was indirectly estimated as a percent of the market value of machinery. Also interest expense is dependent on financial leverage so was not included, but is implicit in the rate charged to real estate and machinery. Finally, although farmers by age group do report various amounts of days of work off the farm (rather than the number of days they worked on the farm), all indicated that their principal occupation was farming, so it was assumed that all farmers work the necessary hours required to operate the farm business. Family labor is not recorded in the Census unless it was paid a wage, in which case it would be included in hired labor. If any age cohort uses more non-reported unpaid family labor then that would produce an upward bias in their estimated productivity.

Revenue from outputs were aggregated into one output by using a Tornqvist aggregator based upon average sales per farm. Average expense per farm were similarly aggregated into one input using the Tornqvist aggregator. Productivity differences were measured between adjacent age groups. Productivity of each age group was then indexed to the youngest age group of farmers under the age of 25. Thus, the productivity of the farmers under the age of 25 are shown as equal to 1.00

Table 1: Receipt and expense items from U.S. agricultural census to be aggregated into a Tornqvist productivity index for each age group over various census years

Item	Notes
Grain sales	Includes corn, wheat, soybeans and other grains
Cotton sales	Cotton and cotton seed
Tobacco sales	Tobacco
Hay sales	In later years hay included in other crops
Vegetables sales	Vegetables, melons, potatoes and sweet potatoes
Fruit sales	Fruit, tree nuts, and berries
Nursery products sales	Christmas trees in other farm income
Other crops sales	Some years included hay
Poultry sales	Poultry and eggs
Dairy sales	Milk from cows
Cattle sales	Cattle and calves
Hog sales	Hogs and pigs
Sheep sales	Sheep, goats, wool, mohair, and milk
Other livestock sales	Aquaculture, horses and mules
Government payments receipts	Government agricultural payments
Other farm income	Custom work performed and farm tourism
Livestock purchases	Both breeding and feeder livestock
Feed purchases	For all livestock
Seed purchases	Seeds, plants, vines, and trees
Fertilizer purchases	Fertilizer and lime
Chemical purchases	All
Fuel purchases	Fuel and oil
Electricity purchases	For the farm
Hired labor costs	Paid by farmer
Contract labor costs	Paid to contractor for farm labor
Repair costs	Supplies, repairs and maintenance
Custom work costs	Machinery hired with labor included
Miscellaneous expenses	All other expenses
Real estate costs	0.05*Real Estate Market Value
Machinery costs	0.10*Machinery Market Value

Note that interest, depreciation, property taxes and rent are not included as direct farm expenses to avoid double counting of expenses, since an opportunity cost is applied to all capital items regardless of whether these are rented or owned, or financed with debt vs equity capital.

for all census years, and the productivity of the other age groups are in reference to the youngest group. A productivity index of 1.15 would indicate that an age group is 15 percent more productive than those farmers under the age of 25.

Results and Discussion

The results support a concave relationship between age and productivity where there is first an increase and then a decrease in productivity as the age of the farmer increases. The results in Table 2 and summarized in Figure 3 show the only exception to this pattern is the census year 1987, where the age group of 55 to 64 years of age shows an increase in productivity over the previous age group of 45 to 54 years of age. In all census years, except for the year 1982, the age group 25 to 34 was more productive. In all census years except again for 1982, the age group 35 to 44 years of age was more productive than farmers under age 25. The farmers from age 35 to 44 were more productive than farmers from the age group of 25 to 34 age group in half of the census year, mostly the earlier years. The farmers in the age group of 45 to 54 were more productive than the farmers under the age of 25 except for the census years of 1987 and 1992, but were less productive than one age group younger except for the year 1978. The farmers aged 55 to 64 were less productive than the farmers under the age of 25 in five of the eight census years, and less productive than the farmers aged 45 to 54 except for the year 1987. Farmers over the age of 65 were less productive than all of the other age groups in every year. Thus one can conclude that the productivity of farmers is generally greatest at the age groups of 25 to 34, or 35 to 45, but then decreases by age group, with the farmer aged 55 and older generally less productive than the farmers under the age of 25.

Tauer (1995) had previously discussed the possible reasons for this concave age productivity pattern. Younger farmers are inexperienced and may begin with less productive capital than older farmers. By age 25 to 34 they have gained experience and may have begun to acquire more productive capital such as new equipment. Productivity then erodes after age 55 as older farmers may fail to adopt new technology and their capital stock is not replenished. This life cycle pattern with respect to productivity is not encouraging as the average farmer continues to age as shown in Figure 1.

However, it is interesting to note that the concave life cycle may becoming muted over time. This was concluded by Fried and Tauer (2016), who estimated Malmquist productivity indices by state for each age group. However, they were forced to drop many younger age groups from their analysis because of data unavailability due to nondisclosure restrictions, potentially biasing their estimates. Figure 3 plots the productivity of the various age groups by year with a line placed through the various age group productivities for the last census year of 2012. Although that is still a concave age productivity cycle with a peak at the age group of age 35 to 44, it appears that the productivity relationship with age is not as concave as previous census years. The increase in productivity from under age 25 to age 25 to 34 for year 2012 is not as great as in previous years, and the decreased productivity for age 45 to 54 is minor. The productivity decrease of those farmers over the age of 65 in 2012 is the second lowest of the census years, with the lowest productivity decrease for the oldest farmers occurring in census year 1978. This muted productivity of first an increase and then a decrease is also displayed in the census year of 2007, and may be due to the changing nature of farming. Technology changes have continued to make farming less physical. Mechanical devices often perform tasks once done by hand labor. Hours may still be long but may not be as physically exhausting when those hours are spent in air conditioned or heated tractors that drive themselves with GPS units.

What if older farmers had not experienced a decrease in their productivity as compared to peak age productivity? Table 3 summarizes the impacts. If the oldest three age groups of farmers had remained as productive as those farmers from age 35 to 44, then 2012 U.S. agricultural output would have been 5.66 percent greater. If all farmers had increased their productivity to the same level as the most productive farmers age 35 to 44,

Table 2: Tornqvist productivity indices by year and age group with indices relative to the under 25 age group for each year

Age	Census year								Average
	2012	2007	2002	1997	1992	1987	1982	1978	
Under 25	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
25 to 34	1.040	1.037	1.054	1.163	1.107	1.015	0.983	1.031	1.054
35 to 44	1.065	1.072	1.054	1.144	1.080	0.954	0.981	1.056	1.051
45 to 54	1.044	1.050	1.022	1.110	1.038	0.935	0.953	1.058	1.026
55 to 64	1.008	0.986	0.961	1.077	1.008	0.963	0.938	0.952	0.987
Over 65	0.928	0.885	0.857	0.969	0.909	0.799	0.826	0.910	0.885

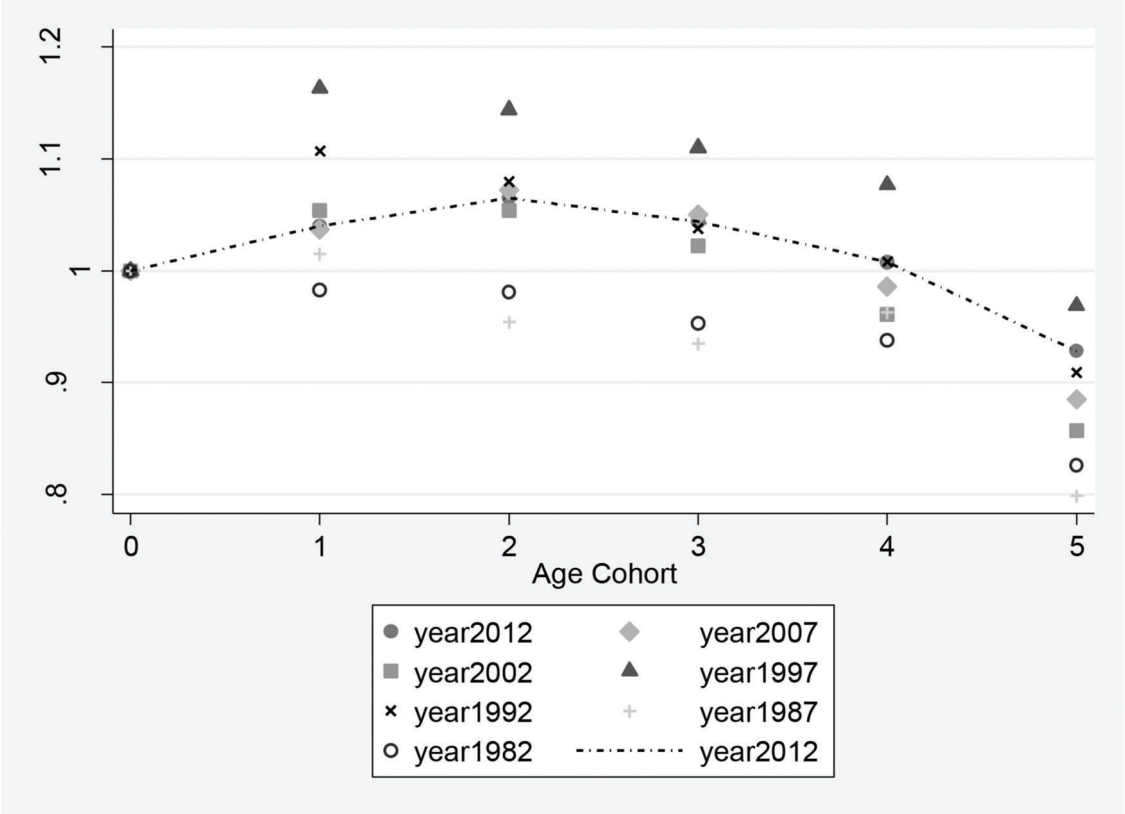

Figure 3: Productivity of farmers by age group for various census years

Table 3: Increase in U.S. agricultural output given productivity enhancements of older and all farmers

Age group	2012 productivity	2012 output (in $1,000)	Output if farmers over age 45 increase productivity to peak productivity of 1.065	Output if all farmers increase productivity to peak productivity of 1.065
Under 25	1.000	1,004,732	1,004,732	1,070,040
25 to 34	1.040	15,593,301	15,593,301	15,968,140
35 to 44	1.065	44,573,767	44,573,767	44,573,767
45 to 54	1.044	98,724,744	100,710,587	100,710,587
55 to 64	1.008	111,707,027	118,023,793	118,023,793
Over 65	0.928	77,722,823	89,196,990	89,196,990
Total		349,326,394	369,103,170	369,543,316
Percentage increase in output			5.66%	5.79%

including those farmers younger than age 35, then 2012 U.S. agricultural output would have increased 5.79 percent. This increase is not much greater than if only older farmers increased their productivity because younger farmers are reasonably productive, but more importantly, they do not produce much of U.S. agricultural output.

Conclusion

It is clear that there still exists a productivity life cycle in U.S. agriculture, such that the productivity of the average U.S. farmer first increases with age and then decreases with age. However, the increase in productivity is only about 5 percent greater at mid-life compared to

farmers under the age of 25, and only decreases 1 percent at age 55 to 64. Unfortunately, the productivity falls 11 percent for those farmers over the age of 65. These are averages over the eight census years and individual census year patterns vary somewhat with the most recent census showing productivity only falling 7 percent for those farmers over the age of 65. If all farmers in the year 2012 were as productive as the most productive age group of 35 to 44, then U.S. agricultural output would have been greater by 5.79 percent.

About the author

Loren Tauer is a professor in the Charles H. Dyson School of Applied Economics and Management at Cornell University where he teaches and conducts research in agricultural finance and production economics.

REFERENCES

Bloom, D.E. and Sousa-Poza, A. (2013). Ageing and productivity: Introduction. *Labour Economics*, 22:1–4.

Bravo-Ureta, B.E., Solis, D., Moreira Lopez, V.H., Maripani, J.F., Thiam, A. and Rivas, T. (2007). Technical efficiency in farming: a meta-regression analysis. *Journal of Productivity Analysis*, 27:57–72.

Diewert, W.E. (1976). Exact and superlative index numbers. *Journal of Econometrics*, 4:116–145.

Fried, H.O. and Tauer, L.W. (2016). The aging U.S. farmer: Should we worry? Chapter 16 in *Advances in Efficiency and Productivity*. (Springer International Series in Operations Research and Management Sciences).

Frosch, K.H. (2011). Workforce age and innovation: A literature survey. *International Journal of Management Reviews*, 13: 414–430.

Gale, H.F. (1994). Longitudinal analysis of farm size over the farmer's life cycle. *Review of Agricultural Economics*, 16:113–123.

Good, D., Nadiri, M.I. and Sickles, R. (1996). Index Number and Factor Demand Approaches to the Estimation of Productivity,'' Chapter 1 of the *Handbook of Applied Economics, Volume II-Microeconometrics*, edited by M. H. Pesaran and P. Schmidt, Oxford: Basil Blackwell, 1997, 14–80, reprinted as *National Bureau of Economic Research Working Paper # 5790*, 1996, Cambridge, MA.

Goodwin, B.K. and Mishra, A.K. (2004). Farming efficiency and the determinants of multiple job holdings by farm operators. *American Journal of Agricultural Economics*, 86:722–729.

Harl, N.E. (1982). Farm estate and business planning Century Communications Inc., Skokie, Illinois.

Katchova, A.L. and Ahearn, M.C. (2015). Dynamics of farmland ownership and leasing: Implications for young and beginning farmers. *Applied Economic Perspectives and Policy*, Published online September 17, 2015, doi:10.1093/aepp/ppv024.

Loomis, C.P. (1936). The study of the life cycle of families. *Rural Sociology*, 1:180–199.

O'Donnell, C.J. (2010). Measuring the decomposing agricultural productivity and profitability change. *Australian Journal of Agricultural and Resource Economics*, 54:527–560.

O'Donnell, C.J. (2012). An aggregate quantity framework for measuring and decomposing productivity and profitability change. *Journal of Productivity Analysis*, 38: 255–272.

Tauer, L.W. (1984). Productivity of farmers at various ages. *North Central Journal of Agricultural Economics*, 6:81–87.

Tauer, L. (1995). Age and farmer productivity. *Review of Agricultural Economics*, 17:63–69.

Tauer, L.W. and Lordkipanidze, N. (2000). Farmer efficiency and technology use with age. *Agricultural and Resource Economics Review*, 29:24–31.

VIEWPOINT

DOI: 10.5836/ijam/2019-08-81

A UK perspective – what happens to UK agriculture post - Brexit?[1]

JOHN GILES[2]

This article from a UK-based author examines the issues leading up to and surrounding the current Brexit negotiations, particularly the impact on their agricultural sector and the possible effects for other countries such as New Zealand.

How did we get here?

The UK voted in a national referendum, and by a close margin of 52-48%, to leave the European Union just over three years ago. Although Article 50 (the legal mechanism by which a country can leave the EU) was then triggered, two dates by when we should have left have already passed. The latest date is now set for the end of October 2019.

Views on the impact of this on the UK agricultural and food sector are almost as polarised as the result of the vote itself. Some will point to a highly positive view of the UK being able to farm and produce food in a manner free from the supposed shackles of the Common Agricultural Policy (CAP), and able to take advantage of new trade deals with the likes of India, China, other Asian markets, the US and Oceania. Others hold a more cautious view and, in some instances, predict a potential disaster.

Political log jam – and a new Prime Minister

In the UK Parliament, there has been an unbreakable political log jam for many months. Some EU countries, such as Ireland and The Netherlands, have made it clear that they would rather the UK didn't leave at all and would be prepared for further discussions on how any adverse impacts of the UK departure can be minimised when it exits the EU.

The agri-food sectors of both these countries are intertwined with the UK, not just over trade, but with a series of significant investments in joint ventures, mergers and acquisitions over a prolonged period of time. In Ireland, there is additional concern over the nature of border and security arrangements between the Northern Ireland and Ireland. Others in the European Commission and European Parliament are more tough nosed in their approach and have stated that there can be no further negotiation on what has been agreed to date.

The ongoing political wrangling in the UK eventually cost Theresa May, the Prime Minister throughout most of this process, her position. She was personally a 'remainer', and looked to reach a consensus across the political spectrum but failed. She therefore ended up pleasing no-one.

Enter a new Prime Minister in July – Boris Johnson. He is a committed 'leaver', and his first Cabinet appointments were also packed full of other committed 'leavers'. He has said repeatedly he is willing to walk away from the EU in October without any deal in place. Even if Johnson wants to do this, it still needs to be ratified by the UK Parliament, but to date this has proved to be impossible. In the spring of 2019, seven different options on how to leave the EU were all rejected by Parliament. However, a US$6 billion package to prepare for a No Deal, and a US$125 million public advertising campaign on this that was funded by the Government, suggests he is deadly serious about this.

Deal or No Deal?

Leaving the EU without a deal would mean reverting to trade with other EU countries on World Trade Organisation (WTO) terms with much higher import and export tariffs in place for the UK and much stricter regulations on the movement of labour around the UK and EU as well as a potential hard border between Northern and Southern Ireland. A ''deal'' would see a much softer approach to all of these issues and maybe the UK staying in the EU customs union for a further period.

Johnson has stated initially that he sees the chances of a No Deal Brexit as minimal and we could still stay in the EU Customs Union for a further two years while the UK re-negotiates what was agreed under May's leadership. In more recent days he has also stated that this could now also be a ''touch and go'' process and that No Deal is still on the table as far as the UK concerned. Even in the time between now and the end of October, it seems likely that a good deal of brinkmanship on both sides is inevitable.

Original submitted November 2019; accepted November 2019.

[1] This article was originally published in *The Journal*, the quarterly publication of the New Zealand Institute of Primary Industry Management, Vol 23, No 3, pp 8-13, September 2019. We are grateful to the NZ Institute of Primary Industry Management for permission to reprint the article here.

[2] Corresponding Author: E-mail: John.Giles@genusplc.com

Johnson has also stated that the blame for a No Deal scenario would be laid squarely at the door of the European Commission in Brussels for failing to re-engage in further talks on what conditions underpin the UK's departure. It is clear to see why he might not be the most popular person in Brussels at the moment.

We need to import

Where has this left the agricultural and food sector and what might be the consequences especially of a No Deal Brexit? Historically, the UK has over a very long period of time been a large net importer of agricultural and food products, and its one reason we had an Empire. We are now only about 60% self-sufficient in food production, and this is even lower in some cases such as horticulture. Put bluntly, we have to import. There is a big danger that these imports could be severely impacted if the UK left with a No Deal. Increases in UK production could be seen, but there is an awful lot of ground to regain and investment required to do this.

WTO tariffs for fresh produce, as an example, range between 15% and 20%; for dairy the rate is 35% and for red meat up to, in some cases, 80%. This would inevitably see supply chain prices rise, but no-one wants that, not least the consumer. And certainly not fresh fruit and vegetable exporters to the UK from the rest of the EU, the US, Chile, Peru, South Africa, New Zealand etc, or dairy exporters from the EU and Oceania countries.

The imposition of import tariffs would see domestic grower/producer prices rise, but on top of import tariffs, additional costs incurred such as border and phytosanitary checks and potential transport delays might add anywhere from 5-8% to import costs. Increased prices in the supply chain would logically lead to food inflation and potentially reduced consumption. This is not good news for UK farmers, the rest of the supply chain or consumers.

New trade deals?

There has also been lots of talk of new trade deals with the rest of the world, post-Brexit, and this includes the US. On his recent visit to the UK, President Trump talked of doing a 'quick and outstanding' trade deal with the UK. But how quick is quick – two years, three years, five years? And 'outstanding' for who? Agriculture and food would be at the heart of this. And rightly or wrongly, the UK has very strong views on areas such as chlorinated chicken, hormone-treated beef and GM soybeans, all of which the US would love to export to the UK. This will not be an easy negotiation.

Talks on this could begin in August though, according to latest reports, and might end up with US exporters having much better access to the UK. This would only add to the competitive pressure faced by UK farmers. They might have also lost great access to lucrative EU markets – something of a double whammy.

There is similar concern that a trade deal with Australia and New Zealand would benefit farmers in these countries, more than it would do so the UK, not least as their producers are already well versed in operating in international markets. Much depends on whether Oceania-based farmers and exporters see the future opportunity in the UK or other exciting markets (such as China), or other South East Asian countries (such as Indonesia, the Philippines and Malaysia), where they have already established an increasingly strong foothold.

Areas of concern

There are a number of areas of huge concern for the UK agricultural industry about the impacts on domestic farming and food such as:

- **The UK Government will need to develop its own agricultural policy**
  This will be in time to replace the EU Common Agricultural Policy. The HM Treasury has in the past stated that the only reason they pay out subsidies is because they have to as part of our EU membership. Given an opportunity to remove these subsidies, they would, as it does not fit UK Government thinking, almost regardless of which political party is in power.

  A new UK Agricultural Bill is working its way through Parliament, but has been bogged down in the Brexit process. There will be increased payments for good environmental practices and the supply of public goods and services, but reductions for more conventional production support. Existing levels of support for farmers will be guaranteed in the relatively short term, but will then almost certainly go through a fundamental review over the next five years.

  The reality is that too many farmers in the UK are overly-dependent on CAP-type support. Without an urgent restructure of how farms are managed and financed, any reduction of CAP type support will put UK farmers under severe financial pressure. This is particularly the case in the beef and sheep sectors, and potentially smaller dairy farms, whereas the horticultural sector has not traditionally received high levels of production support and thus would see less of a detrimental impact from any reduced support.

- **Market access to the EU**
  A very high percentage of UK exports go to the EU, and in return many products are imported from there. For example, in the case of fresh produce, for The Netherlands, the UK is their second most important market with trade in fruits and vegetables worth some £1.1 billion per annum. For Spain, the UK is their third most important market, with fresh produce exports to the UK worth about £1.6 billion. For many horticultural products, especially tomatoes, cucumbers and peppers, there are few alternative external suppliers of high-quality produce beyond the EU, especially The Netherlands and Spain.

- **Access to labour**
  Many farms in the UK are now very dependent on migrant labour from Eastern Europe, and in the build-up to Brexit we have already seen a steady stream begin to leave the country. This is because, in some cases, they no longer feel welcome in the UK per se, but also with a weakened Sterling, the wages of East European nationals living in the UK have already fallen compared to what they might be able to earn in other parts of Europe.

  We are already struggling to find the right labour for our farms and this issue will become more acute.

Post-Brexit, it is likely that the supply of this labour could be restricted and the administrative burden associated with sourcing it will increase.

- **Effects on costs and prices**
  As most crop inputs are traded globally in USD, any weakening of the Sterling would see the costs of fertilisers and chemicals to growers increase. At the same time, a weaker Sterling might also see UK agri-food production become more price competitive against imports per se. It is expected that, overall, there will be more price volatility in the UK market.

Initial impacts on the dairy sector

For individual sectors, at Promar International we have carried out an analysis of a number of specific sub-sectors, including dairy, which is of special interest to New Zealand. We believe that the true impact of Brexit might not be felt for some time, but will accelerate (at least in the short term) many of the trends and changes we have seen already playing out over the last 10 years.

Based on our insight and industry feedback, we also suspect there will be no drastic wholesale exit from the sector, but this will continue at the same levels as seen in the past at around 3% per annum. Herd and farm sizes will gradually get bigger over time. Exit levels will still be driven by the relative age of dairy farmers in the UK and the lack of effective succession planning. In some cases, this might provide opportunities for younger farmers.

Those farmers who are on the so-called aligned contracts with major retailers will be best positioned to continue to invest in their farming operations, while those who are not will remain more vulnerable to volatility in overall market conditions. The key task for dairy farmers will still be to have a greater understanding of the true costs of production and then have the ability to control these.

Most of the farming systems found in the UK dairy sector will largely remain. However, there might be a move, in some cases, towards more specialisation with the increased use of spring calving and robotics, etc, which is already happening.

Welfare standards upheld

At one stage, many farmers who voted for Brexit seemed to believe that exiting the EU and the CAP might end in a 'bonfire of the (EU) legislation'. UK retail support for liquid milk, however, will remain high and standard/accreditation schemes such as 'Red Tractor' will continue to set the minimum requirement for suppliers beyond any statutory legislation.

Supermarkets will raise the standards required by looking for the additional attributes of animal welfare, animal health and the all-round sustainability credentials of their farmers. Animal welfare will still be seen as a key issue for farmers to address and there will be no slackening of these. UK consumers will still want to see dairy products being produced to a high standard.

No-one is totally safe

Lower-performing farms, regardless of size, will be put under pressure first and could easily end up quite quickly with serious financial difficulties and face bankruptcy and insolvency. The pressure to exit the sector will increase on the lower-performing herds. Even the more able farmers might consider exiting the sector when faced with the cold facts, but their decision to do so will be based less on emotion and more on the reality of the situation. Indeed, they might be the first to exit, as some others will continue to bury their heads in the sand and pretend this is not happening. Banks are unlikely to lend to any dairy farmers who do not have in place well-developed business and succession plans.

Processors and retailers alike will want to protect their milk pools and avoid any sense of panic. This will see them look to strengthen the integrated nature of their supply chains.

The really talented dairy farmers will be more involved in the multiple ownership of units on different sites and the development of new units. They will be the farmers to lead any growth in UK production. There might be some farmers switching from beef/sheep (and the arable sectors), as they are likely to be hit harder by Brexit and might end up considerably less profitable than in the past. Farmers who have excellent all-round management skills will do best of all.

More volatility is the new norm

With reduced protection in the mid to long term, UK dairy farmers will truly be more exposed than ever to global milk price volatility, and when/if prices go low the traditional response of 'tightening the belt further' is unlikely to be enough on its own. Farms of between 200 and 300 cows will feel the pressure of labour issues most of all. Some will choose to go down the robotic route and more skilled labour will inevitably be required, but as noted this is already in short supply.

There will be a move towards bigger farms, with more use of larger rotary type parlours and not just the use of robotics. Farmers might find it more difficult to obtain credit with adverse knock-on impacts to the rest of the supply chain such as vets, feed companies and other input suppliers.

The need to control and reduce costs will see more farmers move to more grazing-based systems and focus on keeping farming systems as simple as possible, especially for the use of labour and machinery. There is likely to be a move to more shared farming agreements/arrangements and collaboration between farmers on a 'needs must' basis.

Farmers who can control/manage their costs well will still be able to make money from dairy farming, but those who are not able to do this will find life tough. Those with high levels of existing debt will struggle in particular. All UK dairy farms might be at some risk, but clearly some will be more so than others. Farms still need to be run more efficiently and in a much more business-like manner. UK dairy farmers will be producing in a very different market environment and the overall mindset of the industry will be forced to change.

Supply chain impacts

UK milk production is running at around 14 billion litres over the last few years. The 5 year average UK farm gate

milk price being 27.23 pence per litre (ppl) in the summer of 2019, down 2.4% from the same the month in 2018, when it was 27.91ppl, showing the relative stability of the 5-year average.

The average though, can hide a wide degree of variation though with the highest prices being paid to UK dairy farmers reaching 33 ppl and the lowest, typically for processing contracts, much nearer 25/26 ppl.

The UK dairy sector is strongly intertwinned with the rest of the EU. 90% of our dairy imports are from the EU and 70% of our dairy exports go to the EU too. And a number of the leading processors - the likes of Muller and Arla etc are all EU based businesses too.

The impact of leaving the EU in October 2019 is likely to have far reaching consequences across the supply chain as a result.

High-end retailers will encourage farmers towards outdoor systems of production, but the majority will want them to control the costs of production, and so there will not be an automatic move to these. Indeed, there might be moves to increase indoor production and the development of higher-yielding herds.

The issues surrounding the availability of labour will act as a brake on the development of so-called super units. There will be no major change in the key geographic areas of dairy production in the UK. Any potential expansion in the sector to potentially replace UK imports of dairy products will be driven by the demands made by retailers and the ability of processors to expand capacity and invest in this.

Processors might find it difficult to procure sufficient volumes of milk. The smaller, less efficient of these, in particular those producing non-branded products or own label retail products, will find life much more difficult. The potential lack of milk would drive the further consolidation of processing capacity, especially for cheese.

To do this, there will need to be investment in processing capacity by the leading players, many of whom are somewhat ironically owned by the Irish, Danes, Germans and French. Like it or not, the fate of the UK dairy sector is massively interlinked with Europe, regardless of Brexit. A great British dairy sector? We are part of a global supply chain, but sometimes act like we are not.

The likely reaction of the UK retailers to a No Deal would be that, faced with less options for imported products, they would look to encourage additional production in order to provide a full range of dairy products for their consumers and also help keep a lid on the price of these products. They would still want to be able to meet the full range of choice of products required by UK consumers and have efficient producers to supply them. The more able and talented dairy farmers, in particular, should be able to thrive in this scenario.

Others will be impacted too

It is unlikely that there will be any expansion in the demand for liquid milk, which has been the subject of long-term decline in the UK. Any growth in the UK dairy sector will therefore be driven by increased demand for products such as cheese, butter and ingredients. This would help displace some of the UK's current imports, especially from countries such as Ireland, who under the prospect of a No Deal Brexit will see their exports to the UK become more expensive.

Indeed, the impact of a No Deal will be felt as much in countries that export to the UK, such as Ireland, as it is here. The Irish have as much, if not more, to fear from a No Deal Brexit than the UK. As a result, the well-organised and resourced Irish Food Board, Bord Bia, is stepping up efforts to identify and develop new export markets, especially in Asia and the Middle East.

So – what next?

No-one still really knows. The European Commission has said repeatedly that there is no further room for negotiation on what has been agreed to date. The pro-Brexit members of the UK Government believe there is still time to achieve this, but if not they are willing to walk away with a No Deal. This would still have to be ratified by the UK Parliament and, to date, they have been just as divided on this issue as the wider population.

The Government has a wafer thin overall majority. Getting a No Deal through Parliament will still be a huge challenge – and time is running out. The UK is due to leave the EU by the end of October 2019, but Johnson has indicated that this could be done with a further two-year transition period agreed.

In the meantime, the UK economy overall still continues to do relatively well against some of our European neighbours such as Germany, Italy and France. Consumer confidence is somewhat fragile though – and understandably so. The threat of a No Deal Brexit still acts a brake on many areas of commercial activity. At a retail level, online shopping and the role of the discount stores, Aldi and Lidl, still put pressure on the more established Big 4 supermarkets.

And – for food producers?

For farmers, nothing is agreed, and nothing is certain. What is known though is that the UK farming and food sector is about to go through a huge amount of change in the next five to 10 years. This was happening already, but whatever sort of Brexit we end up with, what we have seen happening over the last 10 years will be accelerated. Farmers need to be preparing for change and doing this now – not waiting to see what happens over the next five years and then pretending the direction of travel has not been seen coming.

There are many highly able and extremely competent farmers in the UK, but we are going to need more of them in the future. We also need:

- More farming for public goods and services
- Less overall subsidy support
- More use of agri-tech in all its forms
- More genuine supply chain partnerships
- More formal benchmarking
- Better marketing and promotional support
- More efficient production per se.

These will all be part of the future. For those who get organised, plan ahead and engage with suppliers, customers and consumers, it will be an exciting time.

Disclaimer

The views expressed in this article are based on a combination of research carried out for organisations such as the UK Agricultural and Horticulture Development Board, the Welsh Government and a range of private sector clients from across the UK and international supply chain, and (in some cases) are of a more personal opinion.

About the author

John Giles is a Divisional Director with Promar International, the value chain consulting arm of Genus plc. He has worked on agri-food marketing and economic analysis assignments in some 60 countries, mainly in the dairy, livestock and horticultural sectors. He is the recent past Chair of the UK Institute of Agricultural Management.

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-86

Development of a Profitability Analysis Prototype with Multidimensional Benchmarks for Dairy Herds

HECTOR DELGADO RODRIGUEZ[1,*], ROGER CUE[1], DENIS HAINE[4], ASHEBER SEWALEM[3], RENE LACROIX[1,2], DANIEL LEFEBVRE[1,2], JOCELYN DUBUC[4], EMILE BOUCHARD[4] and KEVIN WADE[1]

ABSTRACT

The prototype of an information visualisation tool was developed using combined information from the Québec and Atlantic Provinces Dairy Production Centre of Expertise (Valacta Inc.) and the Quebec Animal Health Records (DSAHR Inc.), with the objective of presenting cumulative lifetime-profit results, and the factors that affect them, thereby facilitating the process of analysing and comparing results at the dairy-herd and individual-cow levels.

The information visualisation prototype created benchmarking curves with the possibility to evaluate current profitability at the herd and individual-cow level, and also to monitor the effect of historical decisions and events on the future components of profit. The user is presented with a herd analysis that compares its profit evolution to those of selected cohorts. These values are calculated from the accumulation of average daily profit estimates by herd or cohort. At the individual-cow level, lifetime profit curves are presents that include the effects of health and breeding-service costs among others. It is hoped that this prototype may demonstrate the value, to Dairy Herd Improvement agencies, of analysing and visualizing existing and potential profitability at the herd level, and lifetime analysis at the individual-cow level.

KEYWORDS: Profitability; management information system; information visualisation prototype; dairy cow

1. Introduction

Farm managers are challenged by multiple factors that affect herd profitability. Milk production and feed costs are among the most important components in the profit equation (Beck, 2011). Other factors such as rearing costs of heifers, animal health, and efficiency of reproduction also play an important role in lifetime profitability. Therefore, any producer, striving to succeed, needs not only to keep comprehensive records, but also have a clear understanding of how they relate to profit.

The proliferation of automation in the modern dairy herd for daily tasks means that large quantities of data are being, or can be, routinely collected. These large amounts of data are generated on-farm and off-farm, and their combination creates the "info-fog" (term coined by St-Onge, 2004). Analysis of these data can be undertaken at both a herd level and an individual cow level, in the form of economic decision-making tools (Roche *et al.*, 2009). However, the quantity of information that a user can practically examine and handle at a given time is limited, leading to the possibility of information overload, and the risk that these large, valuable datasets will not be exploited. This is especially true if computer applications are not available to provide an effective presentation and to permit interaction with the data (Chittaro, 2001). Computerized information systems can potentially help a dairy producer to deal with the increased complexity of decision making and availability of information in dairy farming (Pietersma *et al.*, 1998).

Frohlich (1997) proposed the development of visual and interactive tools as one possible solution to help with the processing of relevant information, since profitable decision-making depends on interpreting all of the inputs accurately. However, as critical as good quality data are, visual analysis involves posing questions, formulating hypotheses and discovering results (Eick, 2000). Information-visualisation methods explore, not only the space of successful designs and techniques, but also approach the application of accumulated knowledge in a principled manner (Heer *et al.*, 2005). According to Wright (1997) one of the advantages of information-visualisation systems is the ability to solve real-world problems.

However, in the dairy farming sector, data are collected by separate management and production software,

Original submitted August 2017; revision received October 2018; accepted July 2019.

[1] Department of Animal Science, McGill University, Macdonald Campus, 21111 Lakeshore Road, Ste-Anne-de-Bellevue, QC H9X 3V9.
[2] Valacta, 555 boul. des Anciens-Combattants, Ste-Anne-de-Bellevue, QC H9X 3R4.
[3] Agriculture and Agri-Food Canada, and Canadian Dairy Network, 660 Speedvale Avenue West, Guelph, ON N1K 1E5.
[4] Université de Montréal, Département de sciences cliniques, 3200, rue Sicotte, St-Hyacinthe QC J2S 2M2.
*Email: hector.delgado@mail.mcgill.ca

and there is no real integration of the data. Therefore, the information reports and analyses offered are fragmented by subject (e.g. health, nutrition, production) and it is challenging to understand how management decisions from the past have an effect on current results. With enhanced computing capacity now available, it is possible to combine diverse data sources, create integrated reports, and, through the use of visualisation techniques, provide end-users with new perspectives of how operational and tactical decisions are affecting the management of their operations.

Working with production data, supplied by the Québec and Atlantic Provinces Dairy Production Centre of Expertise (Valacta Inc.) and the Quebec Animal Health Records (DSAHR Inc.), the objectives of this study were 1- to integrate health and production data at the individual and herd level into a relational database; 2- to compute lifetime values of different factors affecting profitability; and 3- to develop individual and herd profitability reports, integrated in a visualisation tool that could facilitate the process of understanding and monitoring different management components that affect profitability.

2. Materials and Methods

For the development of the profitability prototype, a total of 43 herds and 7,850 animals with matched data from Valacta and DSAHR, belonging to cohorts (year when the animal calved for the first time) from 2005 to 2013 inclusive were selected.

2.1 Data editing and integration of datasets

To start the process eleven flat files that described different aspects of milk production (animal and herd identification, test-day production, lactation, body weight, body height, body condition score, equipment, feed, breeding information, auxiliary traits and pregnancy check files) were obtained from Valacta. The data covered the period from 2000 and 2013 inclusive. SAS® 9.4 software was used for data validation and editing (e.g., abnormal values for age, age at calving, lactation length, duplicate events, etc.). Various edit checks were carried out to detect inconsistencies, following the methodology described by St-Onge *et al.* (2002). For the construction of an integrated lifetime dataset, health data were obtained from DSAHR. This dataset consisted of a collection of health records from previously selected and identified herds as described in Delgado *et al.* (2017).

The Valacta records included different qualitative characteristics on herds and animals (e.g. Region, Breed, etc.). These characteristics were considered of potential interest as benchmark tools. Currently available reports only provide herd managers with comparisons by region and by breed, whereas other characteristics such as Feeding Equipment, Milking System or Herd Size might also have potential as benchmarks of interest and are not considered. Five qualitative categories were selected to group the data: Breed, Feeding Equipment, Milking System, Region and Herd Size. The Regions selected correspond to agricultural administrative regions defined by the Quebec Ministry of Agriculture. The selected breeds correspond to the top five dairy breeds in the Province.

2.2 Data transformation

Table 1 presents the different events, of an animal's productive life, that were selected and integrated from the different datasets. These events were integrated and ordered as series of chronological ''event-dates'' for each cow, starting from the first recorded event (birth record) to the last event recorded in the datasets (removal or culling). The Valacta test-day[5] dataset records individual milk values, as well as (for those producers availing of nutritional advice), costs for the calculated feed ration between test-day periods. Milk revenues and feed costs were consequently accumulated on a lifetime basis for every individual cow.

Costs of rearing the heifer to the moment of first calving, health events, and breeding (insemination) costs were calculated following the methodology described in Delgado *et al.* (2017). No indirect costs for effect on milk production or delayed/reduced conception rates were included since these are already accounted for in the individual production records; discarded milk was accounted for explicitly depending on the nature of the event, and the nature of the treatment (Kossaibati and Esslemont, 1997; Guard, 2008; Ruegg, 2011). Different sources (Booth *et al.*, 2004; Guard, 2008 and Lefebvre *et al.*, 2009) were consulted in order to estimate realistic provincial costs. The costs of the different health and breeding services, recorded in the health and reproduction datasets, were accumulated on a lifetime basis. To estimate the profit on any given date, and for visualisation purposes, it was important to interpolate the cumulative values for every single event-date. Lifetime values could, therefore, be estimated by accumulating all event-date values from the datasets over the life of the animal. Cumulative Lifetime Profit (**CLP**) accumulates, on a lifetime basis, the revenues obtained from milk value, and deducts the heifer rearing costs, lifetime cumulative feed, health and reproductive costs. This formula was originally implemented in the 1980s to compare genetic lines in experimental herds (VanRaden and Cole, 2014). The second formula is cumulative lifetime profit adjusted for the opportunity cost of the postponed replacement (**CLPOC**). This is the cumulative lifetime profit of the dairy cow minus the regressed average cumulative lifetime profitability of the herd. This formula was adapted by Kulak *et al.* (1997) and Mulder and Jansen (2001), from the concept originally proposed by Van Arendonk (1991).

Different procedures were required to transform the data and create variables that allowed suitable visualisation points at the different hierarchy levels, including individual cow levels, mean herd-level values, and different category-group levels. For instance, the event coded as ''INT'' or interpolation (Table 1) was inserted on the day before the recording of any health or insemination event in order to calculate the impact of those events on cumulative profit, as detailed in Table 2.

In order to obtain the herd values and the comparative benchmarks, cumulative means of the different values, and their standard deviations, were calculated by day of lifetime. All values were interpolated for each animal from event-date intervals to a daily basis using the Proc-Expand method in SAS® 9.4. The obtained interpolated values per day of life were filtered by the different category-groups presented in Table 3 (Breed, Region,

[5] A test day is a specific date on which an agent of the milk-recording agency (Valacta) takes measures and samples from individual cows. These events typically occur once per month, yielding up to 10 points of sampling throughout a lactation.

Table 1: List of Event Codes for the lifetime dataset and the different source datasets

Event code	Variable	Source	Observations
S	Lactation Start Date	Lactation	
E	Lactation End Date	Lactation	To include the final cumulative milk value by lactation.
LR	Lactation last record	Lactation	To include the complete cumulative feed cost by lactation.
LH	Animal Left Herd	Animal	If recorded in the Animal file.
TD	Test date	Test day	
INT	INTERPOLATION		Created one day before health or breeding events, to calculate the impact of these events.
I	Insemination	Breeding	
H	Health event	DSAHR or Valacta	
DM	Discarded milk		If recorded a health event that requires DM. (14 days after H date)

Herd Size etc.), sorted in chronological order (days of Life), and used to calculate means and standard deviations by category-group per day of life. The same procedure was used for herd values per day of life. All economic indicators were converted to 2012 constant Canadian dollars. Farm Input Prices Index (FIPI) and Farm Product Price Index (FPPI) were obtained from the Statistics Canada website (Canada, 2014a, b, c). The methodology for the construction and analysis of constant prices was described by St-Onge (2000).

With the lifetime integrated dataset constructed, and the qualitative benchmarks defined and stored in datasets (Table 3), a relational database was developed as a repository of information to develop different hierarchical analyses for decision support. To facilitate complex analyses and visualisations, the data were modelled, using three main hierarchical categories – animal, herd, and category-group (benchmarks) – that allowed for the visualisation of information from different perspectives. In order to select time variables, the information was modelled in days of life, parity cycles and calendar dates to facilitate navigation.

2.3 Development of the visualisation interface

Microsoft® Excel® software 2010 was chosen to develop the visualisation interface because its wide use, as well as its ease of connection to the database with the Open Database Connectivity (ODBC) system. For the design of the prototype, Microsoft® Excel® is a powerful tool for data visualisation (Evergreen and Metzner, 2013) and is commonly used for data reporting and analysis in businesses (Clark and Heckenbach, 2005). It is also simple to modify the graphs and queries as the protoype was developed iteratively. To allow users to select and display the different graphs in an organized manner, different codes were programmed in Visual Basic and embedded in the different modules (see Table 4).

The design of all graphs followed the Evergreen and Metzner (2013), the goal was to keep graphs simple, but effective, removing all that did not aid the understanding of the data in the display. Because of the need of longitudinal analysis to make decisions, time series were considered for the graphs, as presented by Tufte and Graves-Morris (1983).

The end-user selects the subsets of information to visualise directly from the interface with the help of ribbon lists. These subsets of information are loaded into sheets from the database and the user can select or filter the desired type of graph or table before passing the information to the graphics encoding process. The detailed process is similar to the one described in Stolte *et al.* (2002). Queries can be posed to obtain reports at the category, herd or individual level and the reports are presented in the form of descriptive tables and performance visualisation curves. If selected, benchmarks are also included.

2.4 Target users

The operation of the interactive system was kept simple, so as to avoid distractions to the user from the goal (Johnson, 2013) which, in this case, was profitability analysis; the interface and output information were improved through iterations of demonstrations to potential users (veterinarians and milk-recording advisors). Their feedback and comments were useful in ensuring that the interactive systems would not distract users from the goal, and the graphs presented were useful for them. Their input and ideas were incorporated into the design of the ultimate prototype.

3. Results

3.1 Description of the information visualisation prototype

The user has the possibility to filter the information using seven different categories (see Table 3), and Table 4 presents the thirteen different profitability-related variables that can be selected in the interface for visualisation. Milk volume and its components were also included for visualisation following the suggestion of the Valacta advisors, based on their interest by producers.

3.2 Herd dimension

At the herd level, it is possible to visualize overall performance, and filter it to any selected benchmark listed in Table 3. The end-user can also select a group of animals from the herd for analysis (e.g., cohort year or parity). This selection allows for the monitoring, over time, of profitability and other variables for different subsets of the herd (e.g., animals that calved for the first time in the same quota year). This analysis is further facilitated by the use of graphics.

An example of the use of cohort analysis is presented in Figure 1, where two cohorts from year 2008 and 2010 were selected. The figure shows the mean CLP for the two year cohorts and the mean and distribution curves (10 and 90 percentiles) for the selected Category-group (Central region of the Province). The CLP for animals of

Table 2: Fragment of lifetime events, costs, revenues and profit for a cow in her third lactation presenting the different event dates and the ''INT'' event date to facilitate visualisation quality

Event date	Event code	Health code	Age (days)	Cumulative feed cost	Health cost	Discarded milk	Service cost	Cumulative milk value	Cumulative profit	Profit w/o avoidable losses
02/12/2009	S		1,632	3,860				16,322	8,746	8,887
02/12/2009	H	DISPLACED ABOMASUM	1,632	3,860	236			16,322	8,511	8,887
15/01/2010	TD		1,676	4,179				17,544	9,414	9,790
27/01/2010	INT		1,688	4,257				17,912	9,704	10,080
28/01/2010	H	CYSTIC OVARY	1,689	4,264	55			17,943	9,673	10,104
16/02/2010	TD		1,708	4,388				18,525	10,131	10,562
07/03/2010	INT		1,727	4,522				19,167	10,639	11,070
08/03/2010	I		1,728	4,529			70	19,201	10,596	11,027
18/03/2010	TD		1,738	4,600				19,539	10,863	11,294
17/04/2010	INT		1,768	4,807				20,484	11,601	12,032
18/04/2010	I		1,769	4,814			70	20,516	11,556	12,057
19/04/2010	I		1,770	4,821			70	20,548	11,511	12,082
27/04/2010	TD		1,778	4,876				20,800	11,708	12,279
30/05/2010	INT		1,811	5,097				21,832	12,519	13,090
31/05/2010	H	CYSTIC OVARY	1,812	5,104	55			21,863	12,488	13,114
04/06/2010	TD		1,816	5,131				21,988	12,586	13,212
17/06/2010	INT		1,829	5,211				22,367	12,885	13,511
18/06/2010	I		1,830	5,217			70	22,396	12,838	13,534
19/06/2010	I		1,831	5,223			70	22,425	12,791	13,557
16/07/2010	TD		1,858	5,390				23,213	13,412	14,178
20/07/2010	INT		1,862	5,416				23,321	13,494	14,260
21/07/2010	H	CYSTIC OVARY	1,863	5,422	55			23,348	13,460	14,281
12/08/2010	TD		1,885	5,564				23,941	13,911	14,732
24/08/2010	INT		1,897	5,641				24,232	14,125	14,946
25/08/2010	I		1,898	5,648			70	24,256	14,072	14,963
26/08/2010	I		1,899	5,654			70	24,280	14,020	14,981
16/09/2010	TD		1,920	5,788				24,789	14,395	15,356
19/09/2010	INT		1,923	5,806				24,847	14,435	15,396
20/09/2010	H	CLINICAL MASTITIS	1,924	5,812	124			24,866	14,324	15,409
04/10/2010	DM		1,938	5,896		276		25,135	14,240	15,594
20/10/2010	TD		1,954	5,992				25,443	14,452	15,806
01/11/2010	INT		1,966	6,046				25,661	14,616	15,970
02/11/2010	I		1,967	6,050			70	25,679	14,560	15,984
05/11/2010	I		1,970	6,064			70	25,733	14,530	16,024
24/11/2010	TD		1,989	6,150				26,078	14,789	16,283
05/01/2011	TD		2,031	6,324				26,746	15,283	16,777
08/02/2011	TD		2,065	6,460				27,189	15,590	17,084

Table 3: Variables for selection of the data for visualisation and benchmarking included in the Prototype

Variable	Name	Description
Herd code	HRD_ID	Code used by Valacta to identify the herd (one per herd)
Animal identification	ANM_ID	Code used by Valacta to identify the animal (one per animal, unique)
Animal breed	ANB_CD	Breeds registered in the animal file provided by Valacta
Region in Québec	REGION	Region where the selected herd is located.
Feeding equipment	EQUIPMENT	Categories of feeding equipment registered by Valacta (according to the latest data provided)
Milking system	SYSTEM	Categories of milking system registered by Valacta (according to the latest data provided)
Herd Size	SIZE	Categories by the number of calvings per year.

Table 4: Variables presented in the form of lifetime cumulative curves and included in the prototype for visualisation purposes

Variable	Unit	Description
Age of lifetime	Days	"X AXIS"
Cumulative Profit after Variable Cost	CAD $	Lifetime income deducted heifer cost, feed costs, service-breeding and health costs
Cumulative Milk Value	CAD $	Lifetime milk value
Cumulative Feed Cost	CAD $	Lifetime feed costs
Cumulative Service-breeding cost	CAD $	Estimated cost of services based on recorded events
Cumulative Disease cost	CAD $	Summary of the estimated cost of all the recorded health events, including discarded milk.
Cumulative Fat Production	KG	Cumulative fat production expressed in kg.
Cumulative Milk Production	KG	Cumulative milk production in kg.
Cumulative Milk Protein	KG	Cumulative milk production in kg.
Cumulative F&L problems cost	CAD $	Estimated cost of recorded Feet and Legs problems
Cumulative Reproduction Problems cost	CAD $	Estimated cost of recorded reproductive health issues
Cumulative Mastitis Cost	CAD $	Estimated cost of recorded clinical mastitis issues
Cumulative Margin over Feed Cost	CAD $	Cumulative milk value minus cumulative feed cost
Cumulative Optimal Profit	CAD $	Cumulative milk value minus (heifer cost, feed cost and one service by lactation)

Table 5: List of animals from a selected herd and cohort-year from the visualisation prototype

Animal	Parity	Age in days	Cumulative days in milk	Cumulative profit	Feed cost	Milk value	Health cost	Insemination cost
1001	1	1,078	115	-2,364	685	2,323	225	140
1002	1	1,688	334	-1,936	1,746	5,538	1,468	630
1003	2	1,234	344	126	1,893	5,798	225	280
1004	2	1,511	732	6,621	4,361	15,955	1,691	280
1005	2	1,505	658	6,731	4,152	14,511	236	210
1013	3	1,634	809	9,194	5,321	18,885	998	280
1014	3	2,136	1,226	12,258	7,435	26,208	2,539	700
1015	3	1,972	1,142	12,368	6,880	24,329	1,220	770
1016	3	1,970	1,129	12,971	6,977	24,245	576	630
1018	4	1,946	1,058	9,027	6,414	20,470	1,286	560

the 2008 cohort of this herd closely follow the top 10% of animals in the Central region of the Province, while the performance for the 2010 cohort was closer to the average profitability of the region. This illustrates an instance where the herd manager should be interested in understanding why the profit to 1,900 days of the latest cohort ($11,000) was inferior to the same age of the 2008 cohort ($14,000). Visualisation will not provide the end-users with the final answers to their management questions; it will, however, show the results of profit and profit-related variables in a way that will help them to understand and explore factors that affect profitability. Figure 2 further shows an important difference between both cohorts, relating to health costs: while the 2008 cohort health costs tracked the mean curve for the region, the 2010 cohort health costs were among the highest (top 10%) in the region. These two comparisons alone should prompt the herd manager to pay attention to the health issues of the 2010 cohort, to, perhaps, explore factors at the individual cow level in that cohort, and to take corrective measures regarding the causes. As a result of the testing of the prototype by the specialists (veterinarians and milk-recording experts), a module that visualizes profitability performance by year of production and other profit related indicators such as feed cost per cow per years were incorporated into the prototype.

3.3 Individual cow dimension

An important part of management involves making operational and tactical decisions concerning individual animals. With this in mind, a second dimension of the

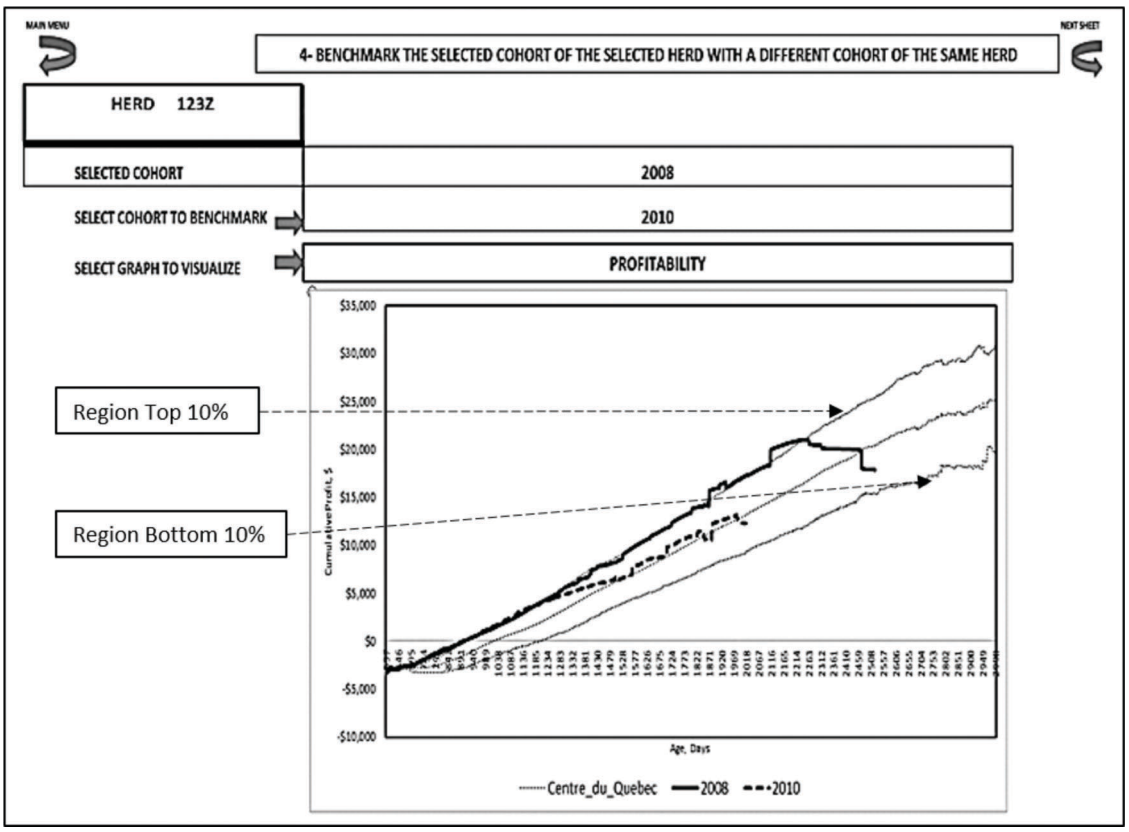

Figure 1: Profitability benchmarks between two year-cohorts of the same herd and category-group

prototype was developed, that permits such individual analyses. The monitoring and visualisation of the results of an individual cow can be presented by using information from an animal that is part of a herd, represented in the prototype. The user is presented with a table containing a list of animals from the selected herd and cohort (see Table 5 where the highlighted animal 1015 was selected to visualise her performance).

Figure 3 presents the evolution of CLP (continuous line), and the vertical bars represent the extra insemination and health costs that have occurred during the lifetime of the animal (secondary vertical axis). The dotted line in Figure 3 represents the cumulative profit that would have accrued without the deductions, caused by the health costs and the extra inseminations (avoidable losses). As can be observed, every health event and every additional breeding has an impact on the profitability of an animal, widening the gap between both curves (theoretical and actual) for the selected animal. In this particular case of animal 1015, a potential profit of $1,780 was not achieved because of the costs caused by health problems and extra inseminations. Going into further detail, Figure 4 allows the end-user to consult the medical history of the animal and find the direct costs of the recorded health events with one simple graph, thus saving time and avoiding the necessity to consult separate historic files. In this particular case (animal 1015), the animal registered a case of Displaced Abomasum during her first lactation, milk fever at the beginning of her second lactation, and finally a retained placenta problem during the third lactation. These cumulative direct costs can be visualised easily (Figure 4), and individual curves for Cumulative Breeding Cost, Health Cost, Feed Cost, Milk Production and CLP can be compared with herd and other benchmarks.

To facilitate the decision-making process, the prototype has incorporated a module that presents the end-user with various combined profit-related graphs that can help to monitor the performance of two animals and their performance within the herd. The visualisation prototype provides the list of animals in the herd including cumulative DIM and CLP information (Table 5). A second animal from Table 5 can be selected (animal 1018). By selecting this cow and repeating the process described for animal 1015 in Figures 3 and 4, the end-user can observe how a cystic ovary and clinical mastitis affected the performance of this second animal. In Figure 5, the end-user can monitor CLP performance of each of these selected cows with the average herd CLP and herd top and bottom 10% distribution curves. Although both animals (1015 and 1018) have presented various health and reproductive problems during their lifetime, the prototype may help the end-user to decide on keeping one animal over the other (or neither) through the use of comparison curves for CLP, health, reproduction, milk production, and milk components.

Finally, with the visualization curves of CLPOC (Figure 6), the end-user can compare the profitability performance of selected animal(s) to the profit obtained by an average animal in the herd (horizontal axis) at the same age. In this case the end-user can confirm that animal 1018 is under performing compared not only to animal 1015, but also to the expected average from that herd at the same age. This visualisation facilitates the process of decision making concerning the retention or culling of these animals.

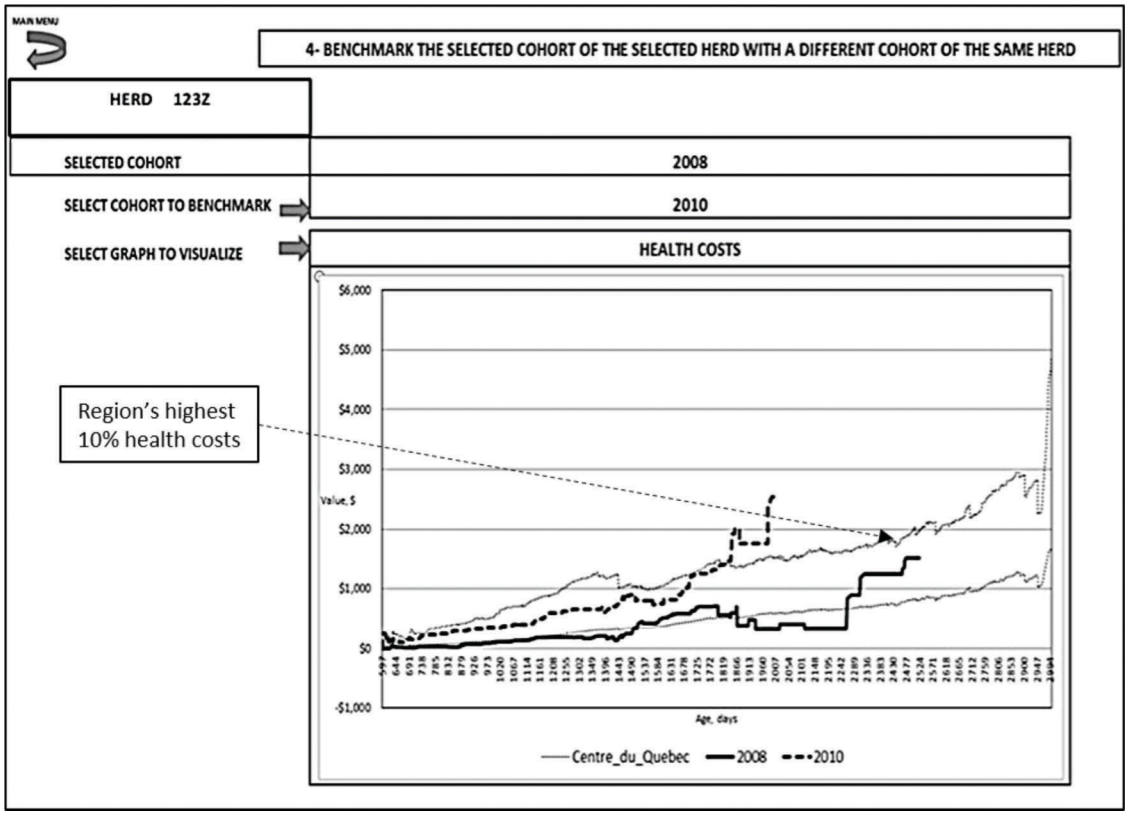

Figure 2: Comparison of cumulative health costs between two cohorts of the same herd with benchmarks by category-group

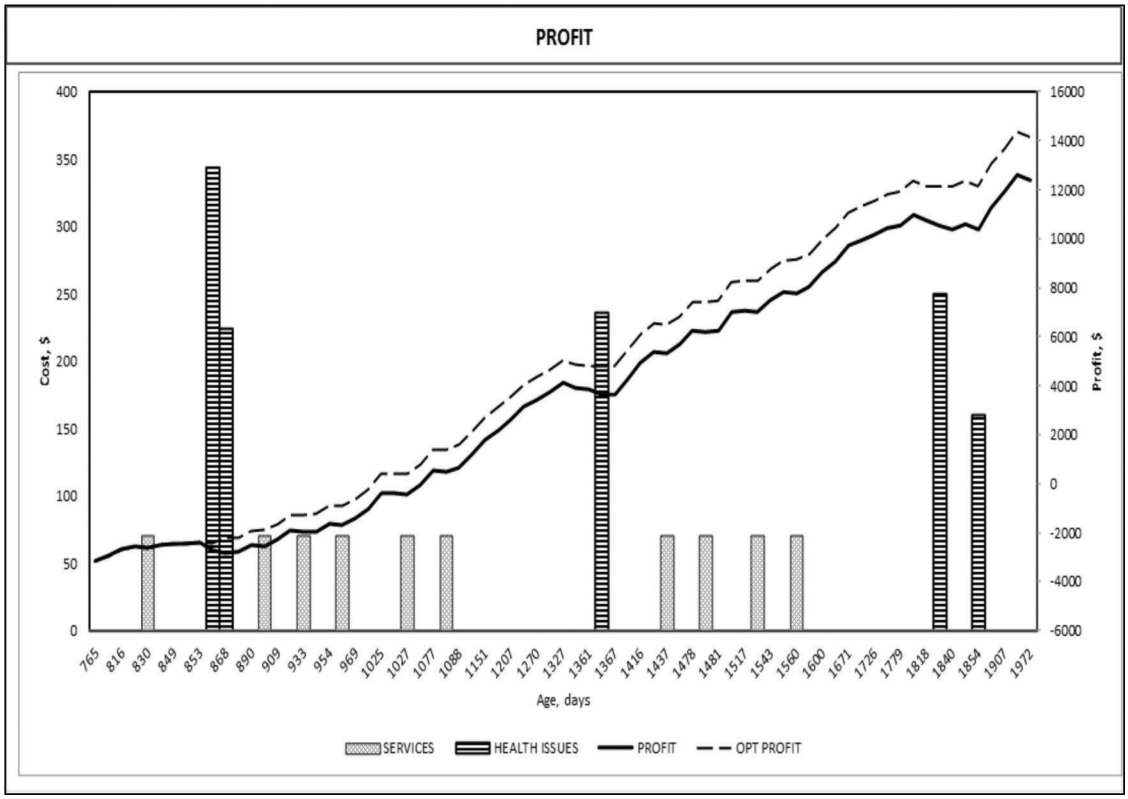

Figure 3: Cumulative Lifetime Profit and Cumulative Profit without Avoidable Losses for an individual cow. The curves in this figure represent the cumulative lifetime profit, interpolated by day of life (solid line), and the cumulative profit without avoidable cost (dashed line). The moment when the avoidable costs (extra services and health events) were incurred is represented by the vertical bars, and their respective costs are measured on the left Y-axis. The right Y-axis indicates cumulative profit

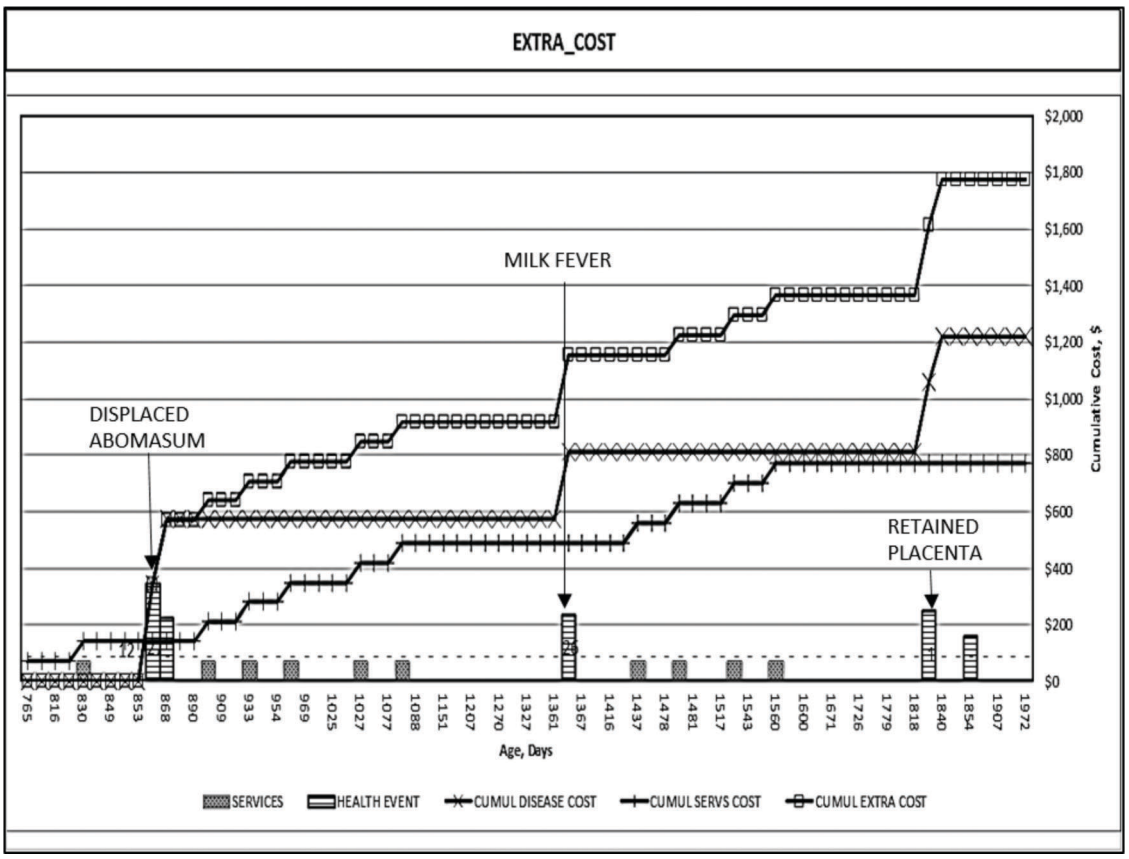

Figure 4: Extra costs cumulative curves for an individual cow. This graph shows the different events in the lifetime of a dairy cow and their cost impacts. The grey bars represent inseminations/services at the age of the animal they occurred (x axis). The cost of these inseminations is accumulated in the CUMUL SERVS COST curve. The white bars represent health events and the numbers in the bars correspond to the codes of these health events. The cost of the health events is accumulated and represented by the CUMUL SERVS COST curve. The total of the additional costs is represented by the CUMUL EXTRA COST curve

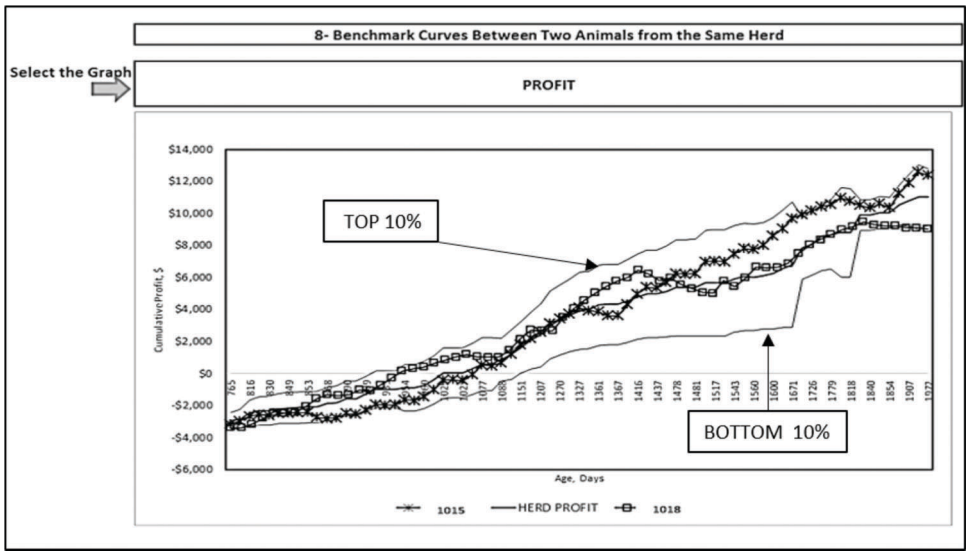

Figure 5: Lifetime Cumulative Profit benchmark between two animals from a selected herd including herd curves of distribution (10 and 90 %)

4. Discussion

Profitability of dairy herds has been a topic approached by management and decision-support systems: Cabrera (2012) developed a tool to estimate net present values of animals with the objective of helping decision makers to decide if an animal in production should stay or be replaced. St-Onge (2004) developed an information visualisation software named ''Herd-Line'' to help producers visualise the overall profile of the herd and specific performances of animals within the herd, through the use of individual phenotypic and genotypic performances.

This prototype presents the decision maker with options to select benchmarks, related to the herd-management

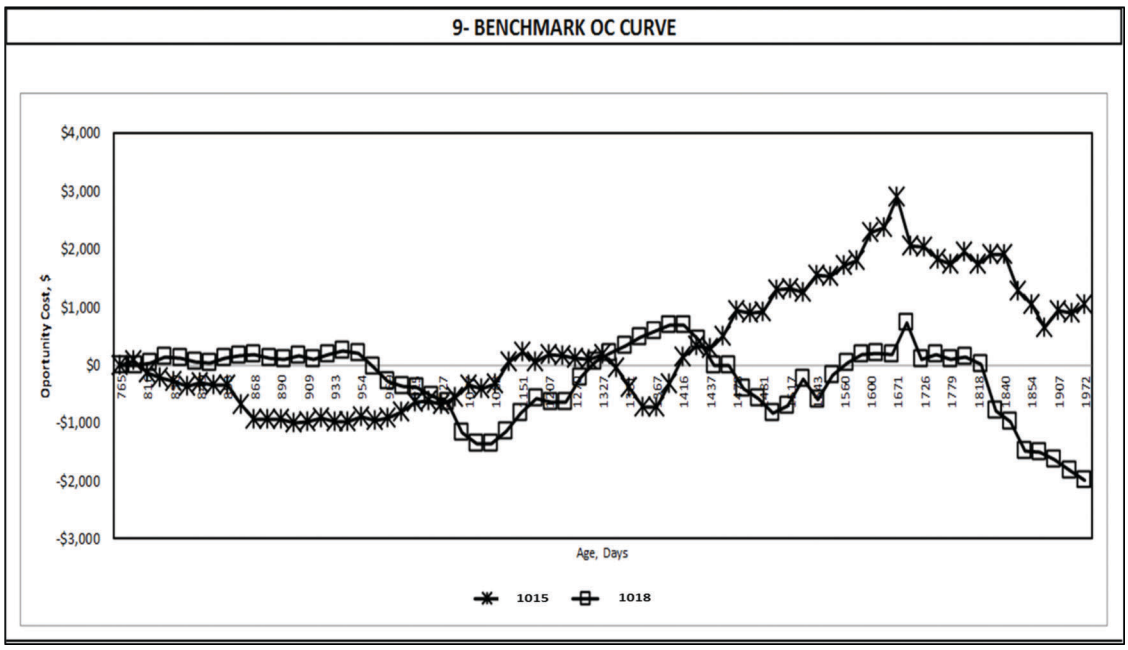

Figure 6: Comparison of the Cumulative Lifetime Profitability, adjusted for the Regressed Opportunity Cost of the Postponed Replacement for two animals in the same herd and cohort-year

characteristics, thus allowing more detailed comparisons. For instance, it might be of more interest to compare the herd profit performance or health costs with results obtained from herds in the same region rather than from the whole province. These specific comparisons can also provide decision makers with the opportunity to set realistic goals, based on specific criteria, such as the region where the herd is located, or the current milking system, or age profile of the herd. So far, this prototype only allows for benchmarking one category at a time; however, the concept could easily be extended to other groupings or combinations (e.g., organic milk producers, the combination of region and milking system, herd size and breed, etc.). Such additions are envisaged for future versions of the prototype, based substantially on the suggestions of the professionals that have tested (and will test) the prototype.

At a herd level, comparisons among different cohorts allow for the analysis of various scenarios (for example, were the criteria for selecting animals in a specific year deemed successful? Or why was the 2011 cohort more profitable than the 2009 cohort?). In the case of the latter example, the user can drill down and observe different aspects such as breeding-service costs, milk production and milk costs, among others, that could help answer the question, and set realistic goals for the future. It is expected that this prototype will help the decision maker to identify the cause(s) of the differences in profitability, or to reassess the strategic and tactical decisions, made in the past.

In contrast to other profit reports that accumulate individual information by different lactation cycles (St-Onge, 2004, Giordano *et al.*, 2011), the profitability information visualisation prototype presents the information, accumulated by lifetime. The productive lifetime is considered as a full cycle where the animal should recover her costs as a heifer at the moment of first calving and also return the expected profit. Currently this expected to happen only around the fourth lactation (Pellerin *et al.*, 2014). Another difference in the prototype, compared to previous reports, is the inclusion of a more-detailed cost analysis thanks to the integration of the data provided by Québec DHI (Valacta) and the provincial Animal Health Records (DSAHR) databases. This combined information in a relational database allowed the inclusion of costs of the recorded health events, and permitted a drill-down analysis documenting, not only summarized health costs, but also specific diseases such as clinical mastitis and reproductive problems. As previously described, the impact of these health costs on profitability can be visualised, thereby alerting herd managers to these costly management situations, and encouraging them to collect more extensive data for the future.

The inclusion of health and breeding events provided the opportunity to include these costs as part of the profit measures, and to visualise their impacts on the cumulative lifetime profitability of the animal. The resulting graph, that combined the interpolated cumulative lifetime profit by day of life with the cost of the different health and breeding services events during the lifetime of the animal (Figure 3) shows, in a clear way, the impact of these events on profitability (obtained CLP versus CLP without avoidable losses). This gives the decision-maker a very clear idea of what has happened with an animal during its lifetime. Having the opportunity to observe all the information recorded for one animal in a visualisation curve, and to benchmark it against other animals, offers the benefit for more well-informed decisions. The act of removing a cow from the herd has been widely studied from different points of view (Nordlund and Cook, 2004, Sewalem *et al.*, 2008). This prototype is intended to help decision makers monitor the evolution of an animal, not only with the aim of optimising culling decisions, but also in providing visual information that might otherwise not be so obvious or difficult to detect.

Different profitability formulae that show various aspects of the performance of the animal were included

for visualisation in the prototype. With CLP formula (VanRaden and Cole, 2014), it is expected that the decision maker can determine if a selected animal is reaching the expected profit goal and compare her performance with other animals in the herd. It also allows the comparison of the individual results with any selected category-group (Figure 5). The inclusion of the CLPOC formula, defined by Van Arendonk (1991) and adapted by Kulak *et al.* (1997) and Mulder and Jansen (2001), as part of the visualisation curves, allows decision makers to monitor the marginal contribution of an animal to the overall herd profitability. This is important because it facilitates the understanding of the role an animal is playing within the overall profitability of the herd. It is not impossible for an individual animal to have negative results for a given period of time (e.g., a lengthy dry period yet still contributes positively to the long-term profitability of the herd. However, if the contribution of an animal has been consistently below the performance of the average individual in the herd – as illustrated in shown in 6 – this would give the decision maker concrete reasons to flag the animal for culling. An additional use of the information presented in this prototype could be the provision of online reports by category, or the export of data (e.g., a csv file) for incorporation into other management systems (e.g., accounting software).

The integration and visualisation features were appreciated by the experts who explored the prototype. Both groups found the lifetime concept useful as well as the possibility to visualize and compare results in an intuitive and fast manner. New versions of the prototype will include modifications in the scales such as age of life expressed in months and not in days. Another concern revolves around the recording system at the herd level: herds included in the design of this porotype were carefully selected following the criteria proposed by Delgado *et al.* (2017), but it is likely the case that, not all the farms keep such good health records – a situation that could not only affect the herd results, but also the benchmark comparisons. Another limitation was the lack of individual herd-specific cost information for the recorded health events in the combined database; this necessitated the use of average values from the literature and previous surveys it is expected in the future to develop a user-version that could ask the user for the actual costs (e.g. specific vet costs, actual drug costs).

The current tool was developed using Microsoft technology that allows the integration of an Access database with the designed interface of Excel. It should be understood that this project was concerned with the production of a working prototype, and that any future large-scale development would require software and systems with a larger capacity. The next phase of this research is to implement a pilot project with a selected number of herds in the Province of Quebec and, through collaboration with Valacta advisors, evaluate the impact of this prototype on decision-making processes regarding profitability.

5. Conclusions

The different profitability measures, explored in this visualisation tool, have previously been used mostly in bio-economic and genetic analyses. This study demonstrates their use as potential tools for decision-making in dairy herd management. In addition, the multi-level hierarchical approach allows different users with different interests and goals, to benefit from the prototype.

Herd analysis by year of cohort allows for the monitoring and benchmarking of the evolution of strategic and tactical decisions, such as genetic management improvement or health plans, and their impact on the profitability performance of those cohorts on a cumulative basis over time. At the individual level, the use of comparative visualisation curves for profitability and profit-related variables simplifies the process of examining (and benchmarking) the cumulative lifetime of an individual animal. Accumulated information allows for the monitoring and comparison of the impact of different profitability components, not only in the current, but also in historical lactation cycles, thus facilitating the process of future tactical decision-making.

About the authors

Hector Delgado Hector completed his Veterinary Medicine studies at Universidad de Caldas (Colombia). He also completed a MBA at Universidad Santo Tomas (1999) and worked at the Veterinary Medicine School of Universidad Cooperativa de Colombia as a full-time Professor in charge of the Agricultural and Farm Management Projects areas (1997-2005). From 2006 to 2009 worked as Veterinary Programs Manager for South America for World Animal Protection (WAP). He obtained his PhD in Animal Science (Information Systems) in 2016 at McGill University.

Roger Cue obtained his PhD in genetics in 1982 (Edinburgh) after completing his undergraduate degree in Agriculture (Newcastle-upon-Tyne, 1978). He joined the department of Animal Science and has served twice as an acting Associate-Dean (Research, and Graduate Education). He has served as the representative of McGill University on the Conseil d'Administration of the Centre de Développement de Porc du Québec and on the Comité consultatif provincial des bovins de boucherie of MAPAQ. He is particularly interested in the analysis of field-recorded data (e.g. from milk or beef recording schemes) for scientific research and for studies where the results can be directly applied back for on-farm management purposes.

Denis Haine, obtained his PhD (Epidemiology) at the the Université de Montréal (2017), he completed his Master's Degree at London School of Hygiene and Tropical Medicine (U. of London, 2002) and his DMV at the Université de Liège (1994). Currently Denis works as Post-doc researcher in epidemiology at the Faculté de médecine vétérinaire, Université de Montréal, within the Canadian Bovine Mastitis and Milk Quality Research Network.

Asheber Sewalem is a PhD in Genetics and his areas of interests are National genetic evaluation of Canadian dairy breeds and various research areas to develop new methodologies and enhance the existing national genetic evaluation systems for Canadian dairy breeds, Mapping of Quantitative Trait Loci (QTL), Marker Assisted Selection, Linkage Analysis, Sustainable Livestock Production system for developing countries.

Rene Lacroix completed his Doctorate inAgricultural Engineering atMcGill University. He works as Analyst – Data Value (Business Intelligence) at DHI-Valacta. Before that, he worked as Planification Analyst at McGill's Planning and Institutional Analysis office from 2005 to 2010 and Assistant Manager of McGill's Dairy Information System Group, in collaboration with the PATLQ, for 10 years. He is author of close to 40 scientific articles for the general publicon new information technologies and data analysis.

Jocelyn Dubuc completed his Veterinary studies and Master's Degree at the Faculty of Veterinary Medicine (FMV) at the Université de Montréal. He also completed a combined doctoral program in research and clinical residency in population medicine (dairy cattle health management) at the University of Guelph. Since 2010, he has worked at the FMV (Université de Montreal) as a Bovine Population Medicine Professor. His main interests in practice and research are uterine diseases, metabolic diseases, nutrition, epidemiology and population medicine in dairy cattle.

Émile Bouchard is a Doctor in Veterinary Medicine from the Université de Montréal (1981), with internship in bovine medicine (1983) at the same university, Residency in Preventive Medicine, Internal Medicine and Theriogenology, University of California (1987) and M.P.V. M., Epidemiology, Preventive Veterinary Medicine, University of California (1988). Currently he works and full-time professor and Vice-Dean of Development, Communications and External Relations at the Université de Montréal. His research interests are development of computerized tools for the management of animal health, bovine mastitis and The Quebec Dairy Herd Improvement Program (ASTLQ) among others.

Daniel Lefebvre completed his Bachelor's degree in Animal Science (1989) and Doctorate in Dairy Cow Nutrition and Physiology (1998) at McGill University. He joined DHIValacta in 1993 and currently he works as the General Manager and Director of Research and Development. He also is an Associate Professor in the Department of Animal Science, McGill University and memberof theBovins Laitiers du CRAAQcommittee.

Kevin Wade was born in Ireland, educated in Agricultural Sciences at University College Dublin (BScAgr, 1985; MScAgr, 1986), and obtained his PhD in Animal Breeding and Genetics from Cornell University (1990). Following a post-doctoral fellowship at the University of Guelph, he was hired in McGill's Department of Animal Science to fill an NSERC-Industry-funded position in Dairy Information Systems (1992). Wade has served at various levels of administration at McGill (including the Faculty's Director of Continuing Professional Development, a Board Member of Valacta, and as a University Senator). Since 2007, he has been Chair of the Department of Animal Science.

Acknowledgements

The authors of this study would like to thank the Fonds de Recherche Nature et Technologies de Québec (FRQNT), Novalait, the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ), and Agriculture and Agri-Food Canada for funding support (FRQNT project LT-163341), as well as Valacta and DSAHR for providing the data. Gratitude is extended to the Hugh Blair Scholarship for financial support of Hector Delgado, and to Maxime Figarol and Camille Thoulon – internship students from the University Paul Sabatier in Toulouse France – for their input on the visualisation techniques.

6. REFERENCES

Beck, T. (2011). How Does Cost Efficiency Affect Farm Profitability? in AgSci » Dairy and Animal Science » Research and Extension » Dairy Science » Capital Region Dairy Team » News » How Does Cost Efficiency Affect Farm Profitability? D. a. A. S. P. S. University, ed. http://www.das.psu.edu/research-extension/dairy/capitalregion/news/df-200712-01

Cabrera, V.E. (2012). A simple formulation and solution to the replacement problem: A practical tool to assess the economic cow value, the value of a new pregnancy, and the cost of a pregnancy loss. *J. Dairy Sci*., 95, 4683–4698. DOI: http://dx.doi.org/10.3168/jds.2011-5214

Canada, S. (2014a). Farm Input Price Index (FIPI). Definitions, data sources and methods. Accessed Sept. 2014. http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getInstanceList&SDDS=2305&InstaId=14940&SurvId=65019

Canada, S. (2014b). Prices and Price Indexes. Statistics by Subject. Accessed Sept. 2014. http://www5.statcan.gc.ca/subject-sujet/result-resultat?pid=3956&lang=eng&id=998&more=0&type=ARRAY&pageNum=1

Canada, S. (2014c). Statistics by subject, Livestock and acquaculture. Farm financial statistics. Accessed Sept. 2014. http://www5.statcan.gc.ca/subject-sujet/result-resultat?pid=920&id=2553&lang=eng&type=ARRAY&pageNum=1&more=0

Chittaro, L. (2001). Information visualisation and its application to medicine. *Artif. Intel. Med*., 22, 81–88. DOI: http://dx.doi.org/10.1016/S0933-3657(00)00101-9

Clark, K., Heckenbach, I. and Macnica, Inc., (2005). Spreadsheet user-interfaced business data visualisation and publishing system. U.S. Patent Application 11/222,183.

Delgado, H.A., Cue, R.I., Haine, D., Sewalem, A., Lacroix, R., Lefebvre, D., Dubuc, J., Bouchard, E. and Wade, K.M. (2017). Profitability measures as decision-making tools for Québec dairy herds. *Canadian Journal of Animal Science*, 98(1), pp. 18–31. DOI: https://doi.org/10.1139/cjas-2016-0202

Eick, S.G. (2000). Visualizing multi-dimensional data. ACM SIGGRAPH computer graphics 34, 61–67. DOI: http://dx.doi.org/10.1145/563788.604454

Evergreen, S. and Metzner, C. (2013). Design principles for data visualisation in evaluation. *New Directions for Evaluation*, 140 (2013), pp. 5–20. DOI https://doi.org/10.1002/ev.20071

Frohlich, D. (1997). Direct manipulation and other lessons. *Handbook of human-computer interaction*, pp. 463–488.

Giordano, J.O. and P. M. Fricke, M. C. Wiltbank, and V. E. Cabrera. (2011). An economic decision-making support system for selection of reproductive management programs on dairy farms. *J. Dairy Sci*., 94, 6216–6232. DOI: http://dx.doi.org/10.3168/jds.2011-4376

Guard, C. (2008). The costs of common diseases of dairy cattle (Proceedings). In Proceedings of the Central Veterinary Conference West, San Diego, Ca.

Heer, J., S. K. Card, and J. A. Landay. (2005). Prefuse: a toolkit for interactive information visualisation. Pages 421–430 in Proc. Proceedings of the SIGCHI conference on Human factors in computing systems. ACM., DOI: http://dx.doi.org/10.1145/1054972.1055031

Johnson, J. (2013). Designing with the mind in mind: simple guide to understanding user interface design guidelines. Elsevier.

Kossaibati, M.A. and R. J. Esslemont. (1997). The costs of production diseases in dairy herds in England. *Vet. J*., 154, 41–51.

Nordlund, K.V. and N. B. Cook. (2004). Using herd records to monitor transition cow survival, productivity, and health. *Vet. Clin. North Am. Food Anim*., 20, 627–649. DOI: https://doi.org/10.1016/j.cvfa.2004.06.012

Pellerin, D., Adams, S., Becotte, F., Cue, R., Moore, R. and Roy, R. (2014). Pour une vache, l'âge d'or c'est la 4e lactation!, In: CRAAQ – 38e Symposium sur les bovins laitiers, Centre BMO, Saint-Hyacinthe.

Pietersma, D., R. Lacroix, and K. M. Wade. (1998). A Framework for the Development of Computerized Management and Control Systems for Use in Dairy Farming. *J. Dairy Sci*., 81, 2962–2972. DOI: https://doi.org/10.3168/jds.S0022-0302(98)75859-X

Roche, J.R., J. K. Kay, N. C. F. riggens. and M. W. Fisher, K. J. Stafford., and D. P. Berry. (2009). Body condition score and its association with dairy cow productivity, health, and welfare. *J. Dairy Sci*., 92, 5769–5801. DOI: http://dx.doi.org/10.3168/jds.2009-2431

Ruegg, P.L. (2011). Managing mastitis and producing quality milk. In: ''Dairy Cattle Production Medicine'' (eds. C. Risco and P. Melendez), Wiley-Blackwell Publishing Ltd, Ames, Iowa, USA.

Sewalem, A. and F. Miglior, G. J. Kistemaker., P. Sullivan, and B. J. Van Doormaal. (2008). Relationship between reproduction traits and functional longevity in canadian dairy cattle. *J. Dairy Sci*., 91(4), 1660–1668. DOI: http://dx.doi.org/10.3168/jds.2007-0178

St-Onge, A., Hayes, J.F. and Cue, R.I. (2002). Economic values of traits for dairy cattle improvement estimated using field-recorded data. *Canadian journal of animal science*, 82(1), pp. 29–39. DOI: https://doi.org/10.4141/A01-044

St-Onge, A. (2004). The interpretation of dairy data using interactive visualisation (Doctoral dissertation, McGill University).

Stolte, C., D. Tang, and P. Hanrahan. (2002). Polaris: A system for query, analysis, and visualisation of multidimensional relational databases. *IEEE Transactions on Visualisation and Computer Graphics*, 8, 52–65. DOI: https://doi.org/10.1109/2945.981851

Tufte, E.R. and P. R. Graves-Morris. (1983). The visual display of quantitative information. Vol. 2. Graphics press Cheshire, CT.

Van Arendonk, J.A.M. (1991). Use of Profit Equations to Determine Relative Economic Value of Dairy Cattle Herd Life and Production from Field Data. *J. Dairy Sci*., 74(3), 1101–1107. DOI: https://doi.org/10.3168/jds.S0022-0302(91)78261-1

VanRaden, P.M. and Cole, J.B. (2014). Net merit as a measure of lifetime profit: 2014 revision. Animal Improvement Programs Laboratory, ARS-USDA, Beltsville, MD. https://www.aipl.arsusda.gov/reference/nmcalc-2014.htm

Wright, W. (1997). Business visualisation applications. *IEEE Computer Graphics and Applications*, 17(4), 66–70. DOI: https://doi.org/10.1109/38.595273

REFEREED ARTICLE

DOI: 10.5836/ijam/2019-08-98

Stock theft control mechanism and economic impact of livestock theft in the Free State Province of South Africa: Implication for agricultural management policies

LOMBARD W.A.[1] and YONAS T. BAHTA[2]

ABSTRACT

The aim of the study was to estimate the financial impact (direct and indirect costs) of livestock theft and to identify different methods farmers used to control stock theft in the Free State Province of South Africa. The study used primary data collected from 292 commercial livestock farmers from the five municipalities of the Free State province. The direct and indirect cost of livestock theft rate was significant and mostly a higher level of management led to lower livestock theft losses. Livestock theft should be controlled successfully in order to sustain the South African livestock industry and competitiveness. The study recommends that there should be coordination and collaboration among all key role players in the industry including government institutions, the South African Police Service, agricultural businesses or organisations, farmer's unions and stock theft units. The role players should target, eradicate or reduce stock theft and encourage controlling mechanisms in order to enhance food security, sustain livestock competitiveness and achieve sustainable development goals by reducing hunger and poverty.

KEYWORDS: Direct cost; indirect cost; livestock theft; control stock theft; South Africa

1. Introduction

Some consider that livestock theft is as old as farming itself and is nothing new to farmers (Clack, 2013). Producers in all South African provinces are victims of stock theft. Both the commercial and emerging farming sectors are affected and statistics show that the occurrence of stock theft has increased over the years (PMG, 2010). With regard to certain livestock theft cases, it seems that more thieves make use of firearms and that theft has been commercialised with crime syndicates stealing larger numbers of animals at a time. This trend can be one of the contributing factors as to why more farmers are leaving the livestock industry, thus placing more pressure on South Africa's food security (PMG, 2010).

The annual economic impact of livestock theft in South Africa was reported at R 878 million[3] (Clack, 2018). Worse still, is that official statistics are underestimated (Scholtz and Bester, 2010; Clack, 2013). While available literature has investigated the number of animals lost (direct costs), no scientific investigation has focused on which loss-controlling practices farmers use and the cost of these practices (indirect cost).

In South Africa, extensive livestock farming is the primary farming activity suitable for 80 percent of the farmland (DAFF, 2012). Regardless of the seriousness of the problem, little research has been done to determine the methods used and actions taken by farmers to control stock theft as well as the effectiveness of these methods. Research investigating these control methods, actions taken and the economic impact of livestock theft in South Africa is a critical issue and requires major support. Such research will be beneficial for the livestock industries of South Africa. Due to the official livestock statistics being underestimated, it is of the utmost importance that the true impact of livestock theft in South Africa is investigated. Once the true impact and the methods used to control livestock theft is known, the total economic impact

Original submitted March 2019; revision received June 2019; accepted October 2019.

[1] Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa, PO Box 339, Bloemfontein 9300. E-mail: LombardWA@ufs.ac.za. Tel: +27 514013109. ORCID: https://orcid.org/0000-0002-7999-3855.

[2] Corresponding author: Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa. PO Box 339, Bloemfontein 9300. E-mail: Bahtay@ufs.ac.za/ Yonas204@yahoo.com. Tel: +27 514019050/27735591859. ORCID: http://orcid.org/0000-0002-3782-5597.

[3] R is Rand (South African currency); 1US$ = R14.84 on 10 June 2019.

thereof can be calculated. The total economic impact consists of the direct cost (cost of animals lost) and the indirect cost (cost of methods used and actions taken).

Most existing international and African studies (Donnermeyer and Barclay, 2005; Kynoch and Ulicki, 2010; Clack, 2013; Sidebottom, 2013; Clack, 2015; Manu *et al*., 2014; Doorewaard *et al.*, 2015; Maluleke *et al.*, 2016) focus on the extent and type of livestock stolen. These studies include the extent of stock theft by focusing on the number of cases reported. Additionally, the studies investigate whether livestock theft patterns reflect variations in the extent to which different animals are concealable, removable, available, valuable, enjoyable, and disposable preference to steal. Also, these authors compiled literature based on the impact of stock theft, the uniqueness of livestock theft, case studies where individuals have been found guilty of livestock theft, examined the situation of policing in relation to the crime committed against agricultural operations, determined the causes of cattle theft and indicators for stock theft in rural areas. Yet research on the extent of economic impact (direct and indirect costs) of stock theft, which includes methods farmers use to control and actions taken against stock theft, remain insufficient and limited. Therefore, the objective of this study was to estimate the true financial impact (direct and indirect cost) of livestock theft and to identify different methods farmers used to control stock theft in the Free State Province of South Africa.

2. Materials and Methods

The Free State Province of South Africa, which is the focus of this study, is situated centrally within South African borders. The Free State Province consists of five municipalities namely, Fezile Dabi, Lejweleputswa, Mangaung metropolitan, Thabo Mofutsanyane and Xhariep (Figure 1). The province does not only share its border with six other provinces, but also with Lesotho. Lesotho, also known as the Mountain Kingdom, is completely surrounded by South Africa (Lesotho, 2015). The border shared between the Free State Province and Lesotho is 450 km long and is guarded by 100 troops of the South African National Defence Force (Steinberg, 2005). The Free State Province has a population of 2 745 590 (Statistics South Africa, 2011) with roughly 54 000 people employed in the agricultural sector (Statistics South Africa, 2014). Mangaung had the highest population density of the five municipalities based on its small size and large population (747 431). The second largest population per municipality was Thabo Mofutsanyane (736 238). Even though the Xhariep is relatively large it had the only housed the smallest population (146 259) of the five municipalities (Statistics South Africa, 2011).

According to the Department of Agriculture, Forestry and Fisheries (DAFF), there are 6 065 commercial livestock farming units in the Free State Province (DAFF, 2013). The province has a total size of 12 943 700 ha, of which 90.9% is used for farming. Commercial farmers have approximately 11.5 million hectares of land at their disposal and emerging farmers almost 323 thousand hectares (DAFF, 2013). Grazing land, which is mainly suitable for livestock farming, makes up 58.1% of commercial farmland and 66% of emerging farmland (DAFF, 2013).

The Free State Province has the third largest number of sheep as well as cattle, estimated at approximately 4.8 million sheep and 2.3 million cattle. The province also houses 230 thousand goats (DAFF, 2014a). The Xhariep municipality houses the largest percentage of the Free State Province's sheep at approximately 41% and the Mangaung municipality houses only approximately 1% (DAFF, 2014a). When investigating the distribution of cattle in the Free State province, one notices that the Thabo Mofutsanyane municipality houses the largest portion (36%) of the province's cattle, the Fezile Dabi municipality houses the second largest (30%) and the Mangaung municipality houses the smallest (2%) portion (DAFF, 2014a). The largest portion of the Free State province's goats (41%) is housed in the Lejweleputswa municipality with the Xhariep municipality housing the second largest portion (40%) and the Mangaung municipality housing smallest portion (3%) (DAFF, 2014a). Carrying capacity differs dramatically throughout the province from 3.5 ha per large stock unit (LSU) in the East to 16 ha/LSU in the West (DAFF, 2014b).

The Free State province was selected, because it primarily consists of grazing land suitable for livestock farming (cattle, sheep, and goats). The Red Meat Producers Organization (RPO) of the Free State Province provided a data set from which the contact details of approximately 2 500 commercial livestock farmers could be sourced. This ensured that only commercial livestock farmers were interviewed. Primary data were collected using a semi-structured questionnaire from 292 livestock farmers over a four-month period (May – August 2014). An appropriate sample size of 292 respondents were selected using the formula developed by Cochran (1977), which was representative of the livestock farmers in the Free State province (Diamond, 2001).

A stratified random sampling process was applied to livestock farmers within five municipalities according to their farm's demographic and topographic location. This allowed for comparison and correlation between the different municipalities and that only livestock farmers were interviewed. The number of livestock farmers within the five municipalities comprised Xhariep (45), Lejweleputswa (72), Thabo Mofutsanyane (97), Fezile Dabi (61) and Mangaung (17). The proportion of livestock in each municipalities determined the respective sample sizes. The questionnaire was administered to the respondents during telephonic interviews. The questionnaire contained questions regarding farmers' years of farming, age, farm size, farm location and farm topography, losses due to livestock theft and practices used to control livestock theft (methods used, actions taken, how often these practices were performed and the annual cost of these practices). Table 1 provides an overview of the number of respondents and livestock surveyed in each of the municipalities.

As indicated in Table 1, 292 respondents[4] were interviewed and represented 4.81% of the 6 065 livestock farmers in the province (DAFF, 2013). The data represented 159 081 sheep (3.31%), 77 675 cattle (3.48%), 8 277 goats (3.61%) and 604 393 ha (5.22%) of land in the province.

Data on sheep per municipality as a percentage of the total in the province, Xhariep represent the largest (1.40%) and Thabo Mofutsanyane the second largest

[4] Each participant was from a separate farming operation.

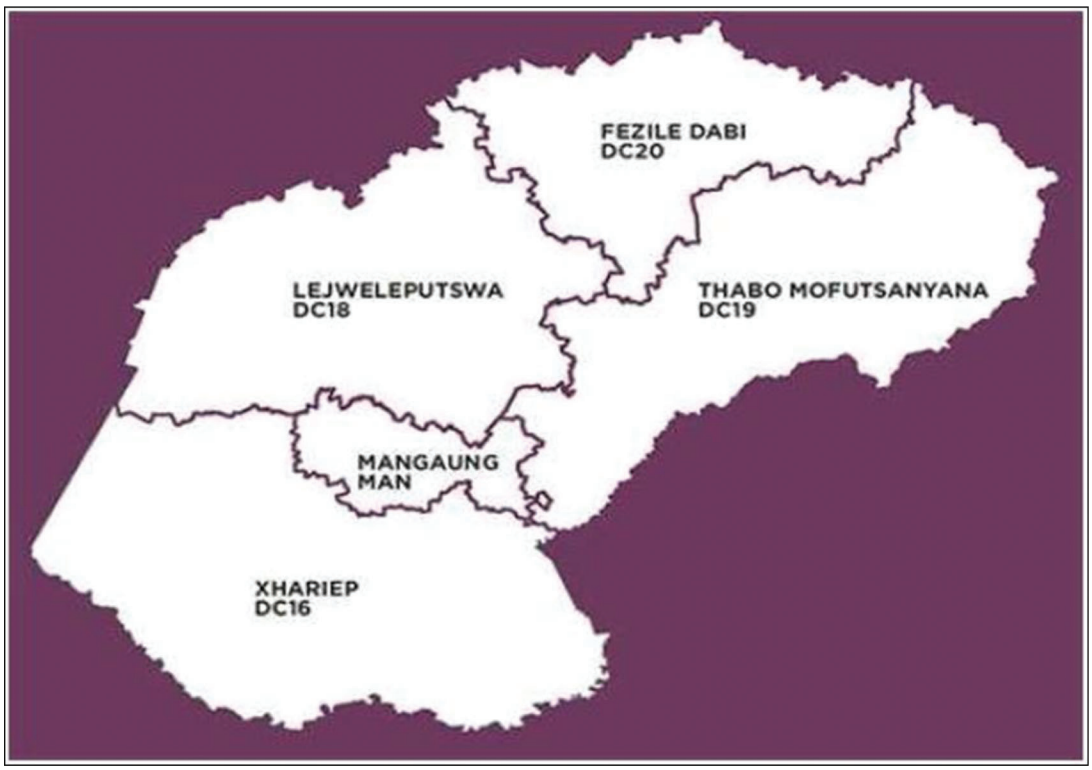

Figure 1: Municipalities of the Free State Province. Source: The Local Government Handbook (2015).

percentage (0.94%). As in the case of sheep, there was a large variation in the number of cattle between the municipalities. Thabo Mofutsanyane (808 984) had the largest and Fezile Dabi (671 481) the second largest number of cattle. In the Thabo Mofutsanyane, the data for 33 216 cattle were captured and represented approximately 1.49% of the cattle in Free State Province. In total, the data captured in this study represented approximately 91 831 head of cattle, which was roughly 4.11% of the cattle in the Free State Province. Lejweleputswa had the largest number of goats (8 554 goats or 3.74%) in the Free State Province, which was contrary to the case of cattle and sheep.

The survey data were processed to estimate the financial impact (direct cost and indirect cost) of livestock theft in the Free State Province and to determine the different methods and actions farmers are used to control stock theft in different municipalities. Prior to the estimation, summary statistics of the farmers were collected to give an overview of the socio-economic characteristics of respondents. The questionnaire was used to identify livestock theft control practices and the percentage of farmers using each method. Livestock theft control practices comprised the method used and the action taken to combat livestock theft. The method used included management practices, physical barriers, animals, and technology. Actions taken includes night patrols and access control.

To estimate the financial impact (direct cost and indirect cost) of livestock theft, quantification of the direct cost consisted of two calculations. Firstly, the total number of livestock lost annually per municipality was calculated:

$$L = R \times S \tag{1}$$

Where R represents the annual loss rate per municipality (%), S represents the total number of livestock (cattle, sheep, and goats) per municipality and L represents the total number of livestock lost annually per municipality.

Secondly, the livestock lost annually per municipality (five municipalities) was added to calculate the total number of livestock lost annually. Once the total losses were determined, the monetary value of the losses were calculated as:

$$C = L \times P \tag{2}$$

Where L represents the total number of livestock lost, P represents the unit cost per animal (sheep, cattle, and goats respectively) and C represents the total annual direct cost of livestock theft in the Free State Province. These calculations were separated for cattle, sheep, and goats.

The annual loss rate was calculated by taking the number of animals stolen and deducting number of animals retrieved (not recovered by the police or by the farmers). This number was divided by the number of animals represented in the survey and expressed as a percentage. To assign a monetary value to animal loss is complex, however, the National Livestock Theft Forum decided on a value of R 10 400 per head cattle, R1 700 per sheep and R 1 950 per goat during the RPO national congress in 2012 (RPO, 2012). This estimated value was used in this study.

The indirect costs represented all of the expenses incurred in an attempt to control/lower livestock theft. Indirect costs were calculated as:

$$K = M/N \times 100 \tag{3}$$

Where K represents the total annual cost of control practices and methods per municipality in the Free State, M represents the total annual cost of control practices

Table 1: Number of respondents and livestock represented in the study area

Number of farmers interviewed, hectare of farm land and number of livestock in Free State			
Variable	**Number**	**Interviewed**	**Percentage**
Farming units	6 065	292	4.81
Sheep	4 806 386	159 081	3.31
Cattle	2 233 784	77 675	3.48
Goat	229 229	8 277	3.61
Farmland (ha)	11 572 000	604 618	5.22

Number of farmers interviewed in the municipalities											
			No. Surveyed			No. in the province			% surveyed per municipality		
Municipalities	**Respondents No.**	**Hectare in the survey (ha)**	**Sheep**	**Cattle**	**Goat**	**Sheep**	**Cattle**	**Goat**	**Sheep**	**Cattle**	**Goat**
Xhariep	45	148 818	67 101	8 570	3 137	1 960 874	250 443	91 677	1.40	3.42	3.42
Lejweleputswa	72	140 798	8 941	16 057	3 328	250 770	450 339	93 333	0.19	3.57	3.57
Thabo Mofutsanyane	97	180 967	45 039	33 216	982	1 096 944	808 984	23 915	0.94	4.11	4.11
Fezile Dabi	61	180 967	34 694	30 204	591	1 451 900	671 481	13 134	0.71	4.50	4.50
Mangaung	17	31 581	3 306	3 784	516	45 898	52 537	7 170	0.07	7.20	7.20
Total	292	604 393	159 081	91 831	8 554	4 806 386	2 233 784	229 229	3.31	3.48	3.61

and methods per municipality and *N* represents the percentage of livestock represented per municipality.

3. Result and Discussion

Table 2 illustrates a summary of socio-economic characteristics of the respondents. The average age of the respondents was 51 years. This finding concurred with that of Badenhorst (2014) where fewer young people considered a career in agriculture. Years of farming experience was on average 25 years, which corresponds to the average farmers' age of 51 years.

Full-time farmers (Table 2) accounted for 86.30% of the respondents. On average, 32 sheep were stolen from each farmer over the data collection period with a maximum of 600 sheep being stolen. Many farmers, however, lost no sheep. A great problem is that on average only 5 sheep were retrieved per farmer. Thus, on average 27 sheep were lost per farmer. An average of 5 cattle were stolen from each farmer with the average recovery of 1 head of cattle per farmer. As in the case of sheep, some farmers did not experience any cattle theft during the study with a maximum of 87 cattle stolen from a farmer. On average, 1 goat was stolen per farmer during the study with a maximum of 76 goats stolen from a single farmer. The average number of goats recovered per farmer was 0.02.

Each farmer employed an average of 7 farm workers. Most farmers (93.5%) indicated that they took copies of employees' identification documents (ID) and checked new employees' criminal history (87%) at their local police station. This had an implication for a lower rate of stock theft incidences. The average size of the farming unit was 2 070 ha and the average distance of the farms from the nearest town was 21 km.

The annual livestock stock theft rate, loss rate and recovery rate calculated from the survey data is shown in Table 3. Lejweleputswa had the highest sheep theft rate (6.78%) and Xhariep the lowest (1.07%). Similar to the sheep theft rate, Lejweleputswa had the highest sheep loss rate (5.98%) and Xhariep the lowest (0.96%). Mangaung had the highest sheep recovery rate (15.83%) and Fezile Dabi the lowest (4.27%).

The highest cattle theft rate (Table 3) was experienced in Lejweleputswa (0.79%) with the Thabo Mofutsanyane in second place (0.64%). The annual recovery rate for cattle was higher in all the municipalities compared to the recovery of sheep. The highest recovery rate for cattle was in Lejweleputswa (27.56%) with Fezile Dabi (23.81%) in second place. When comparing the loss rate of cattle to that of sheep it was clear that the theft of sheep was much higher. Despite the high recovery rate for cattle in Lejweleputswa, this municipality experienced the highest cattle theft loss rate (0.57%) with the Thabo Mofutsanyane a close second (0.56%). Xhariep experienced the highest annual loss rate of goats (1.12%) and was the highest annual theft rate for the five municipalities. Fezile Dabi had the second-highest loss rate (0.34%) with Thabo Mofutsanyane in third place (0.31%).

The annual loss rates (Table 3) were used to calculate the direct cost of livestock theft in the Free State Province. The number of sheep, cattle, and goats used is an estimate was provided by the Department of Agriculture, Fisheries and Forestry for commercial farmers only (DAFF, 2014a). The monetary value of R1 700 per

Table 2: Summary of the respondents' socio-economic characteristics (n = 292)

Characteristic	Average	Minimum	Maximum	Standard deviation
Age of respondent (years)	51.16	20	84	13.02
Years farming	24.58	1	68	13.84
Full-time farmer (%)	86.30	-	-	-
Number of sheep stolen per farmer	32.45	0	600	63.57
Number of sheep recovered per farmer	5.24	0	222	23.85
Number of cattle stolen per farmer	4.86	0	87	12.20
Number of cattle recovered per farmer	0.94	0	47	4.81
Number of goats stolen per farmer	0.43	0	76	4.78
Number of goats recovered per farmer	0.02	0	5	0.29
Number of employees	7.03	0	45	6.76
Take ID copy (%)	93.5	-	-	-
Check employee's history (%)	87	-	-	-
Size of farm (ha)	2 070.61	50	12 000	2 111.91
Distance from town (km)	21.26	0	60	10.79
Distance from informal settlement (km)	20.81	0.9	60	10.49

sheep, R 10 400 per head of cattle and R 1 950 per goat was used as the market value of the animals (RPO, 2012) and served as a base price for this study. Note that this price can be changed for future calculations.

The direct costs of livestock theft in the Free State Province of South Africa are shown in Table 4. The annual direct financial impact of sheep theft in Free State Province is estimated at approximately R144 million. It was estimated that 84 955 (1.76 % of the total sheep population in the province) sheep are annually lost to stock theft in the Free State Province. Thabo Mofutsanyane experienced the largest direct annual loss (R43 076 300) to livestock theft of all the municipalities and Mangaung had the smallest annual financial loss (R2 386 800). Even though Lejweleputswa had the highest loss rate, the small number of sheep in the municipality led to low direct annual losses.

Thabo Mofutsanyane experienced the second highest cattle loss rate (0.56%) and the largest annual cattle losses (4 530) of the five municipalities (Table 4). Although the loss rate was slightly less than that of the Lejweleputswa (0.57%), the large number of cattle caused the highest number of cattle losses. Notice that the losses in Thabo Mofutsanyane were almost double that of the municipality in second place, namely Lejweleputswa (2 567). The annual direct cost of cattle losses in the Free State Province was calculated to be slightly more than R 100 million.

Xhariep recorded 1 027 goat losses per year (Table 4). This number was relatively high and was caused by the large number of goats as well as the high goat loss rate experienced in the municipality. The annual direct cost of goat theft was calculated to be roughly R 2.25 million.

It is clear that sheep theft contributed to the largest share of direct annual cost livestock theft. Although the value per head of cattle was much more than per sheep, the large number of sheep lost caused this large direct cost. The impact of goat theft was small compared to that of sheep and cattle. This was mainly because relatively small numbers of goats were housed in the Free State. Thabo Mofutsanyane experienced the largest annual direct cost of livestock theft in the Free State Province valued at roughly R 90 million (Table 4) with Fezile Dabi in second place at almost R64 million. The total annual direct cost of livestock theft in the Free State Province was calculated to be R 246 744 550.

The indirect cost represented the expenditure associated with practices used for controlling livestock theft. Once the indirect costs were known, the total cost of livestock theft in the Free State Province was calculated. The indirect cost of livestock theft (Table 5) showed that Thabo Mofutsanyane spent the largest amount of capital (R 16 861 172) on actions and methods to control stock theft. Fezile Dabi had the second largest annual indirect cost (R 15 910 488) and Lejweleputswa the third largest (R15 647 899). Notice how the magnitude of the indirect costs of each district corresponded to the magnitude of the direct cost of theft in each municipality. The municipalities that experienced larger losses spent larger amounts of money on actions and methods. This made sense since the more one loses the more effort will be put into controlling the losses. With regard to the Free State Province, the total annual indirect cost was calculated to be R 57 114 006. The total annual cost of livestock theft is represented in the last column of Table 5. The largest total annual cost was experienced in Thabo Mofutsanyane (R107 193 772), which was much higher than the value of Fezile Dabi, which was second (R79 814 238).

The total annual cost of livestock theft in the Free State Province was calculated to be R 303 858 556. This was an astonishingly high value and emphasized that livestock theft required serious attention.

The methods farmers currently used to control stock theft was grouped under either method used (Table 6) or actions taken (Table 7). Methods used included management practices, physical barriers, technology and animals. Management practices included guards, stock theft informants, strategic use of guards and strategic use of theft informants. Physical barriers included corral at night, electric fencing, locking gates, strategic corralling, and strategic electric fences. Technologies included stock theft collars, cameras, lights in the corral, alarms in the corral, strategic collars and strategic cameras. Animals included guard dogs, ostriches, black wildebeest, donkeys, strategic use of dogs.

Table 6 summarises the methods used to control livestock theft in the Free State Province. The use of control methods differed slightly between municipalities with corralling of sheep (actively and strategically[5]) being the

[5] Strategically refers to cases where action and methods are performed during known problematic livestock theft times of the year or month.

Table 3: Number of livestock stolen, recovered and lost in the Free State Province

Municipalities	No. Surveyed			No. stolen per year			No. recovered per year			No. lost per year		
	Sheep	Cattle	Goat	Sheep	Cattle	Goat	Sheep	Cattle	Goat	Sheep	Cattle	Goat
Xhariep	67 101	8 570	3 137	720	15	35	76	2	0	644	13	35
Lejweleputswa	8 941	16 057	3 328	606	127	2	71	35	1.67	535	92	0
Thabo Mofutsanyane	45 039	33 216	982	1 104	211	3	65	25	0	1 039	186	3
Fezile Dabi	34 694	30 204	591	609	126	2	26	30	0	583	96	2
Mangaung	3 306	3 784	516	120	0	0	19	0	0	101	0	0
Total	159 081	91 831	8 554	3 159	479	42	257	92	1.67	2 902	387	40

Municipalities	Annual stock theft rate (%)=No. stolen per year/ No. Surveyed			Annual loss rate (%)=No. lost per year/ No. Surveyed			Annual recovery rate (%)=No. recovered per year / No. stolen per year		
	Sheep	Cattle	Goat	Sheep	Cattle	Goat	Sheep	Cattle	Goat
Xhariep	1.07	0.18	1.12	0.96	0.15	1.12	10.56	13.33	0.00
Lejweleputswa	6.78	0.79	0.06	5.98	0.57	0.00	11.72	27.56	83.50
Thabo Mofutsanyane	2.45	0.64	0.31	2.31	0.56	0.31	5.89	11.85	0.00
Fezile Dabi	1.76	0.42	0.34	1.68	0.32	0.34	4.27	23.81	0.00
Mangaung	3.63	0.00	0.00	3.06	0.00	0.00	15.83	0.00	0.00
Total	1.99	0.52	0.49	1.82	0.42	0.47	8.14	19.21	3.98

Table 4: The direct cost of livestock theft in the Free State Province

Municipalities	Annual loss rate (%)			No. livestock in the province			No. livestock lost annually = Annual loss rate* No. livestock in the province			Annual direct loss (R) = No. livestock lost annually* R1 700/R10 400/R1 950			Total annual direct cost (R) of livestock
	Sheep	Cattle	Goat	Sheep	Cattle	Goat	Sheep	Cattle	Goat	Sheep	Cattle	Goat	
Xhariep	0.96	0.15	1.12	1 960 874	250 443	91 677	18 824	376	1 027	32 000 800	3 910 400	2 002 650	37 913 850
Lejweleputswa	5.98	0.57	0.00	250 770	450 339	93 333	14 996	2 567	9	25 493 200	26 696 800	17 550	52 207 550
Thabo Mofutsanyane	2.31	0.56	0.31	1 096 944	808 984	23 915	25 339	4 530	74	43 076 300	47 112 000	144 300	90 332 600
Fezile Dabi	1.68	0.32	0.34	1 451 900	671 481	13 134	24 392	2 149	45	41 466 400	22 349 600	87 750	63 903 750
Mangaung	3.06	0.00	0.00	45 898	52 537	7 170	1 404	0	0	2 386 800	0	0	2 386 800
Total	1.82	0.42	0.47	4 806 386	2 233 784	229 229	84 955	9 622	1 155	144 423 500	100 068 800	2 252 250	246 744 550

most popular method in all municipalities. In Lejweleputswa, 75% of the farmers corralled their sheep at night (actively and strategically) while in Fezile Dabi, less than 28% of the farmers corralled their sheep at night (actively and strategically).

Besides corralling animals at night, Xhariep data indicated that dogs (active and strategic) were the preferred control method (24.44%). This was also the case in Lejweleputswa where approximately 21% of farmers used dogs as a control method (active and strategic). In Thabo Mofutsanyane, the second most method used was guards (actively and strategically) at 14.43%. Stock theft collars (actively and strategically) proved to be the second most used control method in Fezile Dabi (18.03%). In Mangaung, two methods came in second place, guards (11.76%) and lights in the corral (11.76%).

Taking into account the Free State Province as a whole, the leading method that farmers used to control livestock theft was corralling animals at night. More than 33% of the farmers actively corralled their sheep at night. Approximately 14% of farmers strategically corralled their sheep during known problematic times of the year. Surprisingly though, one farmer specifically indicated that he experienced more livestock theft since he started corralling his animals, because it was easier to catch them in a confined area. The use of a guard was the second preferred method (10% active and 3% strategic). When combining the use of dogs (active and strategic), more than 13.6% of the farmers used guard dogs. It is interesting to note that approximately 10% of the farmers used stock theft collars (active and strategic), 8.2% used cameras (active or strategic) and 3.4% of the farmers used alarms. It seemed that the use of technology was taking place in farming, specifically in the livestock industry, which strived to solve problems with technological answers.

The actions taken against livestock theft represented activities where livestock farmers were directly involved. Actions taken against stock theft included active patrolling, access control, strategic use of patrols, strategic use of access control, count daily, count more than once per day, count once a week, count more than once a week, count monthly, farmers' union patrols, neighbourhood watch patrols, private company patrols. Keep in mind that in some cases farmers only used control methods/actions during problematic times of the year (e.g., Christmas and Easter weekends), which tended to have

Table 5: The indirect and total cost of livestock theft in the Free State Province

Municipalities	Total annual direct cost of livestock theft according to the study (R)	Total annual indirect cost of livestock theft according to the survey (R)	Total annual cost according to survey (R)
Xhariep	37 913 850	7 538 007	45 451 857
Lejweleputswa	52 207 550	15 647 899	67 855 449
Thabo Mofutsanyane	90 332 600	16 861 172	107 193 772
Fezile Dabi	63 903 750	15 910 488	79 814 238
Mangaung	2 386 800	1 156 441	3 543 241
Total	246 744 550	57 114 006	303 858 556

Table 6: Methods used to control livestock thefts (%)

	Xhariep	Lejweleputswa	Thabo Mofutsanyane	Fezile Dabi	Mangaung	Free State
Management practices						
Guards	11.11	11.11	10.31	8.20	11.76	10.27
Strategic guard	2.22	2.78	4.12	1.64	0.00	2.74
Theft informant	2.22	0.00	3.09	1.64	0.00	1.71
Strategic theft informant	2.22	4.17	7.22	6.56	0.00	5.14
Physical barriers						
Corral at night	17.78	51.39	35.05	21.31	29.41	33.22
Strategic corralling	11.11	23.61	11.34	6.56	23.53	14.04
Lock gates	0.00	0.00	3.09	0.00	0.00	1.03
Electric fencing	0.00	6.94	5.15	3.28	0.00	4.11
Strategic electric fences	2.22	2.78	0.00	0.00	0.00	1.03
Technology used						
Lights in corral	0.00	0.00	2.06	0.00	11.76	1.37
Alarm in corral	2.22	4.17	5.15	0.00	5.88	3.42
Camera	11.11	9.72	3.09	1.64	5.88	5.82
Strategic camera	4.44	2.78	2.06	1.64	0.00	2.40
Stock theft collar	6.67	6.94	4.12	13.11	5.88	7.19
Strategic stock theft collar	2.22	2.78	3.09	4.92	0.00	3.08
Animals used						
Ostrich	6.67	1.39	1.03	0.00	0.00	1.71
Donkey	2.22	5.56	5.15	4.92	0.00	4.45
Wildebeest	2.22	0.00	1.03	0.00	0.00	0.68
Dogs	11.11	16.67	10.31	0.00	0.00	9.25
Strategic dogs	13.33	4.17	3.09	1.64	0.00	4.45

Table 7: Actions taken to control livestock theft (%)

	Xhariep	Lejweleputswa	Thabo Mofutsanyane	Fezile Dabi	Mangaung	Free State
Active patrols	60.00	38.89	52.58	39.34	58.82	47.95
Access control	31.11	9.72	23.71	16.39	23.53	19.86
Strategic patrols	6.67	19.44	10.31	29.51	0.00	15.41
Strategic access control	15.56	11.11	11.34	19.67	0.00	13.01
Count daily	24.44	58.33	54.64	42.62	70.59	49.32
Count more than once per day	2.22	1.39	3.09	3.28	0.00	2.40
Count once per week	40.00	33.33	37.11	31.15	17.65	34.25
Count more than once per week	31.11	13.89	15.46	26.23	17.65	19.86
Count monthly	8.89	5.56	2.06	1.64	5.88	4.11

higher livestock theft occurrence. In these cases, actions were specified as strategic actions.

The actions farmers took to control livestock theft in the Free State Province are shown in Table 7. In all of the municipalities, patrols were preferred, followed by access control. In four of the five municipalities, most farmers counted their livestock on a daily basis. However, in Xhariep, most farmers indicated that they counted livestock once a week. Almost half (48%) the farmers actively patrolled and more than 15% strategically patrolled during problematic times of the year (Christmas and Easter weekends). Approximately 20% of the farmers actively used access control a further 13% strategically used access control. It was good to note that almost 52% of the farmers counted their animals on a daily basis, with 3% of these farmers counting more than once a day. Approximately 20% of the farmers did not count on a daily basis, but more than once a week. Approximately 34% of the farmers counted their animals on a weekly basis, but a disturbing number of farmers (4%) only counted once a month. With regard to counting animals, it seemed as if most of the farmers were willing to put in extra effort to control livestock theft and ensure early detection of stolen animals. However, there were still individuals who might detect animal theft too late to act. It should be taken into account that it is not always possible for a farmer to count animals on a daily basis, because of the time required for other farm enterprises. For example, during the planting season of maize, farmers have little time to attend to livestock requirements. It is also possible that the livestock is kept in an isolated area and can only be counted on a weekly basis.

4. Conclusion and Recommendations

The objective of the study was to estimate the financial impact (direct cost and indirect cost) of livestock theft and to identify different methods farmers used to control stock theft in the Free State Province of South Africa. The total annual cost of livestock theft in the Free State Province was estimated to be R 303 858 556. Of this amount, the direct cost of stock theft was R 246 744 550 while indirect costs contributed a further R57 114 006. The results suggested that higher levels of losses led to higher levels of expenditure to combat stock theft (indirect cost). However, in some parts of the study area, minimal control practices (action or method) were applied to control livestock theft.

Farmers are recommended to report stock theft cases as soon as they become aware of them. By not reporting, farmers do more damage to the industry than good. When stolen animals are reported as soon as possible, will ensure maximum time for the police and stock theft units to react, thus maximising the possibility of successful retrieval of animals. Farmers' unions and the police or stock theft units should form reaction teams, which can immediately act on suspicious activity and stock theft cases. It is recommended that support should be provided to livestock farmers by government institutions, the South African Police Service and other agricultural businesses or organizations. Farmers' unions and the police or stock theft units should work together to reduce the direct and indirect cost of livestock theft. If livestock theft is not successfully controlled, it will not only threaten the sustainability of the South African livestock industry, but also the competitiveness of the industry. It is also, recommended that livestock farmers especially (sheep farmers) count their livestock on a daily basis. If the farmer is unable to count the livestock every day, a trusted herdsman or farm manager should be entrusted with the duty.

About the authors

Dr Lombard W.A. is a lecturer at the University of the Free State, Department of Agricultural Economics, South Africa.

Dr. Yonas T. Bahta is a Senior Researcher at the University of the Free State, Department of Agricultural Economics, South Africa.

Acknowledgements

We would like to thank the Red Meat Research and Development Trust (RMRD) for their support and funding for this project.

Declaration and Statement

We declare that this work is an original academic research carried out by the authors and we confirm that the manuscript has not been submitted elsewhere and is not under consideration by another journal. There are no conflicts of interest.

REFERENCES

Badenhorst, C.G. (2014). *The economic cost of large stock predation in the North West province of South Africa*. M.Sc. dissertation, University of the Fee State, Bloemfontein, South Africa.

Clack, W.J. (2013). The extent of stock theft in South Africa. *Acta Criminologica: Southern African Journal of Criminology,* 26(2), 77–91.

Clack, W.J. (2015). Criminology theories: An analysis of Livestock theft cases. *Acta Criminologica: Southern African Journal of Criminology,* 28(2), 92–106.

Clack, W.J. (2018). *Livestock Theft a Global and South African Perspective*. Prepared for the National Red Meat Producers Congress 11 and 12 September 2018.

Cochran, W.G. (1977). *Sampling techniques, 3de Edition*. New York: John Wiley & Sons.

Department of Agriculture, Forestry & Fisheries (2012). *Trends in the Agricultural Sector 2012*. Pretoria, South Africa: DAFF.

Department of Agriculture, Forestry & Fisheries (2013). *Abstract of Agricultural Statistic 2013*. Pretoria, South Africa: DAFF.

Department of Agriculture, Forestry & Fisheries (2014a). *Livestock statistics per magisterial districts in the Free State*. Pretoria, South Africa: DAFF.

Department of Agriculture, Forestry & Fisheries (2014b). *Grazing capacity map of the Free State Province*. Pretoria, South Africa: DAFF.

Diamond, I. (2001). *Beginning Statistics: An Introduction for Social Scientists*. Thousand Oaks, CA: *Sage*. DOI:10.4135/9781446249437

Donnermeyer, J.F. and Barclay, E. (2005). The policing of farm crime. *Police Practice and Research,* 6(1), 3–17. DOI: 10.1080/15614260500046913

Doorewaard, C., Hesselink, A. and Clack, W.J. (2015). Livestock theft: Expanding on criminological profiling and offender assessment practices in South Africa. *Acta Criminologica: Southern African Journal of Criminology Special edition,* 4, 37–49.

Kynoch, G. and Ulicki, T. (2010). It Is Like the Time of Lifaqane: The Impact of Stock Theft and Violence in Southern Lesotho. *Journal of Contemporary African Studies,* 18(2), 179–206. DOI:10.1080/713675621

Lesotho (2015). *The official website of Lesotho*. Retrieved from: http:// www.gov.ls

Maluleke, W., Mokwena, R.J. and Motsepa, L.L. (2016). Rural farmers' perspectives on stock theft Police crime statistics. *South African journal of Agricultural Extension*, 44(2), 256–274.

Manu, I.N., Andu, W.N., Tarla, D.N. and Agharih, W.N. (2014). Causes of cattle theft in the North West Region of Cameroon. *Journal of Agricultural Science,* 4(4), 181–187.

Parliamentary Monetary Group (PMG) (2010). *An overview of stock theft in South Africa*. Meeting report from 25 May 2010. PMG. Retrieved from: http://www.pm g.org.za

Red Meat Producers Organization (RPO) (2012). National Stock Theft Forum Report for 2012, National Congress, RPO.

Scholtz M.M. and Bester, J. (2010). *The effect of stock theft and mortalities on the livestock industry in South Africa*. Peer - review paper 43 de Congress of the South African Society of Animal Science.

Sidebottom, A. (2013). On the application of CRAVED to livestock theft in Malawi. *International Journal of Comparative and Applied Criminal Justice,* 37(3), 195–212. DOI:10.1080/01924036.2012.734960

Statistics South Africa (2011). *Municipal factsheet. Based on the 2011 Census*. Publication of Statistics South Africa.

Statistics South Africa (2014). *Victims of Crime Survey 2013/14. Statistical release*. Publication of Statistics South Africa.

Steinberg, J. (2005). The Lesotho/Free State Border. *Institute for security studies Paper* 113.

The Local Government Handbook (2015). *District municipalities of the Free State Province*. Retrieved from: http://www.localgovernment.co.za/provinces/view/2/free-state

IFMA22 CONFERENCE PAPER

DOI: 10.5836/ijam/2019-08-107

People of Future Agriculture; Trust and Succession in Family Businesses

CATHERINE BELL[1]

ABSTRACT

Intergenerational transfer, or succession, is often a goal for family businesses in general, and family farms in particular. This challenging objective is aided or hindered by interpersonal trust between family members. The purpose of this study is to gain an understanding of the role of trust in succession so that those involved can observe the intergenerational behavioral patterns and estimate the source of trust/mistrust, or they can evaluate the trust issues and predict what behavioral patterns to expect. This meta study of the qualitative research literature on family businesses and succession revealed recurring patterns of intergenerational behavior as it relates to the essential component of trust. Character and competence influence the ability of business founders/predecessors and their children/successors to work within an area of trust, shaping intergenerational relationships and producing characteristic family business behavior patterns. Four typical interactive patterns include long-term stability, authoritarian rule, nepotism and sibling rivalry. Family member trust directly affects, and is affected by, family relationships, which, in turn influence both business performance, and the likelihood of successful intergenerational succession for the business itself.

KEYWORDS: family business; succession; trust; sibling rivalry

People of Future Agriculture; Trust and Succession in Family Businesses

Family businesses (FBs) make up a large proportion of businesses around the world and contribute greatly to the global economy. They have the paradoxical reputation of being long-term, resilient and stable, or of being short lived and producing environments full of conflict and drama. The family farm is a quintessential family business and the backbone of agriculture worldwide, yet it, too, can be either established and robust, or full of struggle and disagreement.

While the desire to pass on the farm may be an integral part of many family farms, relatively few of them are fortunate enough to see this procedure happen successfully. The process of succession has a disruptive potential and is a perilous time in the life cycle of a family farm or business (Osnes, Uribe, Hok, Yanli Hou, & Haug, 2017; Williams *et al*., 2013). Many FBs (approximately 70%) fail to survive to the second generation, around one in ten make it to the third generation, and only about 3% continue to the fourth generation (Cooper *et al*., 2013; Solomon, *et al*., 2011; Ruggieri, Pozzi & Ripamonti, 2014; Williams *et al*., 2013). Although transgenerational succession has proved difficult for a large majority of FBs, it continues to be a fundamental goal for many of them (Gudmunson & Danes, 2013), and those businesses are willing to work through the succession process in order to achieve this ambitious and challenging objective.

Methodology

This study considers the aspect of trust as it affects FBs. While trust has an impact on all businesses, it influences FBs in distinctive ways because of the interaction between the family and the business systems. Family businesses form characteristic patterns partly based on the level of trust between family members, and such patterns affect the working environments and the outcomes of the business. An understanding of how trust affects patterns of interpersonal behavior and succession, can help FBs increase the chances of successful long-term viability. With an understanding of trust and its consequences, those involved can either view the patterns and analyze where the trust issues occur, or conversely, know where the trust issues are and predict what kinds of behaviors may result.

Different levels of predecessor and successor trust combine to produce distinct patterns of behavior which affect FBs, particularly in terms of intergenerational

This paper was originally published as part of the proceedings for IFMA22. We are grateful to the International Farm Management Association for permission to reproduce it here.

Original submitted June 2019; accepted July 2019.

[1] Corresponding author: Box 1403 Drumheller, AB Canada, T0J 0Y0. Phone: +1-403-823-9462, Email: cawbell@hotmail.ca

functioning. While high levels of trust in both parties contributes to the long-term stability of FBs, other combinations are not as positive. Autocratic rule, nepotism, and sibling rivalry are all results of low trust in either, or both, the predecessor and successor. Such conditions shape interpersonal behaviors and affect FB performance.

Research was done by analyzing journal articles from both psychological and business literature. Search engines for the psychology articles included ProQuest – Psychology, and EBSCO Host articles from the psychology and behavioral sciences collection. Business articles used the ProQuest – ABI/INFORM collection. Using key words and terms including family business, family owned businesses, family firms, trust, family relationships, family conflict and succession provided access to articles which investigated FB behaviors through the lens of trust.

What was of particular interest in studying the role of trust within an FB was understanding how it affected FB behavior. With this in mind, articles which considered intergenerational relationships in the functioning of an FB were given priority as they described how real-life FBs reacted to the demands of both business and family dynamics. Fifteen articles were found to outline and describe such relationships and behaviors. While most of the articles range in date from 2011 to 2017, a seminal and often quoted article from Kets de Vries dating from 1993, was also included.

These articles were overlaid with a grid to demonstrate characteristic patterns observed in FBs which indicate the source of trust/mistrust and the consequent behaviors, including deviant and domineering actions as well as nepotism. While these FB behaviors decrease the likelihood of long-term business sustainability, an understanding of them may help those involved deal more constructively with these situations, thereby improving the prospects for FB success.

Trust

Many authors discuss the centrality of trust within an FB, both for the functioning of the family and the business. Trust within a FB is an essential, far reaching, multi-faceted, multi-level concept that is closely tied to norms, values, and beliefs, (Bencsik & Machova, 2016; Cole & Johnson, 2012; Johnson, Worthington, Gredecki, & Wilks-Riley, 2016; Rutherford, 2011). Trust has been defined as the confident set of beliefs about the other party and one's relationship with them which leads one to assume that the other party's likely action will have positive consequences for oneself (Azizi, *et al.*, 2017) or, put more succinctly, trust is a feeling that another person, group of people or the system as a whole, is performing in your best interest (Rutherford, 2011).

Gaining trust, however, is not a one-time achievement. Rather, it involves an ongoing set of practices that earn or increase trust over time as people recognize each other's trustworthiness (Castoro, 2018; Dede & Ayranci, 2014). Still, it is not a person's trustworthiness alone that determines trust. Trust is comprised of both character and competence (Rutherford, 2011). The character aspects of trust, or trustworthiness, include such traits as integrity, consistency, honesty, predictability, loyalty, benevolent motives, a lack of hidden agendas, openness, kindness, respect shown, sincerity and genuine caring (Azizi *et al.*, 2017; Castoro, 2018; Dede & Ayranci, 2014; Rutherford, 2011). The aspects of trust related to competence include ability, skills and capacity, power, and demonstrated reliability (Azizi *et al.*, 2017; Castoro, 2018). Accountability, which is the ability to explain, justify and account for one's actions, is an aspect of trust that straddles both competence and trustworthiness (Brundin *et al.*, 2014).

When integrity or competence is lacking, there is low potential for trust among individuals. The ability to create change is closely related to competence, and the ability to ensure the positive direction of that change is related to character. In an FB, change can be initiated by either the predecessors or the successors. It is a sign of low influence when individuals can't initiate change in others or their situation, or if the change attempted is not positive and is therefore resisted. One person's inability to influence the situation positively, is reflected by others mistrusting that individual.

The opposite stance to having no influence is having control, where an individual has complete power to influence the situation. Others may trust the competence of that individual to enact change, and may even look positively on those changes, but trust will eventually diminish when people know that they have no opportunity to influence the situation should circumstances have a negative effect in the future. People may feel uncomfortably vulnerable to the notions of the one in control.

'No influence' and 'control' represent extremes on the continuum, with 'influence' marking the middle ground, the area of trust. When individuals and organizations, particularly FBs, can learn to operate within the area of trust there is great potential for that business to function successfully.

It requires two things for an FB to function within an area of trust. First, the predecessor must share the control of the business to the extent that others trust that they will have some influence should circumstances produce a negative effect on them. Secondly, successors must have the capacity, in terms of character and competence, to initiate positive changes. Both the predecessor and the successor influence the FB trust dynamics due to their individual traits and their ability to work within the area of trust. Trust is reciprocal in nature and each party must be willing and able to both influence and be influenced by, the other.

In the following grid, the ability to work in the area of trust is labeled 'high trust', and the failure to work in the area of trust is labeled 'low trust'. The individuals' capacity to work within the area of trust is determined by their competence and character, including their propensity to trust others i.e. through delegation or sharing power. A grid producing four quadrants is formed: 1) predecessor

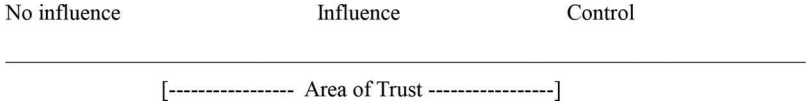

Figure 1: Continuum of Trust.

		Trust of Predecessor	
		high trust	low trust
Trust of Successor	high trust	1)	2)
	low trust	3)	4)

Figure 2: Predecessor/Successor Trust matrix.

high trust and successor high trust, 2) predecessor low trust and successor high trust, 3) predecessor high trust and successor low trust, and 4) predecessor low trust and successor low trust.

Results

Behavioral outcomes or patterns fall into distinct categories depending on the reciprocal abilities of the predecessor and successors to trust each other to function in an intergenerational FB. These categories include successful succession, autocratic rule, nepotism and sibling rivalry.

Category 1), successful succession, shows high predecessor and high successor trust. It has been shown that the levels of trust in FBs significantly and positively influence cohesion and profitability (Ruiz Jimenez *et al.*, 2015).

The ability of the predecessor to move into an area of trust is indicated by the willingness to share control, and demonstrated by such actions as grooming, training and communicating explicit and tacit knowledge with the successor (Carr & Ring, 2017; Williams, *et al.*, 2013). The capacity of the successor to move into an area of trust is shown by a readiness to take on new responsibility regarding leadership and/or work related roles (Marler, *et al.*, 2017). This combination encourages cooperation and collaboration as both parties are able to contribute to decision making and innovation. Having a common purpose and high levels of involvement by family members creates a sense of psychological ownership that motivates the family to behave and act in the best interests of the business, resulting in higher levels of commitment and trust (Cano-Rubio *et al.*, 2016). Category 1) FBs deal with trust issues by making competence and character part of the FB ethos and culture.

While FBs have advantages because of the resources associated with the interactions and involvement of the family (Cano-Rubio *et al.*, 2016; Daspit *et al.*, 2017; Ruiz Jimenez *et al.*, 2015), there are also disadvantages associated with this pairing. One frequent concern is that family conflicts overflow into the business (Cooper *et al.*, 2013; Kets de Vries, 1993). Relationship conflict seems to be particularly characteristic of FBs, harming the decision-making process, firm development and performance (Memili, Zellwiger & Fang, 2013). Lee & Danes (2012) suggest that the interpersonal dynamics among family business members is an important factor in the low rate of intergenerational transmission of businesses. They further warn that if family members are unable to harmonize, ameliorate relationship ruptures and reestablish trust, their business is highly vulnerable and may even fail.

Category 2) indicates low predecessor trust and high successor trust which is demonstrated by the predecessor's unwillingness to distribute control, even as the successors show the capacity to work within the area of trust. Although the successors might display competence, the predecessor may identify with the FB to such an extent that he is averse to letting go of, or sharing power. Having a powerful, domineering patriarch is common in FBs (Kets de Vries, 1993; Solomon, *et al.*, 2011; White, 2018). This has consequences for the FB in that it can lead to family dysfunction, low FB trust, and business stagnation.

Predecessors in this category have difficulty trusting the competence and characteristics of people other than themselves. While the predecessor's characteristics such as industriousness and perseverance are useful for establishing and managing a business, they can be taken to an extreme (Hertler, 2014). Traits such as conscientiousness, competence, self-discipline and achievement striving, can be pushed to the point of becoming authoritarian, autocratic and controlling (Hertler, 2015). The concepts of over-conscientiousness, perfectionism, and workaholism are interrelated and are typified by high interpersonal control, and low trust or difficulty in delegating responsibility (Bovornusvakool *et al.*, 2012; Samuel & Widiger, 2011) One of the outcomes for those with low trust/high control traits is a higher likelihood of interpersonal conflicts (Steenkamp *et al.*, 2015).

Trust becomes an issue when the successors are belittled or controlled by their powerful father and are therefore afraid to challenge him; they don't trust themselves to stand up to a 'giant' of a man. Successors also don't trust the father to listen to new and innovative ideas or to let go of management or control, even if they technically become the head of the FB.

Category 3) is an area of high predecessor trust and low successor trust. This can be shown by the predecessor being willing, or more than willing, to share FB control with successors although the successors may lack technical ability or the capacity for leadership. While some leaders have a strong desire to pass on their business to their heirs, some successors may feel that managing the FB is more of a burden (Williams *et al.*, 2013), and take over the FB out of a sense of obligation or the perception of limited alternative opportunities for income (Pieper *et al*, 2013).

Parents may encourage this feeling of obligation by indicating that successors need to conform in order to receive recognition from the parents, or to collect financial or other benefits from the FB (Pieper *et al*, 2013). Some FBs emphasize family relatedness at the

expense of autonomy. Parents may employ controlled motivation so that the children perceive that their choices are forced by external factors i.e. the children act in order to avoid guilt or shame, or to manage interpersonal controls like rewards or punishments (Osnes *et al*., 2017).

Kets de Vries (1993) notes that many predecessors simply overlook the weaknesses of their children, welcoming them into the FB regardless of their ability to contribute. Parents may be willing to offer pay and gifts in excess of the market value of the work as a means of encouraging their children's participation (Pieper *et al*., 2013). When family connection trumps merit or capacity it can smack of nepotism, favoritism and intra-family altruism which has an impact on other non-family FB employees (Carmon & Pearson, 2013).

The successors' inabilities have financial implications for the business as most FBs can't afford to support unproductive, unskilled family members in the long term. This situation may also postpone normal development when children are not allowed to freely make decisions regarding their involvement in the business, and children may not trust that parental attention and gifts come without 'strings attached'.

In category 4), both the predecessor and the successors show low trust. Predecessors demonstrate low trust by an unwillingness to share power and control, and perhaps even time and attention, with the successors (Kets de Vries, 1993). The founder may be completely obsessed by his business, devoting himself to its demands, and leaving him very little time for his family. In such cases children may perceive the business as the preferred 'sibling', producing intense feelings of competitiveness and jealousy among the children who never really had a chance to be the 'favorite' (Solomon, *et al*., 2011). A parent's emotional unavailability can have ongoing repercussions for children since early feelings of mistrust, envy and jealousy are long-lasting and difficult to resolve (Kets de Vries, 1993). Who was loved more or treated better becomes the issue at the heart of the relationship conflicts that are often transposed on to the business (Pieper *et al*., 2013).

Deviant, self-interested, opportunistic behaviors, including theft, withholding job effort, shirking, free-riding, violence, insubordination, sabotage, poor attendance, misuse of information, drug and alcohol use and abuse, being too dependent on the family, and various types of harassment may be use by dissatisfied family members as a means of restoring control (Cooper *et al*., 2013; Dede & Ayranci, 2014). A successor who perceives him/herself as the cheated and disfavored child, may feel more entitled to unearned benefits, as a way to punish those they perceive as treating them unfairly or unjustly, and as a way to restore a sense of dignity and justice (Cooper *et al*., 2013). When family members 'milk the business' to get what they feel entitled to, it can have devastating results for the business (Cooper *et al*., 2013; Kets de Vries, 1993).

The level of trust amongst family members influences how an FB operates, i.e. the interpersonal behavior patterns. Successful FBs are known for their high levels of trust and stewardship involving employees and the work environment. However, when trust levels are low because of attempts at interpersonal control, family members' feelings of jealousy, rivalry or forced involvement, the behaviors are dysfunctional and the business suffers.

Conclusion

Family businesses are important contributors to the economy worldwide, particularly in the area of agriculture through the family farm. An essential component in the functioning of FBs is the level of trust amongst family members which allows members to influence each other, and is shaped by the character and competence of the members themselves. Family member trust, particularly demonstrated by business predecessors/managers and their children/successors, affects interpersonal interactions, producing characteristic FB behavior patterns. These four typical interactive patterns include long-term stability, authoritarian rule, nepotism and sibling rivalry. The ability of family members to work within an area of trust directly affects, and is affected by, family relationships, which, in turn influence the performance of the business itself.

About the author

Catherine Bell is a family business partner living in central Alberta, Canada. Her family's farm is in the process of transitioning from one generation to the next. In preparation for this step, and to help others in a similar situation, she studied Occupational (I/O) Psychology, with an emphasis on family businesses, at California Southern University.

REFERENCES

Azizi, M., Salmani Bidgoli, M. and Seddighian Bidgoli, A. (2017). Trust in family businesses: A more comprehensive empirical review. *Cogent Business and Management,* 4, pp. 1–17.

Bencsik, A. and Machova, R. (2016). Knowledge sharing problems from the viewpoint of intergeneration management. Janos Selye University, pp. 42–50.

Bovornusvakool, W., Vodanovich, S., Ariyabuddhiphongs, K. and Ngamake, S. (2012). Examining the antecedents and consequences of workaholism. *The Psychologist Manager Journal,* 15, pp. 56–70.

Boyd, B., Botero, I. and Fediuk, T. (2014). Incumbent decisions about succession transitions in family firms: A conceptual model. *International Journal of Financial Studies*, (2), pp. 335–358.

Brundin, E., Florin Samuelsson, E. and Melin, L. (2014). Family ownership logic: Framing the core characteristics of family businesses. *Journal of Management & Organization*, 20:1, pp. 6–37.

Cano-Rubio, M., Fuentes-Lombardo, G. and Vallejo-Martos, M. (2017). Influenceof the lack of a standard definition of ''family business'' on research into their international strategies. *European Research on Management and Business Economics*, 23(3), pp. 132–146.

Carmon, A. and Pearson, J. (2013). Family business employees' family communication and workplace experiences. *Journal of Family Business Management,* 3(2), pp. 88–107.

Carr, J. and Ring, K. (2017). Family firm knowledge integration and noneconomic value creation. *Journal of Managerial Issues*, XXIX(1), pp. 30–56.

Castoro, A. (2018). Speak up or risk losing your best clients (and their kids). *Wealth Management,* (Jan), pp. 1–3.

Cole, P. and Johnson, K. (2012). A perfect fit: connecting family therapy skills to family business needs. *Journal of Marital and Family Therapy,* 38(1), pp. 63–71.

Cooper, J., Kidwell, R. and Eddleston, K. (2013). Boss and parent, employee and child: Work-family roles and deviant behavior in the family firm. *Family Relations,* 62, pp. 457–471.

Daspit, J., et al. (2017). A strategic management perspective of the family firm: Past trends, new insights and future directions. *Journal of Managerial Issues*, XXIX(1), pp. 6–29.

Dede, N. and Ayranci, E. (2014). Exploring the connections among spiritual leadership, altruism, and trust in family businesses. *Qual Quant,* 48, pp. 3373–3400.

Grossman, S. and von Schlippe, A. (2015). Family businesses: fertile environments for conflict. *Journal of Family Business Management,* 5(2), pp. 294–314.

Gudmunson, C. and Danes, S. (2013). Family social capital in famiy businesses: a stocks and flows investigation. *Family Relations,* 62(July), pp. 399–414.

Hadjielias, E. and Poutziouris, P. (2015). On the conditions for the cooperative relations between family businesses: the role of trust. *International Journal of Entrepreneurial Behavior & Research*, 21(6), pp. 867–897.

Hertler, S. (2014). The continuum of conscientiousness: The antagonistic interests among obsessive and antisocial personalities. *Polish Psychological Bulletin,* 45(2), pp. 167–178.

Hertler, S. (2015). The evolutionary logic of the obsessive trait complex: Obsessive compulsive personality disorder as a complementaty behavioral syndrome. *Psychological Thought,* 8(1), pp. 17–34.

Johnson, H., Worthington, R., Gredecki, N. and Wilks-Riley, F. (2016). The relationship between trust in work colleagues, impact of boundary violations and burnout among staff within a forensic psychiatric service. *Journal of Forensic Practice,* 18(1), pp. 64–75.

Kets de Vries, M. (1993). The dynamics of famiy controlled firms:the good and the bad news. *Organizational Dynamics,* 21(3), pp. 59–71.

Kidwell, R., Kellermanns, F. and Eddleston, K. (2012). Harmony, justice, confusion, and conflict in family firms: implications for ethical climate and the ''Fredo effect''. *Journal of Business Ethics,* 106, pp. 503–517.

Lee, J. and Danes, S. (2012). Uniqueness of family therapists as family business systems consultants: A cross-disciplinary investigation. *Journal of Marital and Family Therapy*, 38(June), pp. 92–104.

Marler, L., Botero, I. and De Massis, A. (2017). *Succession-re*; ated role transitions in family firms: The impact of proactive personality. *Journal of Managerial Issues*, XXIX(1), pp. 57–78.

Memili, E., Zellweger, T. and Fang, H. (2013). The deterninants of family ower-managers' affective organizational commitment. *Family Relations,* 62(3), pp. 443–456.

Osnes, G., et al. (2017). Autonomy and paradoxes in family ownership: case studies across cultures and sectors. *Journal of Family Business Management,* 7(1), pp. 93–110.

Pieper, T., Astrachan, J. and Manners, G. (2013). Conflict in Family business: common metaphors and suggestions for intervention. *Family Relations,* 62(July), pp. 490–500.

Pounder, P. (2015). Family business insights: an overview of the literature. *Journal of Family Business Management*, 5(1), pp. 116–127.

Ruggieri, R., Pozzi, M. and Ripamonti, S. (2014). Itallian family business cultures involved in the generational change. *Europe's Journal of Psychology*, 10(1), pp. 79–103.

Ruiz Jimenez, M., Vallejo Martos, M. and Martinez Jimenez, R. (2015). Organizational harmony as a value in family business and its influence on performance. *Journal of Business Ethics*, 126, pp. 259–272.

Rutherford, B. (2011). Trust is the beginningof everything in a family business. Beef (Nov), p. (8).

Samuel, D. and Widiger, T. (2011). Conscientiousness and obsessive-compulsive personality disorder. *Personality Disorders: Theory, Research and Treatment*, 2(3), pp. 161–174.

Sciascia, S., et al. (2013). Family communication and innovativeness in family firms. *Family Relations,* 62(3), pp. 429–442.

Solomon, A., et al. (2011). ''Don't lock me out'': life-story interviews of family business owners facing succession. *Family Process,* 50(2), pp. 149–166.

Steenkamp, M., et al. (2015). Emotional functioning in obsessive-compulsive personality disorder: Comparison to borderline personality disorder and healthy controls. *Journal of Personality Disorders,* 29(6), pp. 794–806.

Venter, E., Farrington, S. and Sharp, G. (2013). The influence of relational-based issues on job satisfaction and organisational commitment in family businesses: The views of non-family employees. *Management Dynamics,* 22(4), pp. 38–57.

White, E. (2018). Top down not always the best management style. The Western Producer, 29 March, p. 68.

Williams, D., Zorn, M., Crook, T. and Combs, J. (2013). Passing the torch: Factors influencing transgenerational intent in family firms. *Family Relations*, 62(July), pp. 415–428.

IFMA22 CONFERENCE PAPER

DOI: 10.5836/ijam/2019-08-112

The Development and Promotion of Environmentally Sustainable Food Products in South Africa

ENOCH OWUSU-SEKYERE[1,2] and HENRY JORDAAN[2]

ABSTRACT

The purpose of this paper was to estimate consumers' preferences for environmentally sustainable beef products, with the aim of developing and promoting environmentally sustainable products in South Africa. The findings reveal that there is profound preference heterogeneity at segment level for environmentally sustainable beef products. Three distinct consumer segments were identified. We demonstrate that socioeconomic factors, public awareness creation and campaigns on threats posed by climate changes, subjective and objective knowledge on environmental sustainability significantly explain consumers' choice of environmentally sustainable beef products. Furthermore, it is concluded that there are relevant segmental equity issues that need to be addressed when designing environmental sustainability policies to promote environmentally sustainable products. Finally, we demonstrate that there is a potential market for environmentally sustainable products in South Africa.

KEYWORDS: Carbon footprint; compensating surplus; sustainable products; water footprint; welfare implications

1. Introduction

Governments and policy-makers across the globe are increasingly getting interested in the development and implementation of environmental or ecological sustainability policies (IPCC, 2007). Carbon and water footprint sustainability assessment in particular is gaining particular attention, as some industries, agribusinesses and governments rely on these sustainability indicators to evaluate their environmental and water-related risks and impacts. The food and agricultural sector is one of the sectors where carbon and water footprint assessment is gaining much prominence as a result of the association between production and consumption of agricultural food products and the effects of these activities on water resources and the environment (IPCC, 2007). For instance, food and agricultural production utilizes about 86% of the global fresh water (IWMI, 2007). In terms of carbon emissions, the agricultural sector in general accounts for about 30-35% of the global greenhouse gas emissions (Foley *et al*., 2011).

Given the significant impacts that the food and agricultural sector have on the environment and water resources, stakeholders and policy-makers in recent years are keen on coming out with policies and strategies aimed at changing producers and consumers sustainability behaviour.

The Carbon Tax Policy Paper of the South Africa outlines ways of dealing with environmental challenges such as water scarcity, water pollution and climate change as a whole (National Treasury, 2013). One of the key initiatives under this policy is the introduction of carbon pricing. Carbon pricing initiative is expected to motivate producers to change their production patterns to a more sustainable one, through the adoption of innovative technologies with minimal environmental effects (National Treasury, 2013). The introduction of the carbon tax and pricing policy is expected to have

This paper was originally published as part of the proceedings for IFMA22. We are grateful to the International Farm Management Association for permission to reproduce it here.

Original submitted June 2019; accepted July 2019.

[1] Corresponding author: Department of Economics, Swedish University of Agricultural Sciences, Uppsala, Sweden. Email: kofiwusu23@gmail.com

[2] Department of Agricultural Economics, University of the Free State, Bloemfontein 9300, South Africa. Email: JordaanH@ufs.ac.za

significant impact on prices of food products, with low footprint products expected to have high prices because of the cost associated with the investment in minimal carbon emission technologies. The cost incurred is either transferred to the consumer or bear by the producer, or shared by both. This implies that the introduction of the environmental policy has significant economic implications on the welfare of consumers (Kearney, 2008). The policy requires food producers, agribusinesses and companies to make their sustainability information available through labelling. Carbon labelling has received some attention in the food and agricultural industry in South Africa.

Currently, the Water Research Commission has also directed their attention to water footprint assessment; particularly in the agricultural sector because the sector has been identified as a major user of the scarce water resource in South Africa (Department of Water Affairs, 2013). Therefore, the commission and concerned food companies seek to rely on sustainability campaigns and awareness creation through footprint labelling as a possible marketing strategy for marketing environmentally sustainable food products.

Consumer preferences for environmental environmentally sustainable food products have received some attention in recent literature (Grebitus *et al*., 2015: 2016; Peschel *et al*., 2016). Additionally, an assessment of carbon footprint labelling in respect of exports of agricultural product (Edwards-Jones *et al*., 2009) and legal issues concerning carbon labelling (Cohen and Vandenbergh, 2012) have been explored. However, the growing body of literature has focused consumer preferences (Grebitus *et al*., 2015: 2016; Peschel *et al*., 2016; Shumacher, 2010), trading (Edwards-Jones *et al*., 2009) and labelling issues (Cohen and Vandenbergh, 2012; van Loo *et al*., 2015). None of these studies have considered the development and promotion of environmentally sustainable product through consumers' preferences and choices of footprint labelled products. Additionally, these studies have focussed only on developed countries, with little or no study in arid and semi-arid African countries, including South Africa. Therefore, current knowledge on the impact of consumers' behaviour and choices on the development of environmentally sustainable products marketing.

The present paper fills this gap in literature and contributes to previous works (Grebitus *et al*., 2016; Peschel *et al*., 2016; Shumacher (2010) by estimating preferences and willingness to pay for water and carbon footprint sustainability attributes in South Africa, with the aim of developing and promoting environmentally sustainable products. Findings from this study can provide evidence based policy scenarios for developing the food and agricultural sector, for improved policy-making and regulations towards environmentally sustainable food production, marketing and consumption.

2. Materials and Methods

2.1 Compensating surplus estimation approaches

The theory of how respondents choose between different discrete choice sets is modelled under the random utility theory which assumes respondents to be rational and preferring products that give them the highest utility (Hensher and Greene, 2003; McFadden, 1974). The underlying assumption of the random utility is that consumers in recent years tend to have heterogeneous preferences for sustainable product attributes (Grebitus *et al*., 2013; Grebitus *et al*., 2015). Hence, the latent class model is adopted to account for unobserved heterogeneity among different consumer segments.

Under the latent class modelling approach, consumers are assumed to be organised implicitly into a set of classes. The class to which a consumer belongs to, whether known or unknown, is unobserved by the analyst. Consumers within each class are presumed to homogeneous but vary across different classes (Wedel and Kamakura, 2000). The number of classes in the sampled respondents is determined by the data. Belonging to a specific latent class hinges on the consumer's observed personal, social, economic, perception, attitudinal and behavioural factors. Assuming that a rational consumer i belonging to class l obtain utility U from product option k, the random utility is specified as:

$$U_{ik/l} = \beta_l Z_{ik} + \ell_{ik/l} \tag{1}$$

where β_l denotes class specific vector of coefficient, Z_{ik} represents a vector of characteristics allied with each product option and the error term of each class is denoted by ℓ_{ikl}. The error term is assumed to be distributed independently and identically. The likelihood that product option k is chosen by consumer i in l class is specified as:

$$\Pr_{ik/l} = \frac{\exp(\beta_l Z_{ik})}{\sum_n \exp(\beta_l Z_{in})} \tag{2}$$

The probability that consumer i belongs to a particular class is denoted by P_{il} and defined by a probability function G. The likelihood that consumer i belongs to class l is represented by the function $G_{il}=\delta_l X_i+\varsigma_{il}$ where X_i denotes a vector of consumers' personal, social, economic and other relevant factors and ς_{il} represents the error term. The error term is assumed to be distributed independently and identically. The likelihood of consumer i belonging to class l is then specified as:

$$\mathrm{P}_{il} = \frac{\exp(\delta_l X_{il})}{\sum_s \exp(\delta_l X_i)} \tag{3}$$

The combined possibility that consumer i belongs to class l and selects product option k is represented by:

$$\mathrm{P}_{ikl} = (P_{ik/l}) * (P_{il}) = \left[\frac{\exp(\beta_l Z_{ik})}{\sum_n \exp(\beta_l Z_{in})}\right] \times \left[\frac{\exp(\delta_l X_i)}{\sum_l \exp(\delta_l X_i)}\right] \tag{4}$$

The choice experiment employed and the random utility underlying the latent class model adopted in this study correspond with utility maximizing theory and demand (Bateman *et al*., 2003). Once the utility estimates for consumer segments are estimated, their willingness to

pay estimates can be computed as:

$$WTP = -\frac{\partial U/\partial X}{\partial U/\partial P} = \frac{\beta_{sustainability\ attributes}}{\beta_{price}} \quad (5)$$

where X is a vector of the product attributes. P denotes the price. $\beta_{sustainability\ attributes}$ is a non-monetary coefficient of sustainability attributes and β_{price} is the monetary coefficient on price. The class-specific WTP estimates are computed using parametric bootstrapping technique.

2.2 Sampling and data description

The survey was conducted in the Gauteng province of South Africa, using trained interviewers. Gauteng is the most populous province in South Africa and very diverse in terms of social, economic and demographic characteristics (Statistics South Africa, 2012). We employed a multistage sampling procedure to select 402 households in Centurion, Pretoria, and Midrand (Johannesburg). Face-to-face interviews were conducted, using samples of the labelled products, after the questionnaire had been pretested with 15 respondents. The questionnaire focused on the choice experiment, respondents' socioeconomic characteristics, knowledge of environmental sustainability and attitudinal data. The survey focussed on meat buyers, with particular note to beef consumers because beef is one of the most purchased livestock products in South Africa, making it easier to ensure high representation. Moreover, the water footprints of beef products in South Africa are known to be quite high, relative to the global averages.

Prior to the experiment, respondents' subjective knowledge were examined. As in Flynn and Goldsmith, (1999) respondents were asked how knowledgeable they consider themselves to be about ecologically sustainable production, water usage, carbon emission and ecological footprint. Responses to each statement ranged from "no knowledge (1)" to "very knowledgeable (5)". An index was calculated for subjective knowledge by averaging the responses of each respondent. After the choice experiment, we further examined respondent's objective knowledge by assessing the level to which they agree or disagree to six statements about ecologically sustainable production, water usage, carbon emission and ecological footprint, using five-point Likert scale ranging from "strongly disagree (1)" to "strongly agree (5)". In the interest of brevity, the statements used are not presented but are available upon request.

2.3 Experimental design

Attribute-based choice experimental design was employed. The choice experiment allows respondents to choose from a set of product alternatives, with different attribute combinations. The choices made by respondents' aid in revealing their preferences, without subjectively asking them to value the product attributes. This method minimizes social desirability bias (Norwood and Lusk, 2011). The choice experiment consisted of different combinations of water usage (water footprint), carbon emissions and prices. Different choice sets were designed for beef rump steak. The water footprint values were estimated using South African data and the Water Footprint Network Standard Approach as outlined in the Water Footprint Assessment Manual. Water footprint estimate for beef from Mekonnen and Hoekstra (2010) was also included. The carbon equivalents were obtained from Milk South Africa (Milk SA) and Scholtz *et al.* (2014). The selected prices considered for the product were the prevailing retail prices from markets across the study area for beef rump steak. Water footprint, carbon footprint and price attributes had three levels each in the choice sets designed (Table 1).

Table 1: Chosen attributes and levels

Attribute	Beef rump steak	Categorical level
1. Water footprint	1. 15415 l/kg	Low
	2. 17300 l/kg	Medium
	3. 17387 l/kg	High
2. Carbon footprint	1. 22.90 kgCO_2e	Low
	2. 26.37 kgCO_2e	Medium
	3. 27.50 kgCO_2e	High
3. Price	1. ZAR 159.99/ kg	Low
	2. ZAR 179.99/ kg	Medium
	3. ZAR 185.00/ kg	High

The attributes and their levels were combined using Ngene software to create random parameter panel efficient design with three alternatives (A, B and "none") (Choice Metrics, 2014). D-error efficiency and blocking strategy were also used during the design. The blocking strategy circumvents respondent fatigue during the survey. Twenty choice sets were generated using the Ngene software and blocked into ten, with each block containing two choice sets. Each person was randomly allocated to a block. Since the concept of carbon and water footprint is new, the possibility that some respondents may not be aware of water and carbon footprints was resolved by generating statements explaining the carbon and water footprints, their measurements and meanings of the footprint values to the respondents in their local and preferred language before the survey.

3. Results and Discussion

3.1 Descriptive characteristics of respondents

The descriptive characteristics of respondents are presented in Table 2. The average age of the sample was about 35 years. This concurs with Stats SA's population estimates which indicate that about 66% of the South African population are about 35 years or less (Statistics South Africa, 2014). The mean number of years of formal education was 15 years and an average monthly income of ZAR10132.24. Most of the respondents were females, as indicated by a percentage of 67.70%. About 53.50% of the respondents were aware of the department of water and sanitation's campaign on threats posed by climate changes in South Africa. This suggests the need for more awareness and campaigns on climate changes, as 46.50 % of the people were not aware.

Most of the respondents (73.44%) trust in food labelling regulatory bodies in South Africa. In terms of respondents' subjective and objective knowledge regarding environmental sustainability, the results revealed an average subjective knowledge (SUBKI) index of 3.41. Similarly, the objective knowledge index was found to be 2.68. The subjective and objective knowledge estimates show that the respondents consider themselves as moderately knowledgeable about environmental

Table 2: Descriptive statistics of respondents' socioeconomic characteristics

Variable	Description	Mean (SD)
Age	Years	35.08 (11.51)
Education	Years of formal education	15.08 (2.31)
Income	Monthly income in ZAR	10132.24 (43.98)
Subjective knowledge index (SUBKI)	Subjective knowledge about environmental sustainability	3.41 (1.00)
Objective knowledge index (OBJKI)	Objective knowledge about environmental sustainability	2.68 (1.10)
Variable	**Description**	**Percentage**
Female	1 if female, 0 otherwise	67.70
Awareness	1 if respondents is aware of the department of water and sanitations campaign on climate changes	53.50
Trust	1 if respondent trust in food labelling regulatory bodies	73.44

Authors' calculations.

Table 3: Latent class results for beef consumers

Attributes	Class 1	Class 2	Class 3
Water footprint			
Low	2.55*** (0.65)	2.07*** (0.43)	-0.63** (0.30)
Medium	-0.75*** (0.23)	-0.50 (0.36)	0.44** (0.19)
High	-1.56** (0.71)	-0.46* (0.24)	0.54** (0.22)
Carbon footprint			
Low	1.57*** (0.41)	1.25*** (0.33)	-0.42*** (0.13)
Medium	-0.69 (0.40)	1.16 (0.81)	1.02 (0.73)
High	-1.36*** (0.42)	-1.08** (0.48)	0.54* (0.3)
None	-3.11*** (0.66)	1.23*** (0.69)	0.74** (0.30)
Price	-0.35*** (0.11)	-0.37*** (0.07)	-0.18*** (0.05)
Class share	**46%**	**35.10%**	**18.90%**
Class membership estimates			
Constant	-1.66*** (0.24)	-2.43*** (0.39)	
Age	-0.57** (0.2)	0.33** (0.12)	
Female	-0.34 (0.24)	0.27** (0.11)	
Education	0.72** (0.22)	0.23 (0.19)	
Income	0.62** (0.31)	-0.32** (0.12)	
Awareness	0.46** (0.22)	0.55 (0.41)	
Trust	0.41** (0.20)	-0.39** (0.19)	
SUBKI	0.27** (0.11)	-0.16* (0.09)	
OBJKI	0.21** (0.09)	-0.13* (0.07)	
Diagnostic statistics	LL= -514.80; AIC=1051; BIC=1251.98; McFadden's (ρ^2) =0.21		

Authors' calculations: Values in parentheses are standard errors.
***=significant at 1%, ** =significant at 5%, * = significant at 10%.

sustainability. Generally, the index for subjective knowledge is higher than objective knowledge; implying that what respondents think they know about environmental sustainability is higher than what is actually observed or practical.

3.2 Latent class estimates

The latent class model estimates are provided in Table 3. Ben-Akiva and Swait (1986) test was conducted to ascertain whether the latent class model or mixed logit models best fit our data. It was found that the latent class model is the best fit and that the heterogeneity in our data is better explained at segment level, rather than at individual level. Therefore, we present the results of the latent class model. Using McFadden's (ρ^2), AIC and BIC selection criteria, three-latent class model was found to be optimal. The McFadden (ρ^2) statistic of 0.21 indicates that the model was fit (Hensher *et al*., 2005).

The results reveal that the respondents are heterogeneous in their preferences for water usage, carbon emission and price. This is indicated by the differences in magnitude, direction and significance of the utility function estimates. This concurs with recent findings of Grebitus *et al*. (2015). Three distinct consumer classes were found. Price is significantly negative in all the classes as expected and in accordance with economic theory (McFadden, 1974). This means that all the three classes of consumers are sensitive to price and consider it as a relevant attribute in their decision to purchase environmentally sustainable food products.

For class 1, the utility estimates show that low levels of water usage and carbon emissions are significantly positive. This means that respondents in this class prefer beef products with low water and carbon footprints. Medium water usage level was significantly negative. Also, high levels of water usage and carbon emission variables were significantly negative. This suggests that apart from low water and carbon footprint levels, respondents in this class will not prefer beef products with medium or high footprint estimates. This is confirmed by the status quo bias observed for the ''none'' option. The significantly negative coefficient estimate of ''none'' option implies that respondents in

Table 4: Class specific willingness to pay estimates and 95% confidence intervals

	Class 1 (ZAR)	Class 2 (ZAR)	Class 3 (ZAR)
Water footprint			
Low	7.29 (5.22 to 9.57)	5.59 (3.55 to 7.99)	-3.50 (-6.30 to -2.05)
Medium	-2.14 (-4.33 to -1.85)	NS	2.44 (1.90 to 4.45)
High	-4.46 (-7.75 to -3.15)	-1.24 (-4.44 to -0.99)	3.00 (2.22 to 5.11)
Carbon footprint			
Low	4.49 (2.45 to 8.10)	3.38 (2.33 to 5.80)	-2.33 (-5.13 to -1.99)
Medium	NS	NS	NS
High	-3.89 (-6.42 to -3.05)	-2.84 (-4.12 to -2.05)	3.00 (2.53 to 5.15)
None	-8.89 (-10.06 to -5.50)	3.32 (2.69 to 5.45)	4.11 (3.24 to 6.90)

NS: Not significant: All values are in South African Rand (ZAR). Values in parentheses are confidence intervals at 95%. Authors' calculations.

this class prefer to select one of the product options than to choose the ''none'' option. This class accounts for 46 % of the sampled respondents. The class membership estimates for this class reveal that having high levels of formal education, income as well as subjective and objective knowledge on environmental sustainability increases the likelihood of a particular respondent belonging to this class, relative to class three. Additionally, members of class one are likely to be aware of threats posed by climate changes through the department of water and sanitations campaigns. They are also likely to trust food labelling regulatory bodies in South Africa. Members of this class are likely to be younger individuals, as indicated by the significantly negative coefficient of age variable.

For the second class, the utility estimates for low levels of water usage and carbon emissions are significantly different from zero and positive. High levels of water usage and carbon emission variables are significantly negative. This suggests that members of this class have negative preferences for beef products with high water and carbon footprints. The status quo variable ''none'' is significantly different from zero and positive. This implies that respondents in this class also prefer beef products without water and carbon footprint sustainability information.

Class two accounts for 35.10% of respondents. The class membership estimates for this segment indicate that respondents in this class are likely to be older females with low income, relative to class three members. Respondents in this class are less likely to trust food labelling regulatory bodies, relative to class three members. They are also less likely to report having high subjective and objective knowledge on environmental sustainability, compared with class three members.

For class three, the significance and directions of the utility function estimates differ. The utility function estimates for low water usage and carbon emission levels are significantly different from zero and negative. This suggests that respondents in class three do not prefer beef products with low water and carbon footprints, relative to the other two classes. Medium and high levels of water usage are preferred by this segment of respondents, as indicated by the significantly positive coefficient estimates. Members of this class also prefer high carbon footprint estimates, compared with the other two classes. The status quo variable ''none'' is significantly positive; indicating that respondents in class three prefer products without water and carbon footprint sustainability information. Class three accounts for 18.90 % of the respondents. Class membership estimates for this class were normalized to zero, such that the other classes could be compared with it.

3.3 Willingness to pay estimates for water and carbon footprints sustainability attributes

Class-specific willingness to pay estimates for the different levels of sustainability attributes evaluated at 95% confidence interval are presented in Table 4. The WTP estimates for the attributes were estimated across the latent classes in order to ascertain the differences in preference structure. The results show that respondents in class one and class two are willing to pay ZAR7.29 and ZAR 5.59, respectively for low water footprint level. Respondents in class three on the hand are willing to accept ZAR 3.50 as compensation to choose beef products with low water footprint. Respondents in class one are willing to accept ZAR 2.14 and ZAR 4.46 as compensations to choose beef products with medium and high water footprint levels, respectively. Contrary to class one members, those in class three are willing to pay ZAR 2.44 and ZAR 3.00 for beef products with medium and high water footprint levels, respectively.

In terms of carbon emissions, respondents in classes one and two are willing to pay ZAR4.49 and ZAR 3.38, respectively for low carbon emission levels whereas those in class three were willing accept ZAR 2.33 to choose beef product with the same level of carbon emissions. Additionally, class one members were willing to accept compensation to choose products with high carbon emissions, whereas class three members were ready to pay for the same emission level. For both classes one and two, willingness to pay estimates for low water usage are higher than low carbon emissions. This implies that preference for low water footprint is higher than low carbon footprints. Finally, class two and three members were willing to pay for beef products without water and carbon footprint sustainability information, whereas class one members will only choose this product when they are compensated with ZAR 8.89.

4. Conclusion

The study concludes that there is considerable preference heterogeneity at segment level for environmentally sustainable beef products. Three distinct consumer segments were identified, with each class exhibiting different preference attitude for the same set of environmentally sustainable beef product attributes. The profound heterogeneity

in preferences is explained by socioeconomic factors such as age, gender, education and income of respondents. Beside socioeconomic factors, public awareness creation and campaigns on threats associated with climate changes as well as trust in regulatory bodies in charge of food labelling, including environmental sustainability labelling play significant role in influencing consumers' preferences for environmentally sustainable beef products. Additionally, respondents' subjective and objective knowledge levels on environmental sustainability significantly impact on their choices of environmentally sustainable beef products. Therefore, demographic targeting of consumer segments, awareness creation and segment-specific educational campaigns aimed at enhancing subjective and objective knowledge on environmental sustainability are important tools for governments, food companies and agribusinesses for promoting and marketing environmentally sustainable food products.

Willingness to pay for different water usage and carbon emission levels of beef production varies across the identified classes. Willingness to pay exists for low water usage and carbon emissions in classes one and two. Class three members on the other hand are willing to accept compensations to purchase beef products with low water and carbon footprint values. For both segments one and two, respondents were willingness to pay higher amounts for low water footprint level, compared with low carbon footprint level. Therefore it is concluded that preferences for low water footprint is higher than carbon footprints.

Generally, the willingness to pay estimates and class membership probabilities indicate that there is market for environmentally sustainable products in South Africa, as about 81% of the respondents have positive preferences for low water usage and carbon reduction. Given that classes one and two have significant positive preferences and willingness to pay premiums for low water usage and carbon reduction, agribusinesses and food companies can capitalize on this consumer segment and create a niche market for environmentally sustainable products in South Africa. Nonetheless, there are imperative segmental equity issues that need to be taken into consideration when designing environmental sustainability strategies to change consumers' behaviour, while aiming at promoting environmentally sustainable products and minimizing environmental impacts.

About the authors

Enoch Owusu-Sekyere (PhD) is an agricultural and resource economist with theoretical and practical experience in a variety of operational environments. Enoch is currently a Researcher at the Swedish University of Agricultural Sciences, Uppsala, Sweden and the University of the Free State, Bloemfontein, South Africa. Owusu-Sekyere is also a research fellow for European Investment Bank-Global Development Network Program in Applied Development Finance. Owusu-Sekyere has a particular interest in agricultural economics and agribusiness related issues, development and environmental economics, impact evaluations, water resource management, food safety, security and policy as well as animal health and welfare economics.

Henry Jordaan (PhD) is a Senior Lecturer with the Department of Agricultural Economics, University of the Free State, Bloemfontein, South Africa. Jordaan is an experienced agricultural economist with a particular interest in agricultural and institutional economics, water footprint assessment, production economics, food policy, food security and farm management, among others. Jordaan is involved in several projects in South Africa and other African countries.

Acknowledgement

The authors' would like to acknowledge the funding from the Water Research Commission (WRC) of South Africa. This research is part of the Water Research Commission's project ''determining the water footprints of selected field and forage crops towards sustainable use of fresh water (K5/2397//4). We also acknowledge the Interdisciplinary Research Grant of the University of the Free State.

REFERENCES

Bateman, I.J., Carson, R.T., Day, B., Hanemann, W.M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D.W., Sugden, R. and Swanson, S. (2003). *Guidelines for the use of stated preference techniques for the valuation of preferences for non-market goods*. Cheltenham: Edward Elgar.

Ben-Akiva, M.E. and Swait, J.D. (1986). The akaike likelihood ratio index', *Transport Science,* 20, pp. 133–36.

National Treasury (2013). *Carbon Tax Policy Paper. Reducing greenhouse gas emissions and facilitating the transition to a green economy*. https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwjC7aHPj7_RAhVpAsAKHQgUAFgQFggbMAA&url=http%3A%2F%2Fwww.treasury.gov.za%2Fpublic%2520comments%2FCarbon%2520Tax%2520Policy%2520Paper%25202013.pdf&usg=AFQjCNEe-OzPBf1Mhy4ZMf2XHWycCrEnww&sig2=is6I0kSXmkoEnnq4RQyuuQ (Accessed 15 Oct. 2015).

Choice Metrics. (2014). *Ngene 1.1.2. User manual and reference guide*. https://dl.dropboxusercontent.com/u/9406880/NgeneManual112.pdf. (Accessed 10 Oct. 2017).

Cohen, M.A. and Vandenbergh, M. (2012) .The potential role of carbon labelling in a green economy. *Energy Economics*, 34, pp. 553–563.

Department of Water Affairs (2013). *Strategic overview of the water sector in South Africa*, Pretoria: Department of Water Affairs, 2013. Available online: http://nepadwatercoe.org/wp-content/uploads/Strategic-Overview-of-the-Water-Sector-in-South-Africa-2013.pdf (Accessed 4 Jan. 2016).

Edwards-Jones, G., Plassmann, K., York, E., Hounsome, B., Jones, D. and Canals, M. (2009). Vulnerability of exporting nations to the development of a carbon label in the United Kingdom. *Environment Science and Policy,* 12, pp. 479–490.

Flynn, L.R. and Goldsmith, R.E. (1999). A short, reliable measure of subjective knowledge. *Journal of Business Research,* 46, 57–66.

Foley, J., Ramankutty, N., Brauman, K., Cassidy, E., Gerber, J., Johnston, M., Mueller, N., O'Connell, C., Ray, D., West, P., Balzer, C., Bennett, E., Carpenter, S., Hill, J., Monfreda, C., Polasky, S., Rockström, J., Sheehan, J., Siebert, S., Tilman, D. and Zaks, D. (2011). Solutions for a cultivated planet. *Nature,* 478, pp. 337–342.

Grebitus, C., Steiner, B. and Veeman, M. (2016). Paying for sustainability: A cross-cultural analysis of consumers' valuations of food and non-food products labeled for carbon and water footprints. *Journal of Behavioral and Experimental Economics,* 63, pp. 50–58.

Grebitus, C., Steiner, B. and Veeman, M. (2015). The roles of human values and generalized trust on stated preferences

when food is labeled with environmental footprints: Insights from Germany. *Food Policy,* 52, pp. 84–91.

Grebitus, C., Jensen, H.H. and Roosen, J. (2013). US and German consumer preferences for ground beef packaged under a modified atmosphere, different regulations, different behavior. *Food Policy,* 40, pp. 109–118.

Hensher, D., Rose, J. and Greene, W. (2005). *Applied Choice Analysis: A Primer* Cambridge: Cambridge University Press.

Hensher, D.A. and Greene, W.H. (2003). A latest class model for discrete choice analysis: contrasts with mixed logit', *Translational Research,* 37, pp. 681–698.

IPCC (2007). *Climate change 2007: IPCC Fourth Assessment Report*. Cambridge: Cambridge University Press.

IWMI (2007). *Water for food, water for life: a comprehensive assessment of water management in agriculture. International Water Management Institute*. Earthscan: London, UK.

Kearney, M. (2008). *Modelling the impact of CO_2 taxes in combination with the Long-Term Mitigation Scenarios on emissions in South Africa using a dynamic computable general equilibrium model*. University of Cape Town: Energy Research Centre (ERC), 2008. Available at: http://www.erc.uct.ac.za/Research/publications/08Kearney-Dynamic_CGE_on_LTMS.pdf. (Accessed 10 Feb. 2016).

Mekonnen, M.M. and Hoekstra, A.Y. (2010). *The green, blue and grey water footprint of crops and derived crop products Volume 1: Main Report. Value Of Water Research Report Series, 2010a. 1(47)*. Available at: http://www.waterfootprint.org/Reports/Report47-WaterFootprintCrops-Vol1.pdf. (Accessed 19 Feb. 2016).

McFadden, D. (1974). Conditional logit analysis of qualitative choice behaviour'. In: *Zarembka, P. (Ed.), Frontiers in Econometrics*. New York: Academic Press, pp. 105–142).

Norwood, F.B. and Lusk, J.L. (2011). Social desirability bias in real, hypothetical, and inferred valuation experiments. *American Journal of Agricultural Economics*, 93, pp. 528–534.

Peschel, A.O., Grebitus, C., Steiner, B. and Veeman, M. (2016). How does consumer knowledge affect environmentally sustainable choices? Evidence from a cross-country latent class analysis of food labels. *Appetite*, 106, pp. 78–91.

Schumacher, I. (2010). Ecolabeling, consumers' preferences and taxation. *Ecological Economics,* 69, pp. 2202–2212.

Scholtz, M.M., Du Toit, J. and Neser, F.W.C. (2014). Antagonism in the carbon footprint between beef and dairy production systems. *South African Journal of Animal Science,* 44, pp. 17–20.

Statistics South Africa (2014). *Mid-year population estimates. Statistical release P0302*. Available at: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0ahUKEwiNroHb4fbQAhXFCcAKHZRjBGwQFggoMAI&url=https%3A%2F%2Fwww.statssa.gov.za%2Fpublications%2FP0302%2FP03022014.pdf&usg=AFQjCNH5YuztIsIeXilwJSj3ezWp76jypQ&sig2=ADFMzXVhQFo9K5rgc-KSTg&cad=rja (Accessed 19 Mar. 2017).

Statistics South Africa (2012). *Census 2011: Census in brief', Pretoria. ISBN 9780621413885*. Available at: http://www.statssa.gov.za/Census2011/Products/Census_2011_Census_in_brief.pdf. (Accessed 10 Oct. 2016).

van Loo, E.J., Caputo, V., Nayga, R.M., Seo, H.S., Zhang, B. and Verbeke, W. (2015). Sustainability labels on coffee: consumer preferences, willingness-to-pay and visual attention to attributes. *Ecological Economics*, 118, pp. 215–225.

Wedel, M. and Kamakura, W. (2000). *Market Segmentation: Conceptual and Methodological Foundations*. Boston, Mass: Kluwer Academy.

CASE STUDY

DOI: 10.5836/ijam/2019-08-119

Exploring territorial embeddedness in rural entrepreneurship: a case-study in a remote rural area of Italy

MARCELLO DE ROSA[1], LUCA BARTOLI[2] and MARIA PIA[3]

ABSTRACT

Entrepreneurship has become a key success factor for rural businesses. This paper puts forwards the distinction between rural entrepreneurship and entrepreneurship in the rural and deals with definition and measurement of entrepreneurial anchoring in rural contexts, by focusing on different dimensions of territorial embeddedness. More precisely, the paper aims at testing eventual links between levels of embeddedness and the entrepreneurial profile of farmers. Three-fold embeddedness is individuated: *Societal embeddedness, Network embeddedness* and *Territorial embeddedness*. Area under study is localised in central Italy, in an extremely rural context marked by depopulation processes and marginalisation of economic activities. Through the help of a questionnaires submitted to a sample of farmers, a cluster analysis has been carried out with the purpose of aggregating homogeneous farms in relation to their rural embeddedness. Results evidence a diversified set of embeddedness to which different degree of entrepreneurial orientation and performance are linked.

KEYWORDS: entrepreneurship, rural embeddedness, Italian farms

1. Introduction

In their book chapter ''Researching rural enterprise'', McElwee and Smith (2014, 435) cast ''*the question of whether rural enterprise can be framed as a distinctive category of entrepreneurship theory in its own right, and by doing so paves the way for future theorizing about the distinctive nature of rural entrepreneurship*''. In this paper we intend to banish every doubt about it.

To this end, this paper deals with rural entrepreneurship as an embedded entrepreneurial activity, which involves particular engagement with its place and in particular the rurality of the place and the environment. Set against the background of farm management, this implies taking into account economic, social and environmental aspects of agricultural management (Korsgaard *et al.* (2015, 7). The aim of the paper is to establish key determinants of rural embeddedness, by emphasising three variables: territorial, societal and network embeddedness (Hess, 2004; Methorst *et al.*, 2017). Under this perspective, the paper provides a contribution to literature, by taking up embeddedness as key determinant of farm's strategy. Consequently, research questions are following: how to measure the level of embeddedness in rural entrepreneurship? How to link rural embeddedness with both the farmer's entrepreneurial profile and farm's performance?

The paper is articulated as follows: next paragraph analyses theoretical background, with the purpose of providing the key features of the recent debate concerning embeddedness in rural areas and rural entrepreneurship. The definition of a three-fold level of embeddedness and the attempt to measure it will introduce the empirical analysis, developed in the region Lazio of Italy. Some conclusions will end the article.

2. Theoretical background

Farming activity has been reconceptualised within the framework of wider rural development processes (van der Ploeg, Marsden, 2008). More precisely, the perspective of endogenous rural development is at the basis of the recent paths of development in rural areas, mainly grounded on local resources and local control (van der Ploeg *et al.*, 2000; Oostindie *et al.*, 2008). This definition points out new roles and new functions for farming activity, which are mainly based on farm diversification strategies, aiming at exploiting strategic local resources (McElwee, Bosworth, 2010; Micheels and Gow, 2014). As pointed out by Stathopoulou *et al.* (2004, 405), rurality offers an innovative and entrepreneurial milieu in which rural enterprises may flourish and prosper or become inhibited.

Original submitted August 2018; revision received March 2019; accepted May 2019.

[1] Corresponding author: Universita degli Studi di Cassino e del Lazio Meridionale, Via S.Angelo – Loc. Folcara, Italy. Email: mderosa@unicas.it

[2] University of Cassino and Southern Lazio – Department of Economics and Law. Email: bartoli@unicas.it

[3] University of Cassino and Southern Lazio – Department of Economics and Law. Email: marymaru84@hotmail.it

Set against this background, the entrepreneurial activity is joined with activities engaging with the social life of the place, boosted by processes of animatorship (McElwee, Smith, Sommerville, 2018), which may contribute to support rural entrepreneurship. As underlined by McElwee, Smith and Sommerville (2018, 176), entrepreneurship follows in new ways that break with tradition but simultaneously build on the particular place, being re-embedded in place.

As a matter of fact, the strong ties between farm development and rural context engender processes of territorial embeddedness and bring about fundamental implication for rural entrepreneurship (McElwee and Smith, 2014; Korsgaard *et al*., 2015), in account of rurality viewed as an entrepreneurial milieu. A composite idea of rurality, including economic, social and environmental components redesign entrepreneurial scenario and, consequently, specify the boundary conditions for rural entrepreneurship.

This is also evident in the political discourses: recent reforms of the Common Agricultural Policy look at either more entrepreneurial farming models and higher farmers' capability to adapt (Phillipson *et al*., 2004). As consequence of a more competitive scenario and in order to cope with new complexities, new skills for farmers are demanded (Rudmann, 2008). This is particularly true under the purpose of developing both internal and external entrepreneurial environment, which is considered as an essential step to create a diversified range of entrepreneurial business in rural areas (McElwee, 2008).

Set against this background, entrepreneurship has become a key success factor in rural business. How to analyse rural business from the perspective of entrepreneurship is an important and recent field of research (McElwee and Smith 2014; McElwee, 2005). Under the perspective of endogenous rural development, ecological entrepreneurship is at stake (Marsden, Smith, 2005), with multifunctional forms of value capture and with the purpose of promoting trajectories of sustainable development and strategies of valorisation and qualification of products. Ecological entrepreneurship redefines the role of farmer as entrepreneurs, by addressing new connections with the rural context. This brings about the fundamental distinction between two ideal-types of entrepreneurship (Korsgaard *et al*., 2015): a) entrepreneurship in the rural represents entrepreneurial activities with limited embeddedness enacting a profit-oriented and mobile logic of space; b) rural entrepreneurship represents entrepreneurial activities strongly rooted in rural contexts: consequently, coherent with the new rural development models.

Under the second perspective, territorial anchoring is fundamental as farming activity is entrenched in rural areas. Therefore, the analysis of entrepreneurial anchoring is strategic in order to activate "coherent" models of ecological entrepreneurship. The way through which building up a consistent territorial anchoring is the exit of entrepreneurial activities. Recent literature has deeply analysed diversification paths at farm level in rural areas and how these strategies are territorially linked. However, the intensity of the links and the way entrepreneurial profile boosts higher or lower levels of embeddedness has been just touched upon. Consequently, this paper tries to fill this gap in literature, by providing a first preliminary study in a rural context of Italy.

With the purpose of providing a contribution by filling this gap in literature, we adhere to a constituent perspective of rural embeddedness, where constructivist approaches are at stake (Sonnino, 2007) and where the role of the entrepreneur in building up levels of embeddedness must be explored (Uzzi, 1996). To this end, we point out that embeddedness is a strategy to be implemented in rural contexts, through processes of reterritorialization grounded on local resources, bringing about different kinds of embeddedness.

Recently, Methorst *et al*. (2017) delineate three-fold embeddedness:

1. Societal embeddedness, which makes reference to the societal (that is, cultural, political, etc.) background.
2. Network embeddedness, which describes networking skills (Rudmann, 2008) of the entrepreneurs, for example the network of actors a person or organization is involved in.
3. Territorial embeddedness, which considers the extent to which an actor is 'anchored' in particular territories or places.

In this paper we posit that the process of embedding and the success of a strategy based on embeddedness depends on the entrepreneurial profile. Consequently, placial embeddedness may not be the only winning strategy, in account of different patterns of rural entrepreneurship, involving "*a deep consideration of how entrepreneurs' embeddedness in spatial contexts as well as their bridging across local and non-local contexts enables entrepreneurial activities*" (Korsgaard *et al*., 2015, 578). Therefore, "*the entrepreneurs are actively seeking the best of two worlds, first by exploring and developing the use of locally bounded resources, and then by reaching beyond the local context to secure locally deficient but strategically vital business resources in non-local specialized networks*" (Korsgaard *et al*., 2015, 575). In what follows we will try to explore territorial embeddedness, as entrepreneurial strategy carried out by farms located in a remote rural area of Italy.

3. Methodology

Area under study is localised in central Italy, in an extremely rural context marked in recent decades by outmigration processes and marginalisation. In the last years more than half of farms, above all small farms, ceased their activity. In order to survive in the new competitive scenario, strategies of qualification and valorisation of agricultural products have been recently carried out. Most of them are grounded on the links between the farm and the territory, then originating mechanisms of territorial anchoring and rural embeddedness.

With the purpose of testing degree of farm's embeddedness and entrepreneurial orientation, we put forward an in-depth qualitative research (Yin, 2008) based on a questionnaire submitted to a sample of rural entrepreneurs (32 valid respondents). The questionnaire is articulated in three main parts:

1. The first part deals with the characteristics of the farm, through a segmentation framework, aiming at exploring (Mcelwee, Smith, 2012):
   - Personal characteristics of the farmers.
   - Business characteristics.
   - Business activities and processes.

2. The second part, investigates the threefold embeddedness (Hess, 2004; Methorst *et al.*, 2017) as follows:
   - Societal embeddedness.
     - Constitution of the farm (*ex novo* farm, inherited farm, bought farm) and family background.
   - Network embeddedness.
     - Links with other agrifood firms.
     - Types of links: bridging, bonding, linking ties (Woolcock, Sweetser, 2002).
     - Temporal continuity.
     - Performance (degree of satisfaction) of the links.
   - Territorial embeddedness.
     - Effects of the origin on the product quality.
     - Variables affecting product quality and their territorial anchoring.

   The degree of embeddedness has been classified according to a 5-points Likert scale, as in the following table 1:
3. The third part tries to specify the entrepreneurial identity of farmers (McElwee, 2008), by analysing both individual and economic values (Vesala *et al.*, 2007). Individual values rely on personal characteristics of the farms, like optimism and personal control; economic values refer to farmer's aptitude towards risk taking, innovativeness and growth orientation.

Data collected have been processed through a quantitative analysis, more precisely a cluster analysis is carried out through the Wald method (ascendant hierarchical). The following active and illustrative variables have been considered to classify the farms:

- Active variables (3 variables, 8 modalities)
  - Territorial embeddedness
  - Societal embeddedness
  - Network embeddedness
- Illustrative variables (25 variables, 115 modalities)
  - Characteristics of the farms
    - Sociodemographic variables (e.g, sex, family composition, age, education, etc.)
    - Economic variables (farm's size, employees, turnover, exports, etc.)
  - Entrepreneurial profile
    - Individual values
    - Economic values

4. Results

Comino Valley is a remote rural area located in the region Lazio of Italy, more precisely in the National Park of Abruzzo, Lazio and Molise. It is made up of 14 municipalities, with 29,223 inhabitants, a low population density of 119 inhabitants / km^2. Agricultural activity is relevant in this area; however, due to the topology of the territory, where mountainous areas prevail, price-costs squeeze of the 'productivist' agriculture has dramatically revealed its effects in the last decades (van der Ploeg *et al.*, 2000). In the last years, farms have dramatically reduced. As a matter of fact, according to the last two census of the Italian agriculture (table 2), between 2000 and 2010 more than half of farms ceased, while surface remained substantially stable (-3.2%). Consequently, the smallest farms ceased their activity, above all in the animal production, where the percentage of smaller farms ceasing their activity reached 90% in specific sectors.

As a consequence, necessity diversification has been the answer, alongside the emergent rural development paradigm, which pushed many of these farms to engage along new trajectories of development (Bosworth *et al.*, 2015). As a matter of fact, in order to countervail price-costs squeeze many farmers have adopted processes of boundary shift (Banks *et al.*, 2002), marked by the attempt of starting up new activities, oriented towards both qualification of agricultural products (e.g direct selling, organic farming) and diversification of agricultural activity into non-agricultural activities (agritourism, bioenergy production, didactic farming etc.).This has brought about a diversified set of farming styles, coherently established along the line of multifunctional agriculture (van der Ploeg, 1994). Against this background, different strategies emerge, with reference to territorial anchoring of farming, synthesized in the concept of rural embeddedness.

4.1 Cluster analysis

The application of cluster analysis has been effective in designing different trajectories of territorial anchoring and entrepreneurial orientation. As a matter of fact, four homogeneous clusters of farms have been extracted, with similar characteristics related to rural embeddedness, but with high differences in entrepreneurial orientation (EO):

1. 19 farms with high levels of each one of three levels (*3 L*) of embeddedness (59.4%);
2. 6 farms with average levels of territorial and societal embeddedness (18.8%);
3. 4 farms with low levels of both societal and network embeddedness (12.5%);
4. 3 farms with low levels of each type of embeddedness (9.4%).

Table 2: Farms and utilised agricultural surface in the last census of agriculture

	2000	2010	% var.
Farms	3,101	1,355	-56.4
UAS	13,882	13,429	-3.2

Source: Italian Institute of Statistics.

Table 1: Likert scale to measure embeddedness

	lacking	weak	average	strong	very strong
Territorial Embeddedness Societal Embeddedness Network Embeddedness					

Entrepreneurial orientation is not homogeneous among these farms, with high/medium/low levels of EO within the same homogeneous group of farms. Therefore, a variety of entrepreneurial patterns emerges, ranging among three poles:

- three-fold embeddedness (coherent with Methorst *et al.*'s results) as source of competitive advantage;
- entrepreneurs leveraging their 'placial embeddedness' and non-local strategic networks to create opportunities (coherent with Korsgaard *et al.*'s results);
- Entrepreneurs with no embeddedness.

The consideration of farmer's entrepreneurial profile engenders a big variety of situation and farm's performance, where *3 L* embeddedness is not always associated to high performance. A significant part of the 3 L farm shows good performance, so confirming rural embeddedness as winning strategy, but only if associated with high entrepreneurial orientation. On the other side, a less intensive placial embeddedness may bring about higher performance, in account of higher levels of entrepreneurship boosting farm's competitiveness.

5. Conclusions

The specificity of rural enterprise's strategy is at the basis of this paper, aiming at embedding farming activity in rural context and demonstrating how paths of rural competitiveness may be grounded on rural local resources. Under this point of view, this paper may offer a contribution and lets to positively answer to the initial McElwee and Smith's question (*rural enterprise can be framed as a distinctive category of entrepreneurship theory*).

Nonetheless, before saying we have banished every doubt about it, we stress that our analysis has to be considered as a first step towards a deeper comprehension of entrepreneurial mechanisms at stake in building up strategies of rural embeddedness in remote rural areas. As a matter of fact, the analysis presents limits that require further investigation, in that a limit of the empirical analysis is the reduced number of farms interviewed, which calls for further researches to confirm these results.

Nonetheless, on the basis of our results, we can affirm that multifunctional agriculture has been the right root to relaunch agricultural sector in remote rural areas, by letting so many farms to escape the price-costs squeeze, which has to be considered as a clear consequence of the modernisation paradigm. On the other side, the specification of different levels of embeddedness casts some doubts on how possible lock-in negative effects may come around. As a matter of fact, empirical analysis shows that higher levels of embeddedness are usually, but not always, associated with good economic performance. In fact, farms with lower embeddedness reveal good performance, thanks to their ability in networking outside the rural context. More precisely, the relevance of bridging ties, with respect to the bonding ones, confirm literature on the strength of weak ties (Granovetter, 1973) in performing farming activity, by making it more competitive on extra-local networks. However, good results of farms in clusters where both bonding and bridging of ties are at works, underline recent literature suggesting that "*bonding and bridging social capital may not be mutually exclusive but may instead be two aspects of the same process*" (Townsend *et al.*, 2016). Moreover, our paper adds further insights concerning the role of entrepreneurship literature in farm management. As a matter of fact, our analysis backs up that embeddedness is a necessary but not sufficient condition for boosting farm's performance, in account of the relevant role played by entrepreneurial profile.

Consequently, if, on the one side, embeddedness may be a winning strategy if linked to high levels of entrepreneurship, on the other side it is also true that: *Rural entrepreneurs mix what we refer to as placial embeddedness – an intimate knowledge of and concern for the place – with strategically built non-local networks, i.e. the best of two worlds* (Korsgaard *et al.*, 2015, 574).

Policy implications are also evident, at the beginning of the new programming period for rural development 2021-2027, where measures for boosting higher territorial anchoring and entrepreneurship will be surely provided. Under this perspective the new keywords, distinctiveness, would be recalled to promote endogenous rural development, by emphasising local specificities and local economies as relational assets (Storper, 1997). Contextualisation of entrepreneurship (Welter, 2011) addresses new instances for a diversified typology of rural areas, by suggesting an articulated set of targeted measures aiming to raise all levels of rural embeddedness. How better accessing these policies and how these policies are contributing to empower higher entrepreneurial anchoring should be also questioned in future researches.

About the authors

Marcello De Rosa is associate professor of agrofood economics at University of Cassino and Southern Lazio. His main research interests are: entrepreneurship and rural development, consumption of rural development policies, family farm business and the role of geographical indications in the agrifood sector.

Luca Bartoli is researcher in Demography at University of Cassino and Southern Lazio. He works on the family farm business, consumption of rural policies from a demographic perspective and demographic trends in rural areas.

Maria Pia is a farmer who collaborates with the University of Cassino and Southern Lazio within researches on farming in rural contexts and the role of collective action in supporting farming marketing initiatives.

Acknowledgement

Authors are grateful to professor Gerard McElwee (Huddersfield University, The School of Business), for useful suggestions provided.

REFERENCES

Banks J., Long A. and van der Ploeg, J.D. (2002). *Living Countryside: Rural Development Processes in Europe - The State of the Art*, Elsevier, Doetinchem.

Bosworth, G., McElwee, G. and Smith, R. (2015). Rural enterprise in Mexico: a case of necessity diversification. *Journal of Enterprising Communities*, 9(4), pp. 327–343. https://doi.org/10.1108/JEC-05-2014-0006

Granovetter, M.S. (1973). The strength of weak ties. *American Journal of Sociology*, 78(6), pp. 1360–1380

Hess, M. (2004). Spatial relationships? Towards a reconceptualization of embeddedness. *Progress in Human Geography*, 28(2), pp. 165–186.

Korsgaard, S., Ferguson, R. and Gaddefors, J. (2015). The best of both worlds: how rural entrepreneurs use placial embeddedness and strategic networks to create opportunities. *Entrepreneurship & Regional Development*, 27(9-10), pp. 574–598. DOI: https://doi.org/10.1080/08985626.2015.1085100

Korsgaard, S., Muller, S. and Tanvig, W. (2015). Rural entrepreneurship or entrepreneurship in the rural – between place and space. *International Journal of Entrepreneurial Behavior & Research*, 21(1), pp. 5–26. DOI: https://doi.org/10.1108/IJEBR-11-2013-0205

Marsden, T. and Smith, E. (2005). Ecological entrepreneurship: sustainable development in local communities through quality food production and local branding. *Geoforum*, 36 pp. 440–451. DOI: https://doi.org/10.1016/j.geoforum.2004.07.008

McElwee, G., (2005). Developing entrepreneurial skills in Agriculture; A literature review on entrepreneurship in Agriculture. Public report of EU-project Developing Entrepreneurial skills of farmers. University of Lincoln.

Mc Elwee, G. (2008). A taxonomy of entrepreneurial farmers. *International Journal of Entrepreneurship and Small Business*, 6(3), pp. 465–477. DOI: https://doi.org/10.1504/IJESB.2008.019139

McElwee, G. and Bosworth, G. (2010). Exploring the strategic skills of farmers across a typology of farm diversification approaches. *Journal of farm management*, 13(12), pp. 819–838.

McElwee, G. and Smith, R. (2014). Researching rural enterprise. In Fayolle, A. (ed.) *Handbook of research on entrepreneurship: what we know and what we need to know*, Edward Elgar, Cheltenham, pp. 432–470.

McElwee, G., Smith, R. and Sommerville, P. (2018). Conceptualising animation in rural communities: the Village SOS case. *Entrepreneurship & Regional Development*, 30(1-2), pp. 173–198. DOI: 10.1080/08985626.2017.1401122

Methorst, R., Roep, D., Verstegen, J. and Wiskerke, J.S.C. (2017). Three-Fold Embedding: Farm Development in Relation to Its Socio-Material Context. *Sustainability*, 9(10), pp. 1677. DOI: https://doi.org/10.3390/su9101677

Micheels, E.T. and Gow, H.R. (2014). Market driven innovation and entrepreneurial behaviour: The strategic value of a market orientation in primary agriculture. *International journal of agricultural management*, 3(1), pp. 21–29. DOI: https://doi.org/10.5836/ijam/2014-01-04

Oostindie, H., van Broekhuizen, R., Brunori, G. and van der Ploeg, J.D. (2008). The Endogeneity of Rural Economies, in van der Ploeg J.D., Marsden T. (eds.): *Unfolding webs*, van Gorcum, Assen pp. 53–67.

Phillipson, J., Gorton, M., Raley, M. and Moxey, A. (2004). Treating Farms as Firms? The Evolution of Farm Business Support from Productionist to Entrepreneurial Models, *Environment and Planning C*: *Politics and Space*, 22(1), pp. 31–54. DOI: https://doi.org/10.1068/c0238

Rudmann, C. (ed.) (2008). Entrepreneurial skills and their role in enhancing the relative independence of farmers, ESoF Report, Research Institute of Organic Agriculture, Frick, Switzerland.

Sonnino, R. (2007). Embeddedness in action: Saffron and the making of the local in southern Tuscany. *Agriculture and Human Values*, 24(1), pp. 61–74. DOI: 10.1007/s10460-006-9036-y

Stathopoulou, S., Psaltopoulos, D. and Skuras, D. (2004). Rural entrepreneurship in Europe. *A research framework and agenda, International Journal of Entrepreneurial Behaviour & Research*, 10(6), pp. 404–425.

Storper, M. (1997). Regional Worlds, Guilford, New York.

Townsend, L., Wallace, C., Smart, A. and Norman, T. (2016). Building Virtual Bridges: How Rural Micro-Enterprises Develop Social Capital in Online and Face-to-Face Settings. *Sociologia Ruralis*, 56(1), pp. 29–47.

Uzzi, B. (1996). The sources and consequences of embeddedness for the economic performance of organizations: The network effect. *American Sociological Review*, 61(4), pp. 674–698. DOI: 10.2307/2096399

van der Ploeg, J.D., Renting, H., Brunori, G., Knickel, K., Mannion, J., Marsden, T., de Roest, K., Sevilla-Guzmán, E. and Ventura, F. 2000. Rural Development: From Practices and Policies towards Theory., *Sociologia Ruralis*, 40(4), pp. 391–408. DOI: https://doi.org/10.1111/1467-9523.00156

van der Ploeg, J.D., van Broekhuizen, R., Brunori, G., Sonnino, R., Knickel, K. and Tisenkopfs, T.Oostindie, H. (2008). Towards a new theoretical framework for understanding regional rural development., in van der Ploeg, JD and Marsden, T (eds.): *Unfolding webs*, van Gorcum, Assen, pp. 1–28.

van der Ploeg, J.D. and Marsden, T. (2008). *Unfolding web*, van Gorcum, Assen.

van der Ploeg (2010). Rural Development and territorial cohesion in the new CAP, document prepared for the European Parliament's Committee on Agriculture and Rural Development, Brussels.

van der Ploeg, J.D. (1994). Styles of farming: An introductory note on concepts and methodology. In J.D. van der Ploeg and A. Long. (eds) Born from within: Practice and perspectives of endogenous rural development. Assen: van Gorcum: pp. 7–30.

Vesala, K.M., Peura, J. and McElwee, G. (2007); The split entrepreneurial identity of the farmer. *Journal of Small Business and Enterprise Development*, 14(1), pp. 48–56.

Yin, R. (2008). *Case study research: design and methods*, Sage Publications, London.

Welter, F. (2011). Contextualising entrepreneurship. Conceptual challenges and ways forward, Entrepreneurship theory and practice, 35(1), pp. 165–184.

Woolcock, M. and Sweetser A.T. (2002). Bright Ideas: Social Capital—The Bonds That Connect. *ADB Review*, 34(2), pp. 1–26.