REFEREED PAPER

DO FARMERS ADOPT A STRATEGIC PLANNING APPROACH TO THE MANAGEMENT OF THEIR BUSINESSES?

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Little is known about the application of strategic management and strategy tools on farms. The use of benchmarking has been widely endorsed by agricultural consultants and academics but it is unclear what use farmers make of this and other analytical frameworks. The responses of 144 farmers in the south of England showed a minority have vision or mission statements in written form and many have no strategic mission at all. Few farmers showed a comprehensive appreciation of strategy tools available. Additionally, despite the fact farmers strongly recognized its constituent elements, the deliberate implementation of PESTEL analysis was rare. The principal constraints to the development and creation of strategic plans are time and market uncertainty.

Keywords: Strategic management, mission statement, strategy tools, farm management, benchmarking

1.0 Introduction

The importance of planning has been expressed by a number of personalities from the world of literature, science, business and politics – there is widespread agreement as to its usefulness:

> *"A goal without a plan is just a wish" Antoine de Saint-Exupery (1900-1944)*
>
> *"Being busy does not always mean real work. The object of all work is production or accomplishment and to either of these ends there must be forethought, system, planning, intelligence, and honest purpose, as well as perspiration. Seeming to do is not doing." Thomas Alva Edison (1847-1931)*
>
> *"Planning is an unnatural process; it is much more fun to do something. The nicest thing about not planning is that failure comes as a complete surprise, rather than being preceded by a period of worry and depression." Sir John Harvey-Jones (1924-2008)*
>
> *"In preparing for battle I have always found that plans are useless, but planning is indispensable." Dwight D Eisenhower (1890-1969)*

This paper focuses on analytical tools drawn from what has been termed the "classical perspective" (Whittington, 2001) of the considerable body of publications in strategic management theory. It is contended that strategic management is essential to the long-term survival and success of firms, and that farm businesses are no different in this respect (Inderhees and Theuvsen, 2006). Analytical tools can and should be used to inform strategic planning. Whilst Mintzberg famously claimed that "strategic planning has proved to be an oxymoron" (1994, p321), his argument was essentially that strategies cannot be formed by planning and he himself recognised the necessity of the process of planning in order to implement a strategy and that the systematic analysis of problems was as essential as intuitive approaches to their solutions. Glaister and Falshaw (1999) found that firms in both UK manufacturing and service sectors were engaged in strategic planning, were making considerable use of a number of strategy tools, and that they had increased their usage during the previous five year period. There is evidence that thinking about strategic planning provides the catalyst for effective strategic thinking and management; thus whilst strategic management need not be subject to stringent formalities and the inflexible, mechanistic planning ideas of early theorists, there is value in utilising strategy tools to help negotiate a more hostile environment. There are many advantages of disciplined strategic management over "freewheeling improvisation, gut feeling, good deals and drifting along" (Olson, 2004, p23).

Farmers in the UK increasingly find themselves operating within markets subjected to pressures related to global trade agreements, climate change and other political issues which are reflected in frequent revisions to European and national legislation. A greater degree of multifunctionality is expected of agriculture. The changing balance of the global energy economy will also force farmers to reappraise their farm management practices (Blaney, 2006). The effects of these factors, the demographic impacts of increasing world populations and changes in cultural preferences in developing nations are having effects on agricultural markets which "point to the need to add value (and to hold on to it)" (Pollock, 2007). Uncertainty about future forms, continuation, duration or payment rates of Common Agricultural Policy (CAP) support instruments after Agenda 2000 reforms and the CAP stocktaking reforms suggests that a different strategic direction will be required (Commission of the European Communities, 2007).

Franks (2006) examined the financial effects of the Fischler Reforms on an example 424 ha UK upland livestock farm and showed that in 2012 the Single Farm Payment is likely to be only 54% of the value of the payment in 2005. He concludes that the current reforms will "increase the rate of evolution and structural change within agriculture" presenting farmers with "a turning point", such that those who want to be in farming in the longer term "need to plot a route to deliver that outcome". The figures published in the appendices of the two most recent *Hill Farming in England* reports for 2006/07 (Franks *et al*, 2008) and 2007/08 (Harvey and Scott, 2009) show that, for hill farmers, the agriculture net margin (i.e. from agricultural sales only) is negative across all performance quartiles and that both the highest and lowest quartiles performed less well in 2007/08 than had been the case the previous year. For the lowest quartile performers, however, even the combined value of agri-environment schemes, diversification income and single farm payment were insufficient to bring the total farm business income (net margin) into a positive financial position; in both years the loss amounted to an average of more than £10,000.

The highest quartile performers, by comparison, achieved an average farm business income of around £35,000 in both years. After 2012 the top quartile can expect to have a positive income (albeit reduced) despite cutbacks in subsidy, whilst those in the bottom quartile are likely to accrue greater losses. We might hypothesise, therefore, that better performers have managed to plot a more effective strategic course than many others – planning, or at least implementing, actions to secure competitive advantage in survival if nothing else.

The majority of farms may be considered to fall into an intersecting subset of both the set of small businesses and the set of family businesses operating in predominantly mature markets. Taking literature only from these sub-disciplines, Robinson and Pearce (1984) reviewed empirical studies of the value of strategic planning to small business and concluded that whilst many small firms did not plan, those who did were more successful than those who did not, even if the planning was relatively informal. A later study (Robinson and Pearce, 1988) showed that higher performing firms were those with at least moderate levels of both planning sophistication and strategic orientation, and a high level of one or both of these dimensions. A study of small, mature firms by Bracker and Pearson (1986) showed that increasing planning sophistication was positively associated with financial performance. These findings have been supplemented more recently by Miller (2001) similarly showing that rural family firms displaying medium and high level strategic practice generated, on average, over 60% higher gross incomes than those displaying low level strategic practice. Harling and Quail (1990) studied the strategic management of 50 farms who were selected as being "successful" by local ministry officials in Ontario. These farmers indicated that a range of competitive emphases were important including the planning of farm activities. Whilst they enjoyed office work less, only 12% thought that the practicalities of farming were more productive than their office work.

Although these studies have all been conducted in North America, recent findings from DEFRA confirm that UK farmers who had no business plan and applied no management accounting techniques consistently underperformed (Woodend, 2009). Nevertheless, only 35% of UK land-based businesses have a business plan compared with 61% of all businesses in England and Wales (Lantra 2009). Woodend (2009) suggests that 29% of low-performing UK farmers say they have no *formal* plan and around 45% have no plan at all; of the high performers, 45% have no formal plan although 78% claim to have a plan of some kind, adding weight to the suggestion that informal planning can be effective. Only 14% of high performing farms reviewed their plans regularly, while for low performers the proportion was a mere 5% (Woodend, 2009).

The long-term positive effect of planning may be limited. Powell (1992) compared companies in an industry with "planning equilibrium" against those with "planning disequilibrium" and found that the positive effect on performance was only maintained where substantial differences between firms were observed within the industry (on measures of planning adherence and sophistication) – but whilst planning may not confer long-term advantage (where everyone does so) the implication is that a "non-planning" stance is increasingly untenable as more firms undertake planning. Thus strategic planning is a competitive advantage whilst "disequilibrium" exists in levels of strategic planning adoption amongst competitors, and its adoption may "give managers the confidence and sense of purpose to act" instead of stagnating (Whittington, 2001, p23). Beijeman *et al* (2009) examine three case study New Zealand farms that industry leaders identified as having strategic expertise. The cases show that whilst the realised strategy was not always what was intended, nonetheless strategic planning had been undertaken by all of the families, thus underpinning Giles and Stansfield's (1990) claim that "planning promotes flexibility not rigidity" (p42) because it involves "intelligent anticipation of future events" (p35). Whilst Dalton (2005) has suggested that strategies are only created when time is available, the maintenance of future competitiveness requires time for strategic planning and this is likely to benefit from the application of analytical tools.

The application of analytical management tools is a higher level business skill; a recent UK report on Farmers' Skills asserted that "there is overwhelming evidence to demonstrate that higher skills increase productivity and improve business outcomes" (IGD, 2008 p6), an assertion supported by earlier research (McKinsey and Company, 2007). Duffy and Nanhou (2002) found that financially successful farmers in Iowa were better educated; they were able to maintain higher yields, were more efficient in use of machinery and equipment, and achieve lower variable and fixed costs; they spent more time on marketing, technology and relied upon specialist service providers for their information. For successful farmers, timing and attention to detail were more important than accurate information about the farm and, unlike unsuccessful farmers, government policies did not appear in the list of factors they deemed important to their success. Successful farmers are more likely to have undertaken higher level training (Woodend, 2009, Kilpatrick 1996) although only 19% of managers of holdings exceeding 8 Economic Size Units (ESUs) – a "one-man full-time" farm – have formal full agricultural training, and only 25% of those managing holdings larger than 40 ESU (DEFRA, 2008). Sachs (1973) has pointed out, however, "without a strong interest in learning and a readiness to consider change, training by itself is not going to lead to change" (p205).

The Lloyds TSB Focus on Farming Survey (2003) suggested that farmers generally make poor use of management information. Whilst over eighty percent used end-of-year accounts and/or monitor their cash position from bank statements, only 34% monitored actual cashflow against a budgeted cashflow, and only 30% used regularly updated management accounts. Only 36% of dairy farmers had drawn up a detailed budget or business plan (though this had improved from only 30% in 2001). More recently, Woodend (2009) found that cereals farmers were most likely to apply management accounting tools while livestock farmers in less favoured areas were considerably less engaged in financial monitoring and were more likely than cereal farmers to feel they had no gaps in their knowledge. Whether upland farmers are happy to be unsophisticated or feel too constrained by environmental difficulties to make use of additional knowledge, the evidence in the Hill Farming in England reports cited above suggests that half or more of farms in LFAs will be receiving negative net farm incomes after 2012 which suggests this may be a short-sighted perspective.

Despite the cited evidence, there will be cases where exceptional performance occurs despite a lack of formal education. Additionally it has been noted that farmers have other goals besides profit maximisation (Perkin and Rehman, 1994) and that economic decisions are not necessarily rational (Simon, 1979). Clearly, not all UK farmers will be in such dire circumstances as those of many upland farmers, but as Makadok (2003, p1045) observes:

> *"...firms that earn positive or zero economic rents* [i.e.profits] *can persist indefinitely, and firms that earn negative economic rents can persist temporarily until they deplete their resource stocks, but firms that persistently earn negative economic rents cannot persist indefinitely..."*

Some farmers may have reached a point where they are resigned to consuming their assets, but the reality of persistent negative incomes is stark. The willingness to continue in the face of problems has been attributed to being "trapped in farming" because the personal cost of ceasing is unacceptable or because the value attached to farming or a rural lifestyle exceeds the cost of underwriting it with other income-generating activity (Marsh, 2001). For some farming families, without better farm business strategies, the determination to remain on the land may involve the strategy of abandoning (full-time) farming in favour of other employment, whilst for others the current negative income stream is strategically sustainable because the objective of remaining resident until death can be achieved through pension receipts and consuming assets (Potter and Lobley, 1992). For those who do not wish to become "trapped", however, a more entrepreneurial orientation is required.

An entrepreneurial orientation to the business involves the recombination of resources with the intention of improving outcomes. This may involve the development of new products and markets. Harling and Quail (1990) found that the "successful" farmers surveyed considered *customers* to be the most important external factor affecting the achievement of business goals, and that marketing management was their most serious shortcoming in terms of management practices. Awareness of their shortcomings seems to have influenced their strategy as most chose enterprises because the farm had the skills and capacity to undertake them and few pursued enterprises based on optimal profitability (which may have required new skills or greater risks). Those focussed on optimising profitability were more proactively pursuing opportunities in the environment (Harling and Quail, 1990). In order to pursue these opportunities it is important to be able to recognise and realise opportunities. McElwee and Baker (2008) show that conventional farmers in England are less confident of their abilities in these respects than those who were engaged in value-added or non-farming enterprises. McElwee (2006) cites De Lauwere *et al*.'s finding that management and strategic planning are, *inter alia*, critical success factors in entrepreneurship and suggests (McElwee, 2007) that strategic management, marketing and entrepreneurial skills are some of the skills which are most in need of improvement in the English farming community.

An entrepreneurial approach need not, however, be limited to the development of new products or markets. It may also be applied internally to find new ways of doing things such that the same products or markets are served more efficiently. Zellweger *et al.* (2010) found that three case study mature family firms were not engaged in much development of new products and markets but had been innovative internally by finding new ways to do things.

A variety of dimensions of behaviour have been found to characterise entrepreneurial orientation including autonomy, innovativeness, risk-taking, proactiveness and competitive aggressiveness (Lumpkin and Dess, 1996). Verhees *et al.* (2008) found that proactiveness, in particular, had a positive effect on Dutch and Slovenian farm performance and was associated with higher levels of risk-taking and innovativeness, whilst the direct effects of risk -taking (positive in Slovenia) and creativity (a component of innovativeness, negative in The Netherlands) were context specific. Risk-taking is less prominent – and has been associated with negative performance – in family firms whilst past performance and independent ownership gave better forecasts of future performance (Naldi *et al.*, 2007). This demonstrates the importance of "path dependency" – past decisions affect the decision environment of the present, and current decisions will affect the decision environment of the future. Naldi *et al.* hypothesise, from their literature review, that the failure of risky ventures may be due to the lack of external accountability which makes family businesses reluctant to plan strategically and deters them from systematic, unbiased assessments of risk. Zellweger *et al*. (2010) consider that risk aversion in family firms is associated with the fear of losing socioemotional wealth (family identity, family influence, and dynastic ambitions) and long tenures of CEOs. Sachs (1973) cites Rheinwald's observation that farmers rarely make the "real decisions" which characterise entrepreneurial behaviour because they repeat routines without reflection and frequently fail to "realize the multivalence of the situation" – that is, the variety of alternative possibilities. Without the identification, analysis and assessment of potential alternatives it is likely that the "real decisions" required for effective strategic management will be suboptimal.

If farmers are lacking in skills they could "buy-in" management expertise from, for example, accountants, farm consultants and land agents. Garforth and Rehman (2006) found, however, that (in relation to advice on changing their farming practice in response to the Single Payment) whilst accountants and farmers' clubs enjoyed a reasonable degree of respect in the farming community, there was little motivation to comply with advice from consultants, Defra or land agents, and "other farmers" were least trusted. They were most inclined to trust their own experience but this did not correlate with an *intention to change* (Garforth and Rehman, 2006).

Harling and Quail (1990) note that in order to compete in "an uncertain and unstable environment...the managerial skills required in those managing farm businesses approach those required in other businesses". They continue by noting that:

"To date...farm management specialists have not drawn on the developments in general management found in the business literature. This failure is reflected in farm management texts and course syllabi which approach the subject as series of topics congruent with the functional areas of the business. They do not present nor are they structured to deal with the integrative thinking needed to take a strategic approach to managing a business – strategy being the keystone to general management today".(p426)

Their empirical evidence showed that one in five farmers considered their deficit in general management skills to be their single most serious problem in terms of dissatisfaction with their performance of management activities. A further 10% felt their business planning skills were their most serious problem whilst 16% specified scheduling (another form of planning).

A cursory examination of the main farm management textbooks in 2010 suggests that little progress has been made in incorporating work from related disciplines. Most of the farm management textbooks focus their attention on traditional financial appraisal and production programming techniques rather than general management or strategic planning. Whilst a greater variety of academic papers in the farm management field have been published since 1990, most of these have sought to apply the theoretical principles of a single technique or concept from the wider literature to agriculture and there has been no attempt to apply the major strategic management theories to farming in a comprehensive manner. Nell and Napier (2006) and Olson (2004) have adopted or adapted some of the most frequently cited concepts and techniques from the strategic management textbooks (mainly those written by Thompson and Strickland) and applied them to farming but leave out a good deal which could be useful. Warren (1998) devotes eight pages to general business planning (which is substantial compared with many others) whilst Giles and Stansfield (1990) recommend further reading in the wider management field. In none of the available texts is an extensive use made of specific sources within other related disciplines, though special mention is occasionally made regarding the ideas of Michael Porter, Henry Mintzberg and Kenneth Blanchard. The detailed content analysis of course syllabi is beyond the scope of this paper, as is the content of non-English language farm management texts.

2.0 Strategic Management

Nell and Napier (2006) modified Thompson and Strickland's (2000) definition to create an agricultural-based definition of strategic management:

"Strategic management is the integration of all the business functions of

the farm, so that the total farming system is managed proactively, and in harmony with the internal and external environment (at business and macro levels) to achieve the vision and long-term goals of the farming business" (p3)

Strategic management is the process which clarifies the long-term vision of the business, creates a strategic plan, implements or operationalises it, and controls and adjusts it both proactively and reactively in order to increase the "probability of success in meeting both strategic and financial objectives" (Olson, 2004). Strategic management should be systematic; involving constant monitoring and including feedback loops at later stages to ensure that strategy formulation is an entrepreneurial action which responds "to the dynamic environment of competition within which it was formulated" (Nell and Napier 2006). Broadly speaking, a certain amount of logical order is required. The formulation of strategy is, however, not simply sequential, but an iterative process with 'feedback loops'. Personal values and/ or the business environment will undoubtedly change, thus necessitating changes to all or some of the existing strategy – whether the means of achieving the vision or the vision itself.

3.0 Strategic Management Tools

Strategic management tools are "concepts, ideas, techniques and approaches" that guide thinking or influence strategic activity and which focus on "achieving constructive outcomes" (Knott, 2006; Shadbolt, 2008). They are the starting point, not a blueprint (Knott, 2006). When applied correctly their benefits include the enhancement of manager and staff performance – by education, sensitisation to relevant issues, fostering shared values and closer identification with the strategic objectives – and the reassurance of bankers and non-resident owners.

Despite the demands of busy managers, there is no single tool which is simple, does everything, and gets it right every time – they need to be selected, adapted and interpreted in the local context – and it is the *outcome* which determines their success as perceived by managers (Knott, 2006). Strategy tools may take the form of highly defined mathematical techniques or loosely structured mental models or frameworks – but the use of some at the expense of others may introduce cognitive bias into the decision-making (Knott, 2006). Thus some farmers' decisions may lead to superb technical efficiency at the expense of profit, or specialised excellence at the expense of flexibility. Care must be taken in their application; slavish but inappropriate application of a tool may waste valuable resources, whilst excessive adaptation or selectivity may compromise coherence of interpretation (Knott, 2006).

Knott (2006) presents a typology of strategy tools which classifies them into five generic modes: analytical, dynamic, metaphorical, facilitative and interventionist. The techniques which this paper examines in more detail are predominantly analytical (engendering focussed thinking which generates a specific output), facilitative (encouraging divergent thinking and broader

Figure 1. Key strategic management tools

The arrows moving left to right indicate a logical order of events. This is not intended to rule out the opportunity for, or need to, return to an earlier phase at any stage in the development of a strategy. Indeed, the returning arrow indicates that this is required after any monitoring phase. The tools listed under each phase form only a small part of the entire collection of tools which have been developed and applied over the past four decades. Only those which have been high-lighted have been considered in detail in this paper but the larger number shown indicates the diversity of tools which may be selected and applied by a decision maker.

Phase of strategy development	PERSONAL / CORPORATE VALUES	INTERNAL ENVIRONMENT (Strategic Capability)	EXTERNAL ENVIRONMENT (Strategic Capability)	STRATEGIC CHOICE	STRATEGIC PLANNING	IMPLEMENTATION	MONITORING
Strategic management tools	Purpose identification (what for?)	(Internal) Stakeholder Analysis	(External) Stakeholder Analysis	Porter's generic strategies	**Activity maps**	**Mission / Vision Dissemination**	Return on investment ratios (e.g. ROI, ROCE etc)
	Competing commitments (rank in order of importance)	Stakeholder Mapping: - Power / Interest Matrix - Power / Dynamism Matrix - Power / Legitimacy / Urgency Map		**Scenario planning**	**Flow charts**	**Scheduling**	Yield assessments
	Identify core business / key customers (who for? who facilitates/enables purpose?)	Business profiling	**Five forces framework**	Marketing competition strategies	Sequencing		**Environment scanning** (prices, news, legal developments etc)
	Mission statement	Portfolio analysis	PEST/ STEP/ EPEST/**PESTEL**	Portfolio strategies	Cashflow planning	Human resource management techniques	Cashflow analysis
	Envisioning	**SW ...**	**...OT analysis**	Product life-cycle strategies	Budget planning	Technical skills acquisition (i.e. training)	Budget Review (against outcomes)
	Vision Statement	**SSWOFT analysis**		GE matrix strategies	Investment appraisal techniques	Total Quality Management (TQM)	**SSWOFT analysis**
		Value Chain Analysis (Value Plates)	Market Research			**SMART**	**Benchmarking**
		Identify Competitive Advantage(s) (Cost, scope, time, differentiation, competitive linkages)		**Balanced Scorecard**			

understanding) or interventionist (need-centred process improvement). Figure 1 indicates the main components of a typical model of the strategy process in the top row with a selection of tools which might be used to assist the manager in each phase. These are indicative and should not be considered a comprehensive selection (a useful, more comprehensive guide can be found in Cadle *et al.* (2010)). Those shaded and highlighted in bold were selected for use in the survey and are explained in more detail.

3.1 Tools to Clarify Personal / Corporate Values

The most important foundation tools for strategic management are those which identify the aim and direction of the business, as "planning on its own cannot produce strategic vision and direction in an organization where this is lacking" (Langley, 1988):

> 'Mission' is the dominant intention of the business, in line with the stakeholders expectations or beliefs. It must answer the questions what, who, how and why, indicate the core competencies and highlight the influences that drive the vision. It is the present.
>
> 'Vision' ('strategic intent') is the long term ambitions of the business and an important management instrument. It is the future.
>
> 'Goal' is the general statement of the aim or purpose (can be referred to as values). Goals can be financial, strategic, personal, succession.
>
> 'Objective' is a precise statement of the goal.

The mission and vision must align comfortably with the personal values of the manager and other stakeholders if they are to be achieved. Castle *et al.* (1987) recommend to farmers that:

> *"Defining goals clearly enough to write them down provides additional motivation, makes priorities more explicit and encourages family cooperation."(p5)*

Mullane (2002) reviews a study by Rigby in 1994 suggesting that mission statements are the most used tool (of 25 assessed) and that users rate it second highest in terms of satisfaction. Users' satisfaction was founded on its usefulness in creating and fostering organizational integration, unity of purpose and direction, shared expectations and values, and emotional commitment. Research suggests that companies with mission statements have better performance than those without (Green and Medlin, 2003), especially where they include "key constructs" and that this constitutes a "coming of age" of the business (Sheaffer *et al.*, 2008). Baker and Leidecker (2001) found that high performing Californian tomato processors placed a significantly higher (p=.025) degree of emphasis on their mission statement than the low performers. Management commitment and proper communication of ideals are, however, crucial (Mullane, 2002). Harling and Quail (1990) reported that over 90% of "successful" Ontario farmers selected a financial-type goal as the single most important:

> *"Nearly all surveyed had a general idea of what results they wanted to achieve in their farm business in the long run, but they appeared to lack an operational view of these results. Almost three quarters had specific goals for three to five years, only half said that they actually used goals, and less than a quarter had written them down. Thus, while the managers had a feel for what they were trying to accomplish in the business, many had not formally incorporated them in the management process of their business."(p431)*

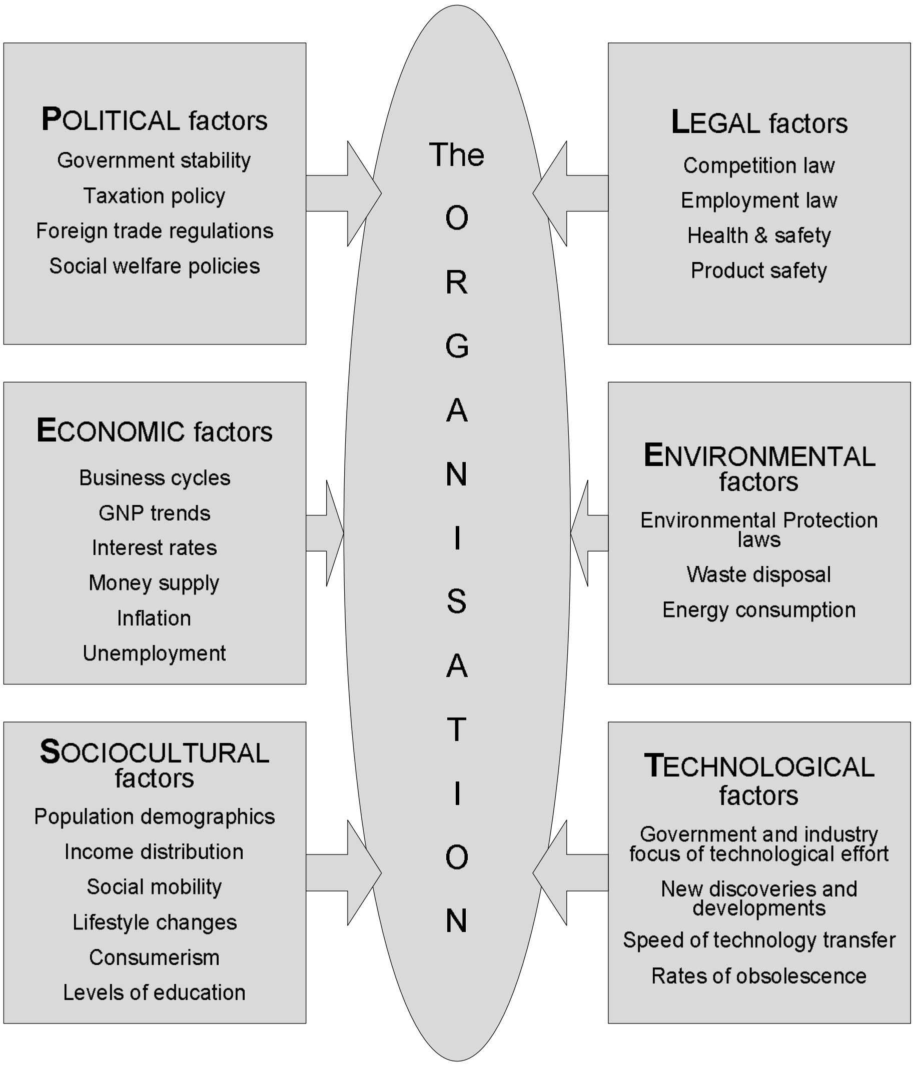
They noted, however, that whilst financial goals were most important, that farm managers saw their business as a family business and, whilst many recognised that they could earn more from alternative employment, they did not choose this nor did they place great emphasis on off-farm sources of income. Despite such high emphasis on financial goals, the maintenance of financial records was predominantly handled by spouses, bookkeepers or accountants. The goals were used to plan and control the business but with most emphasis on production practices and "balance to the business". Castle *et al.* (1987) cite Patrick and Blake who suggested that farm families find goals hard to verbalise, but when expressed are often short-term and diverse. It would seem that whilst there is widespread agreement in farm management texts about the importance of (strategic) goals as a precondition of any useful farm planning there may not be widespread clarity of these on the farm.

3.2 Tools to Analyze the External Environment

Scanning and monitoring the external environment is important in strategic management. PESTEL is a tool that can be used to indicate the key external drivers of change (see Figure 2). It is an extension of the STEP/PEST tool frequently used in the general management literature. An analysis with this tool highlights the key areas of how an industry is being influenced. Sayers (2005) generated a considerable list of external factors which affect farm businesses in the United Kingdom.

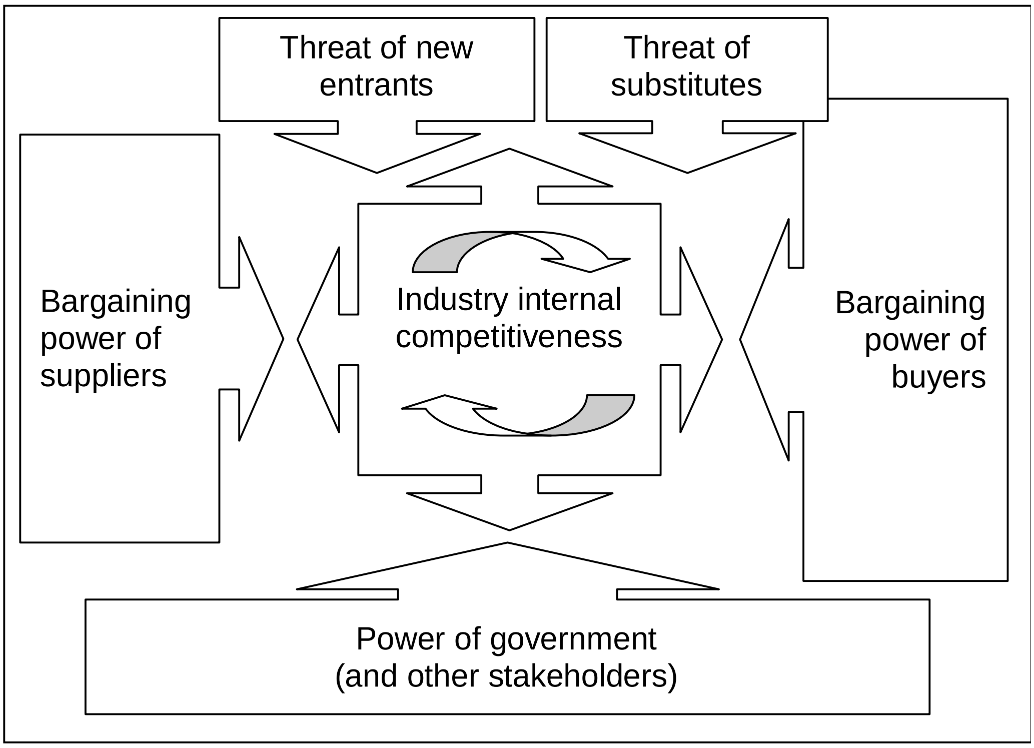
Porter's (1980) 'Five Forces Framework' is an analytical tool (Knott, 2006) which looks at external forces and particularly competitive rivalry. The forces are not independent of each other and it is important to understand the connections between them. Boehlje *et al.* (2004) cite Porter's suggestion that the collective strength of these forces determines the profit potential. Boehlje *et al.* adapted this framework to include a sixth force: the government stakeholder which also has the ability to manipulate the strategy. This is an important adaptation of the framework as many of the other forces are relatively weak in some agricultural markets (eg. the threat of new entrants and substitutes are weak forces in the UK liquid milk market due to high costs of entry and low demand for substitutes). The power of buyers is very strong in many agricultural markets, whether processors, supermarkets or end

Figure 2: Macro-environmental influences- the PESTEL framework (Johnson et al., 2006)



consumers, though the balance may vary depending on whether the market is seen as local or global, niche or commodity. Forward contracting and Quality Assurance (QA) schemes are customer driven vehicles and have allowed the buyers to dictate aspects of control such as milk quality benchmarks, stocking rates, pesticide controls and even servicing of vehicles. Figure 3 shows the adapted five forces framework though the relative strength of different forces should be analysed for each market sector in which the business operates. When applied at the individual business level the framework may vary according to local circumstances; a farm which is forward-contracted to produce for a specific buyer will operate in a different framework of forces to one which has placed most of its land in the HLS agri-environment scheme.

Figure 3: The adapted five forces framework (Boehlje et al., 2004)



Using the five forces framework Porter (1980) identified three key principal strategies:

1. Cost Leadership
2. Differentiation
3. Focus (Niche) or branding

Cowap (2006) equates these basic generic business strategies with (1) the primary production countryside, (2) the stakeholder countryside and (3) the entrepreneurial countryside respectively. Fundamentally, all good strategy relies upon a satisfactory and realistic appraisal of the environment in which an organisation operates. Downey and Erickson (1981) believe that:

> *"many failures in prediction result from sloppy, ambiguous, generalized thinking. Forecasting change is not a guessing game; it is based on a hard, disciplined, tough approach to planning" (p33)*

A badly conceived strategy will be irretrievable if the base assumptions are flawed (Sterling, 2003). Thus it is important that the assessment of the external environment results not in producing to where the market *is* but to where the market *will be* (Olson, 2004).

3.3 Tools for Combining the Internal and External Environments (Strategic Capability)

Strategic capability (Lenz, 1980) is the business' ability to perform at the level required for success. This involves creating a 'strategic fit' between the external environment and the internal resources. The traditional SWOT analysis has been popularly promoted since the late 1960s and is described by Warren (1998) and Olson (2004) in their farm management texts. Nell and Napier (2006) have elaborated on this facilitative analysis (Knott, 2006) to create the SSWFOT analysis (strengths, successes, weaknesses, failures, opportunities, threats) (see Figure 4). This variation on the original SWOT analysis accommodates the important strategic concept of 'path dependency' (future paths are dependent on past and present paths) by incorporating experience and past performance into the strategy development process.

Figure 4: The SSWFOT Analysis (Nell & Napier 2006)

	Internal Farm can manage it		**External** Farm must adapt to it
	Past	Present	Present
Helpful	**S**uccesses	**S**trengths	**O**pportunities
Harmful	**F**ailures	**W**eaknesses	**T**hreats

It is important that any form of SWOT analysis is not seen as an end in itself. It is important that internal and external are adequately distinguished, and that the results are categorised, prioritised and form an input into the next stage of the process – making choices and informing decisions (Barichello *et al.*, 1997). Shadbolt (2008) notes that SWOT analyses are often poorly applied by farm businesses because the external audit (the O and the T) is "often poor and too narrow in its focus", and the internal audit (the S and the W) suffers a "lack of rigour" resulting in lists of features of the business. Combined this fails to deliver the "expansive and divergent thinking" that Knott (2006) suggests should develop.

3.4 Tools for Strategic Choice

Once the analyses have been undertaken the business should be better able to identify its position (revising its mission and vision if necessary) and choose its trajectory. Whilst many tools exist to assist with this choice, scenario planning is particularly useful when the marketplace is uncertain or turbulent.

One of the key reasons for strategy failure is unanticipated market changes (Sterling, 2003). Scenario planning involves considering possible circumstances and consequences – but assuming the future will be *very* different from the past. It uses a systematic 'what if?' approach to predict effects on the business if the main influences are altered substantially. Starting with assumptions about the main drivers for change – as identified in the PESTEL analysis (Cowap, 2006) – but uncertainties about the exact nature of the effects, successful scenario planning requires the identification of the *most important* factors. Hodge (2009) suggests a matrix with two dimensions (importance and uncertainty) to identify "predetermined elements" (important and certain) as distinct from "critical uncertainties" (important and uncertain). The latter can be classified into independent uncertainties (e.g. base interest rate, crude oil price) and dependent uncertainties (e.g. the bank lending rate, forecourt diesel price) (Olson, 2004). Anything which, on reflection, is deemed unimportant should be assigned to the "scanning domain" if its long-term importance may change (e.g. carbon trading regimes) or consigned to "not relevant" if it is certain they are not important. The impact of 'unknown unknowns' should not be overlooked (Hodge, 2009).

The 'critical uncertainties' should be used to create 3-4 potential scenarios and the different strategic options which might be generated to optimise the scenario for the business. It is important to identify the independent uncertainties which have the largest impact on dependent uncertainties – and hence the scenario – to assess the scenario's sensitivity to variation in those uncertainties. Scenario planning expands people's thinking and identifies holes within an existing plan; if alternative scenarios are examined and no dramatic problems are envisaged, then it increases the robustness of the plan.

Current (and somewhat perennial) uncertainties affecting UK agriculture include those relating to input prices, the future revisions to the CAP support regime, and climate change (Hodge, 2009). Similarly world trade, weather and many other factors are rarely predictable. The strongest business is one which is confident of its survival and profitability even in the most difficult circumstances – either because the business is organised in a way which makes the uncertainties irrelevant, or because the answer to 'what will I do if...?' has already been considered and an action plan devised.

3.5 Strategic Planning Tools

Management in accordance with the strategic mission and vision requires objectives and goals at the tactical and operational levels. Many strategic tools exist at these levels and are used in businesses of all sizes.

Flow charts and mapping techniques such as PERT network diagrams can be used in project, process or activity mapping to identify and understand the points at which decisions are made. The key actions form a critical path enabling both detailed in-depth analysis and control of the business. The analysis also identifies Critical Success Factors (CSF); e.g. the process features that lead to product characteristics which are valued by customers such as quality, reliability, service etc.

Management accounting tools such as cashflow forecasts, forward budgets and investment appraisal are important operational planning tools to control finances. Strategies often fail due to lack of investment (Sterling, 2003) and it is important to thoroughly cost any investment required and plan its repayment. Conversely, inventory management techniques are important to minimise costs, streamline physical operations, and thus positively impact the viability of the business. Recent evidence from the Farm Business Survey suggests that around 24% of low performing UK farms applied no management accounting tools, compared with only 8% of high performers (Woodend, 2009).

Whilst these tools can only be considered 'strategic' if there is a clearly defined long range plan, their application in any context is likely to be beneficial. Wastefulness (of both materials and people) can be as detrimental to the success of a strategy as underinvestment (Sterling, 2003).

3.6 Strategic Implementation Tools

Strategic implementation relies heavily on managing other people so it is critical that the strategic mission and vision are disseminated and adequately understood by key stakeholders such as employees, the family and the bank manager. Implementation is most successful when there is consensus and commitment (Dooley *et al.*, 2000) whilst the failure to 'buy-into' or understand the strategy by those responsible for implementation will cause its failure (Sterling, 2003). Internal stakeholders need to be managed through objectives and good teamwork improves the uptake of strategy (Senge, 1990). Both Olson (2004) and Nell and Napier (2006) summarise the aspects required for an objective using the SMART acronym as a tool:

***S**pecific*
***M**easurable*
***A**greed*
***R**ealistic*
***T**ime Schedule*

`Scheduling and sequencing can also be useful; scheduling principally looks at the decisions taken in allocation of staff time and other resources; sequencing is the order of operations. A good analysis of these should enable improved rules of execution and better time planning. Inefficiencies can be acknowledged and dealt with. If the point of choice is identified then the differing choices available may be more easily identifiable. Gantt charts can be helpful in visually displaying such information.

3.7 Strategic Monitoring Tools

A successful business must have good control systems for evaluation, monitoring and correction, and be capable of reviewing and therefore adapting its strategy. Financial management and monitoring is a crucial determinant of success. Operational monitoring may involve establishing a quality assurance system, whilst environmental scanning involves regular information seeking. The SSWOFT tool can be used for monitoring as well as analysis. Two interventionist techniques (Knott, 2006) which attempt to incorporate these diverse needs and have been championed within the farm management literature are benchmarking and the balanced scorecard. Selected papers from this body of work are reviewed in the following sections.

3.7.1 Benchmarking

Benchmarking attempts to provide a 'blueprint' tailored to respond to farm -specific needs. It allows assessment to be made in relative terms, comparing 'like-with-like' the costs and physical efficiencies of activities. Properly implemented farm benchmarking scrutinises the competitive strengths and weaknesses of the business; it allows the establishment of targets and priorities but if it is to be truly useful it must identify "processes underpinning performance" (Franks and Haverty, 2005) such that improvements can be implemented. Historical benchmarking on the same farm allows the effectiveness of action plans to be assessed. Industry benchmarking allows cross-sectional comparison with others in agriculture. "Best-in-class" benchmarking compares against the most progressive farm businesses. It encourages behavioural change but "you get what you measure" (Johnson *et al.*, 2006); conclusions can be blurred by industrial convergence as the technological differences between players becomes smaller and the real sources of superior performance go unquantified.

It is crucial that 'key performance indicators' (KPIs) are chosen to reflect the specific farm and its enterprises. Selectivity is equally important when choosing the benchmark farm(s) against which comparison is to be made and to use the same method to calculate both your own and the benchmark farms' KPIs (Franks and Haverty, 2005). Comparison with the chosen benchmark provides the opportunity to identify performance gaps which, if undesirable, should inspire active changes to reduce the gap. An early adopter of (internal) agricultural benchmarking was Sentry Farms who began using this method of evaluation in the 1970s (Atkinson 2003, 2004). Their "4 Thought" program has exposed people to new ideas, provided a catalyst for learning, overcome natural disbelief that a business can perform to a higher level and lowered the cost of production simply by comparison of farms within the group (Atkinson, 2003). Despite this example, Franks and Collis (2003) cite research which found that only 9% of farmers were using benchmarking in 2003 (although 86% aspired to its use); these users of benchmarking cited better understanding of costs as the key benefit. There has been greater uptake amongst farmers over time – the most recent data (Woodend, 2009) suggests that around 18% of the lowest performing third of farms are using benchmarking rising to about 38% of the highest third of farms. Over 40% of dairy farmers use benchmarking compared with less than 30% of livestock farmers in Less Favoured Areas (Woodend, 2009).

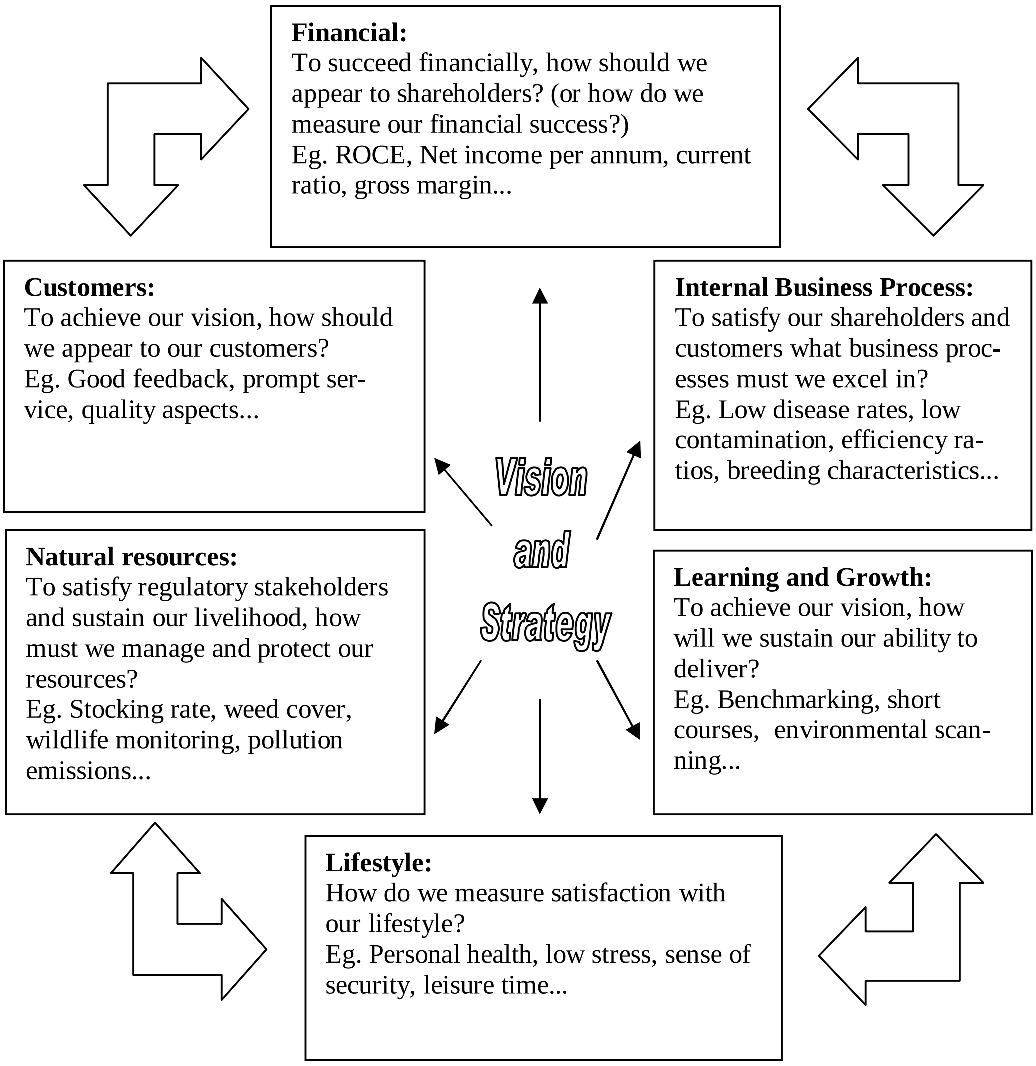
Benchmarking may not always be well applied – if the target business' objective is *profit* maximisation this will not always be achieved by technical super-efficiency or maximising output. Similarly KPIs for benchmark farms which have been constructed using different methods or assumptions to those of the target farm will yield invalid and unreliable results (Franks and Collis, 2003). Insufficient breadth of KPIs may skew the thinking which is applied to solving performance gaps, or effectively prevent the performance gaps from being identified (inducing a false sense of security). Many data surveys used for benchmarking fail to collect data for key variables which determine the success of an enterprise (Franks, 2009). The appropriateness of benchmarking also depends on the mission – if the farmer's key KPI is maximum leisure time then benchmarking itself is detrimental to this objective (Franks and Collis, 2003). Similarly if the cost of benchmarking exceeds the savings, or the implementation of improvements fails to occur at all, then it is a wasteful cost in itself. If key objectives remain undefined KPI selection is itself a challenge (Barriball and Byles, 2003). Farmers who aspire to benchmarking frequently use informal methods and information gleaned from publications such as industry costings books, *Farmers' Weekly* and bulletins of The Arable Group. Such comparisons, however, generally fail to adequately identify the "processes underpinning performance" (Franks and Haverty, 2005) – the attribute which differentiates benchmarking from merely making idle comparisons (Fogarty *et al.,* 2003). Additionally, benchmarking, as currently practised, often fails to adequately measure non-technical and non-financial measures such as personal growth or customer satisfaction (Byles, 2003; Barriball and Byles, 2003; Fogerty *et al.,* 2003). Other potential drawbacks of scheme participation may include the commercial misuse of confidential data (Franks and Haverty, 2005). If however, the fear of this waste, irrelevance or impropriety prevents farmers from participating they may be missing out on valuable opportunities to improve.

3.7.2 The Balanced Scorecard

The "balanced scorecard" approach was developed by Kaplan and Norton (1992) to focus the attention of business managers on the four long term drivers which create profit and a desirable image of the business from some key stakeholders' perspectives. The technique is used to inform the execution of a strategic plan to better exploit these drivers – *customers* to buy the product, profits to satisfy owners (*financial*), customer/owner satisfaction delivered by *processes* undertaken by employees/managers requiring *learning/ growth*. The plan should be a mix of short and long term goals, all of which must be "balanced" to create an integrated framework that allows the translation of the strategy into operational terms (Shadbolt *et al.,* 2003). The technique links qualitative and quantitative performance measures to the corporate vision and tracks a firm's performance.

The original 'balanced' scorecard of Kaplan and Norton has been criticised for being too narrow and not encompassing all relevant variables and business types (Shadbolt, 2008). In the USA the technique has been broadened in its application to farm/ranch management to include scorecards not only for customer, financial, commodities production (i.e. business process) and learning/growth, but also natural resources and lifestyle (Dunn *et al.,* 2006). These additional scorecards provide a place for stewardship and familial objectives which are important to farmers but are often irrelevant to corporate commerce (see Figure 5). The balanced scorecard must be selective in the metrics included on each card – the object is not to create a complex monitoring system but to focus attention on the really key attributes of the business which define its mission and direction (Shadbolt, 2008). The object is

Figure 5: The Balanced Scorecard (Kaplan and Norton 1992, adapted by Dunn et al 2006)



to create a focussed but responsive organisation based upon a template which does not become a strait-jacket (Kaplan and Norton, 1996).

4.0 Methodology

Little research has been undertaken into whether or how UK farmers use strategic tools to develop their businesses. The empirical work presented in this study considers farmers' awareness and usage of the contents of the strategic toolbox. The large number of strategic tools available has inevitably led to selectivity in the choice of tools considered within the survey. The presence of a vision and mission statement was observed in the literature to be a key factor for business success and was therefore considered in some depth.

The barriers that occur in the development of strategies are also investigated and the frequency of strategic review is examined in the light of changes to the CAP.

A postal survey of farmers in the south of England was conducted during June 2008. A total of 466 questionnaires were mailed and 144 useable responses were returned. A clustered purposive sampling method was used to implement a cross-sectional study. The study employed multiple sampling frames that included:

a. Close clients of Strutt & Parker
b. Members of the John Edgar Memorial Trust
c. Members of the Burford Farming Club
d. A random sample from Yell.com of farmers in Gloucestershire, Wiltshire, Dorset and Hampshire (the same geographical area covered by the other three sample frames)

Access to these sampling frames was negotiated or else utilised freely available data from members' lists and from websites. The questionnaire was pilot tested on five farmers to ensure face validity. The researcher asked the pilot group to time themselves in addition to providing feedback on the content. The reassurance that the information would observe the Data Protection Act was given. The questionnaires were then modified in the light of the feedback and adaptations were made particularly to improve statistical analysis. This doubled the number of questions but did not significantly alter completion time on a further pilot test. The questionnaires took approximately 25 minutes to complete. Respondents were invited to indicate their willingness to be contacted further and to provide contact details. A number of these respondents were contacted further in an attempt to augment the questionnaire with further detail.

Further statistics have been applied where appropriate. In some cases the test is a simple Pearson's chi-squared test of independence, whilst in others further post-hoc tests have been applied to test the strength of association e.g. Phi coefficient and, where the direction of the correlation between two ordinal variables is of interest, Goodman and Kruskal's Gamma. The statements made are thus interpretations of statistics based mainly on contingency tables. For brevity the contingency tables are not reproduced.

4.1 Characteristics of the sample

The median farm size was 323ha and the mean was 566ha. The inter-quartile range was 178-708ha. The sample is not strictly representative of the statistical population of holdings in the geographical area (DEFRA, 2007). The true variation of the sample from reality is, however, difficult to establish. The sampling frames may have favoured larger commercial holdings, but also official statistics have long been flawed. The official number of holdings is overstated due to the difficulty in amalgamating statistical returns from multiple land holdings run as a single business (Harrison, 1981).

Thirty-five percent of respondents classed themselves as arable farmers, 48% as mixed farmers and the minority of 17% as livestock farmers. This ratio suggests that arable farmers were over-represented in comparison with the DEFRA (2007) data for the counties, but may also reflect that small holdings are predominantly grassland. Both the mode and median suggested that the average farm had two full time employees and one part time employee.

The majority of the respondents were directly involved with the management of the farm business (48% owner occupiers, 28% tenants, and 19% farm managers) and consequently should be involved with strategy formulation for that business. The remainder were formed from 3% consultants and 2% 'other'. The 'other' respondents included two directors of farm companies and a contract farmer. The inclusion of consultants' opinions in the analysis was deemed acceptable as they often influence these decisions and indeed manage farms in their own right.

The education level of the respondents was higher than might be expected from official figures; 55% had National Diploma in Agriculture, Higher National Diploma or higher qualification (BSc/BA/MSc/MA) though not necessarily in agriculture. A further 27% had some form of certificate or diploma (e.g. OND, NCA or Dip Farm Management) whilst 24% had no further or higher education. The survey assessed the overall level of education which is not strictly comparable to DEFRA statistics which focus on agricultural education.

While the sample may or may not be a good representation of all *persons* who control land, more *farmland* is controlled by managers of larger holdings (85% of UK farmland is in holdings exceeding 50ha: Eurostat, 2009) and thus managers of larger holdings represent the management of a greater proportion of the land area. Additionally many smaller holdings may be little more than paddocks or non-commercial 'hobby' farms, the managers of which may find strategic management concepts of limited value in relation to their balance of objectives.

5.0 Results

5.1 Mission and vision statements

Figure 6 shows those that had a vision or mission statement. There was a positive relationship between the presence of a vision and a mission statement ($p<0.001$; Phi coefficient=0.761). Both higher level education ($p<0.05$; Phi coefficient=0.210) and college level education ($p<0.05$; Phi coefficient=0.220) had a significant effect on the presence of a vision statement, although neither higher nor college level education qualifications were associated with a mission. Thirty-five percent of farmers had no mission or vision statement.

Relatively few respondents claimed to have written down their mission or vision. Table 1 shows the relationship between the incidence of written documents and the presence of a vision or a mission. In all cases where written documents existed, both a mission and vision were claimed to be written down. These 22 respondents accounted for only 15% of the sample.

Respondents who were willing to be contacted further were invited to supply their written mission/vision statements or telephoned to determine their reasons for not having them in writing. Only one respondent provided his

Figure 6: Form of vision and mission statement, by percentage

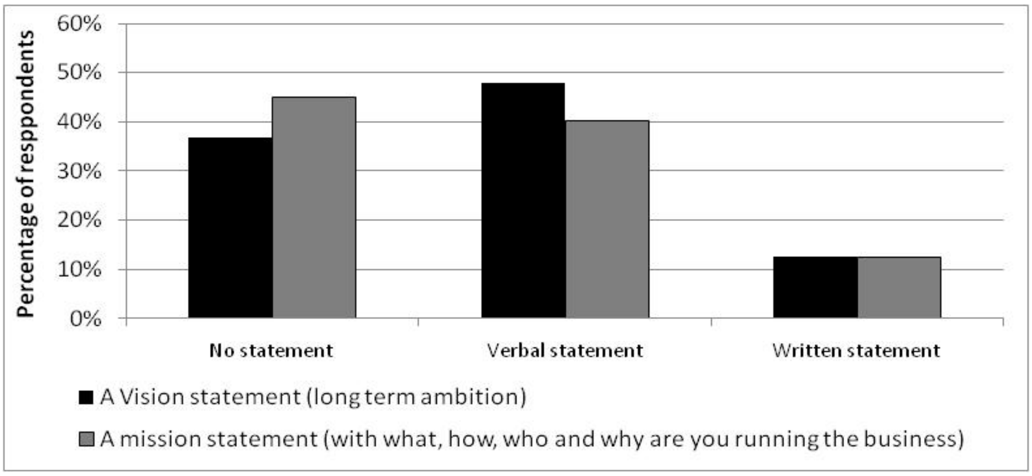


Table 1: Presence of mission and vision by form held:

	No reply	Written mission or vision or both	Verbal only	None	Total
No reply	2	-	\2	1	**5**
Vision and Mission	-	22	50	-	**72**
Vision only	-	-	14	-	**14**
Mission only	-	-	3	-	**3**
Neither	-	-	-	50	**50**
Total	**2**	**22**	**69**	**51**	**144**

mission statement (written as a consequence of the request) though it does not conform to Langley's (1988) definition of a mission statement; it does not identify core competences and influences. It does, however, describe elements required for a vision. It emphasises that perhaps the definitions of the two statements are not clearly understood. Another believed that as he managed a small family business he did not feel the requirement for written documents, but did acknowledge that whether it was written or verbal it could just as easily be changed. Clearly these instances cannot be considered representative of any other farmers but offer insight into the type of misunderstandings which may occur.

Of the mission and vision statements which existed (whether expressed verbally or in writing), 60% were made by the farmer, 32% by family members and 6% by a consultant. Thus in about two-thirds of cases the main individual running the business is the dominant architect of these statements, whilst one third involve a more democratic process. Table 2 shows that family members are considered important recipients of dissemination, many of whom may be part-owners or in other ways key stakeholders.

Farm managers are more likely to give written statements to parties who have ownership in the business compared with owner/tenants.

Table 2: Persons to whom mission/vision disseminated, percentage (Farmers with mission or vision only: n=94)

	No reply	No Dissemi-nation	Verbal	Written
To Employees	18%	21%	53%	7%
To Bank Managers	13%	29%	46%	13%
To Advisers/Consultants	17%	23%	50%	10%
To Family Members	15%	6%	67%	12%
To Parties who have ownership in business	31%	15%	38%	16%

5.2 Strategic planning tools

Nine key tools that were identified as being potentially useful for developing strategies were chosen and assessed in terms of awareness and use by farm owners and managers. Table 3 shows low awareness of the Five Forces Framework, PESTEL, SSWOFT analysis, Balanced Scorecard and SMART tools. More were aware of scenario planning but it was not widely considered useful. Benchmarking has a long history of use in agriculture and has been widely promoted in the last decade within the industry, whilst SWOT analysis had clearly also been used quite widely. Interestingly, whilst awareness of production management tools was quite high, less than a quarter of farmers had found them useful.

Further analysis of these tools in connection with the use of mission and vision statements showed a high degree of association. Whilst displaying high awareness of benchmarking, the highest overall association was for SWOT and production management tools. In all cases where a relationship exists, those with mission/vision/both/written are more likely to have used or found useful the tool indicated. The results suggest that anyone with a mission and/or vision is more likely to use SWOT and production management techniques and that those with written documents are more likely to use a range of tools. The latter group are more likely to be farm managers than owner/tenants. Alternatively the application of analytical tools informs and enables the creation, definition and development of a clear mission/vision. Very likely they are mutually reinforcing.

Analysis of the awareness and use of tools by reasons for farming showed some weak associations suggesting that those with family-oriented reasons for farming (tradition, inheritance) were less likely to show awareness and use of the more popular tools, whilst those with financial-oriented reasons (financial reward, profitability through excellence) were more likely to have used or be using tools such as SWOT, benchmarking and production management tools.

Table 4 shows the influence on the business perceived to be exerted by the components of the PESTEL tool. Most farmers felt the influence of political and environmental factors but a substantial number failed to take much account of the end consumer in the food chain. One in ten never considered social and consumer trends.

Table 3: Awareness and use of strategic tools; association of strategic tool use with presence of mission/vision

	Awareness and use of strategic tools			Summary of chi-squared test results: association between strategic tool use and presence of mission / vision			
N=144	(a) Heard of it	(b) Never Used /Not Useful	(c) Used/Useful	Presence of mission	Presence of vision	Presence of both mission and vision	Presence of at least one written mission / vision document
Benchmarking	88%	30%	58%	+	**	***	***
Production management tools (Activity maps, flow charts etc.)	76%	53%	24%	***	**	***	***
SWOT	76%	28%	48%	***	**	***	***
Scenario Planning	51%	33%	19%	*	**	+	**
SMART	41%	31%	10%		+		**
Balanced Scorecard	32%	26%	6%		+		***
SSWOFT	28%	23%	6%	+	+	+	***
PESTEL	24%	19%	4%				
Five forces framework	21%	19%	1%				

Key to result of chi-squared test: *** Significant at 1% level ** Significant at 5% level * Significant at 10% level
+ Showed signs of association but user numbers/ tabular variation insufficient to be statistically significant

Table 4: Respondents opinion of the extent to which PESTEL factors were felt to affect their business decisions; weighted mean and percentage who felt influence (influence+strong influence)

	Weighted mean score*	Percentage of respondents who were influenced moderately or strongly by this factor in their decisions
Political eg taxation, CAP	2.1	76%
Economic, eg Interest Rates	1.9	65%
Social eg lifestyle changes, consumer demands	1.6	56%
Technological eg information technology	1.8	68%
Environmental eg environmental protection laws	2.1	79%
Legal eg employment law, health & safety	1.7	62%

* Respondents weighted according to categorical response: strong influence=3, influence=2, small influence=1, not considered=0.

Despite the fact that PESTEL and the Five Forces Framework are at the bottom of Table 3 in terms of awareness and use it seems that many farmers undertake some analysis of their external environment albeit in an informal and unstructured way.

Table 5: Sources of benchmarking information

	Once a week	Once a month	Once a year	Very Rarely	Never	No reply
Nix Agricultural Notebook	-	18%	24%	27%	26%	4%
ABC Agricultural Book of Costings	-	13%	19%	15%	47%	6%
Regional Farm Data Survey	-	5%	25%	29%	33%	8%
Professional Benchmarking (eg S&P, Savills, Grant Thornton)	-	7%	17%	19%	27%	30%
Farmers Weekly	40%	17%	8%	17%	12%	6%
TAG (The Arable Group)	5%	14%	13%	18%	34%	16%
Market Reports	45%	33%	4%	9%	4%	5%

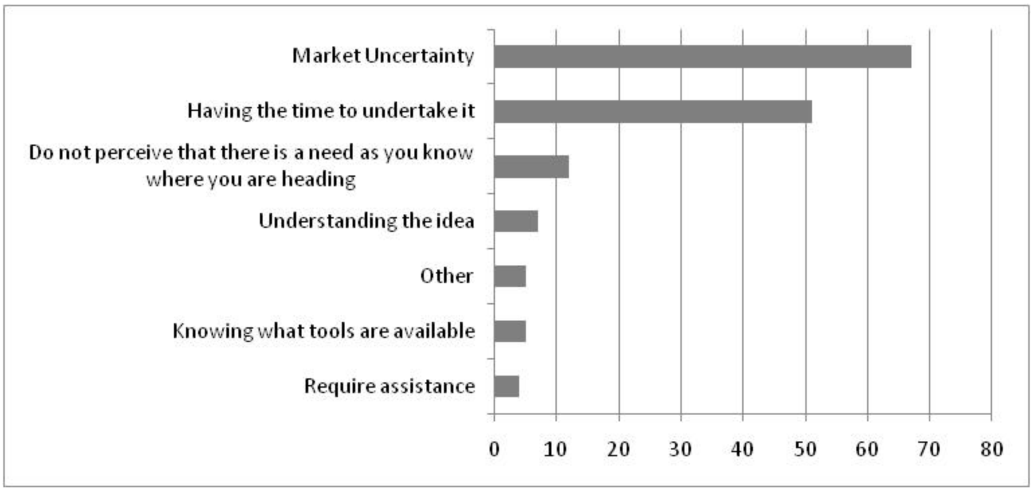
The methods of benchmarking and the frequency of use were also investigated. Table 5 shows that the main methods of ‘benchmarking’ were market reports and a review of information published in the Farmers’ Weekly. Whilst such sources provide an opportunity to assess whether sales were made at an optimal time of year, or to compare a specific price received with the average price achieved in the week of sale, comparisons of this kind are unlikely to yield much *evidence of how best practice can be achieved*, which is the purpose of genuine benchmarking. The activity reported by respondents suggests that on the majority of farms only a very small number of KPIs are employed and few farmers participate in regular professional benchmarking activities.

5.3 Barriers to the uptake of strategic planning

Figure 7 shows farmers’ perceived barriers to the uptake of strategic planning. They perceive two principal reasons for not undertaking planning activities, namely time constraint and market uncertainty. Despite the evidence suggesting a lack of awareness of the practical tools available to assist strategic planning this lack of knowledge was not perceived to be the most serious barrier.

The mean worked week was 50 hours with a mean ratio of 15:35 hours between office and field, though the ranges of these values were 0-60 for office time and 0-112 hours for field time and the median indicated that the most common ratio was 10:40. Thus a typical farmer spends only 20% of his or her time in the office, with 80% spent in the field, though this may vary seasonally. Arable farmers spent significantly ($p=0.006$; ANOVA, post-hoc SNK) more time in the office compared with mixed and livestock farmers, whilst livestock farmers spent significantly (p=0.024; ANOVA, post-hoc SNK) less time in undertaking planning in contrast to mixed and arable farmers.

Figure 7: When planning, what do you find is the hardest issue in undertaking it for the farm business?



There is a positive correlation between time spent in the office and time spent planning (p<0.01; Pearsons correlation). The mean time spent planning was 4 hours though the median was only 2 hours. As with other uses of time, there was considerable variation with a range of 0 to 20 hours and an interquartile range of 1-5 hours. Where less than 5 hours/week was spent in the office, less than 20% of this was spent on planning. The fact that the mean is considerably higher than the median indicates a small, but important subset of farmers who clearly *make time* to spend planning (5 farmers spent 15-20 hours per week planning), despite a larger but equally important subset who spent no time planning (19 farmers (13%)).

One potential method of overcoming the barriers to planning is to “buy in” the expertise specialists with other areas of expertise. Table 6 shows that production specialists are greatly favoured over others and that despite being third in the table, the end user/consumer is very rarely or never consulted by over one third of the respondents.

5.4 What are the timescales of change in the pattern of strategic development?

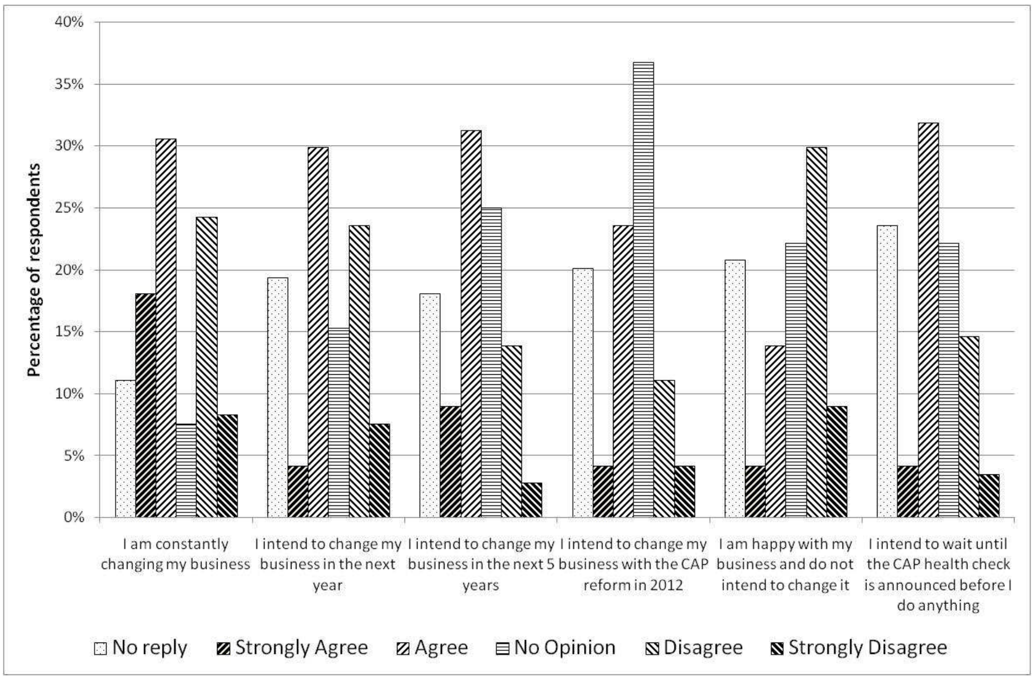
The introduction to this paper showed that reforms to the EU CAP are likely to present increasingly significant challenges to profitable farming over the next five years. Figure 8 shows the distribution of the results in relation to attitudes towards the timing of change in the business. What is clear here is that, whilst there is significant agreement that changes will occur during the next five years, many intended to wait for the results of the CAP healthcheck to be announced before doing anything, and 37% have no opinion on their

Table 6: Frequency of use of consultants

	Once a week	Once a month	Once a year	Very Rarely	Never	No reply
Agronomist	27.8%	44.4%	6.9%	4.9%	10.4%	5.6%
Accountant	2.1%	30.6%	56.3%	5.6%	1.4%	4.2%
The end user/customer	6.3%	27.1%	23.6%	20.1%	15.3%	7.6%
Other specialist farmers	3.5%	16.7%	17.4%	33.3%	16.7%	12.5%
Farming social networks	2.1%	13.9%	8.3%	25.7%	37.5%	12.5%
Land agent	0.7%	13.9%	16.7%	36.8%	24.3%	7.6%
Farm business consultant	0.7%	12.5%	24.3%	23.6%	27.1%	11.8%
Farm business adviser	1.4%	9.7%	25.0%	27.1%	28.5%	8.3%
Business link	0.7%	0.7%	9.7%	29.2%	47.9%	11.8%

attitude to changing their business in 2012 at the end of the SPS transition period. Almost half, however, agreed or strongly agreed that they were constantly changing their business and only 18% were happy with their business and did not intend to change it.

Figure 8: Attitudes to changing business direction



It is typical of such groups of statements to show a significant association between them in which systematic positive (or negative) correlations are observed, such that agreement with one statement is strongly associated with agreement (or disagreement) with others. Table 7 shows a summary of crosstabulation results, which confirms a strong systematic association between the scale points recorded when most variables are paired with another. There is, as we might expect, a negative association between intentions to embrace change and intentions to avoid change. This is reversed, however, in relation to the announcement of the CAP health check, which apparently opens the possibility of change even to those who wish to avoid it. Conversely those who embrace change disagree that they will wait for the CAP healthcheck.

Table 7: Summary of Goodman and Kruskal's Gamma test results on crosstabulations; [approximate significance value in square brackets below]

Attitude to change	Change in the next year	Change in the next 5 years	Wait for CAP healthcheck	Change with re-form 2012	No change
Constantly changing	**0.768** **[0.000**]**	**0.449** **[0.000**]**	**-0.330** **[0.020*]**	**0.411** **[0.003**]**	**-0.501** **[0.000**]**
Change in the next year		**0.739** **[0.000**]**	**-0.267** **[0.036*]**	**0.484** **[0.000**]**	**-0.631** **[0.000**]**
Change in the next 5 years			**-0.363** **[0.007**]**	**0.526** **[0.000**]**	**-0.700** **[0.000**]**
Wait for CAP health-check				0.035 [0.815]	**0.324** **[0.021*]**
Change with reform 2012					**-0.507** **[0.000**]**

Note: Gamma test was calculated (using SPSS) on the crosstabulations of the relevant paired variables.
** significant at the 1% level, * significant at the 5% level

The data from these questions was used to construct a single variable which broadly categorised farmers into four groups; (1) those who disagreed or had no opinion that they would change at any time *and* who agreed or had no opinion that they were happy with their business, (2) those who agreed that they were always changing, (3) those who agreed they would be changing in the next year, and (4) the remainder who agreed they might make some changes some time but neither constantly, nor in the next year (summarised in Figure 9).

Figure 10 shows the significant ($p<0.01$; Chi-squared) association between these groups and the presence of a mission statement. It is clear that there is a strong association between a mission and a determination not to change. Those who intend to "wait and see" are those most likely to have no mission. There is a similar (but weaker) relationship between the four groups and presence of a vision, but there was no association with having a *written* mission or vision.

Figure 9: Attitude to change

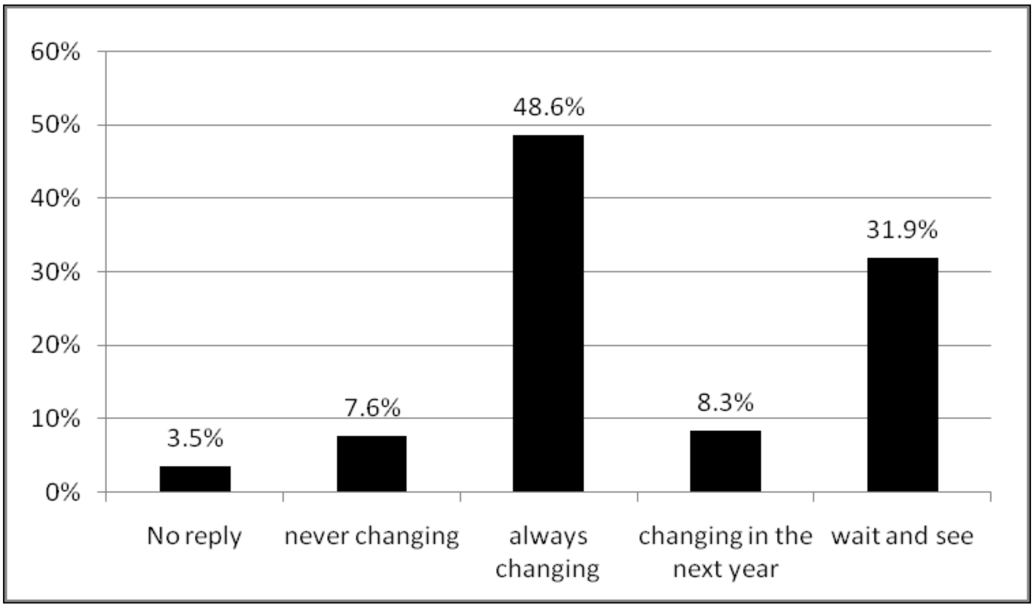
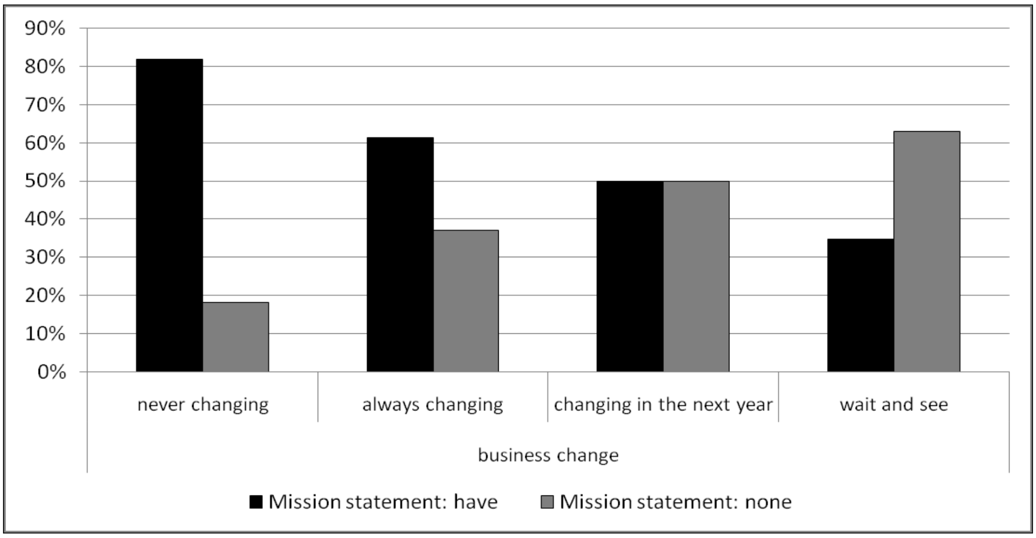


Figure 10: Attitude to change by presence of mission statement



6.0 Discussion, conclusions and recommendations

Over one third of farmers had no clear mission or vision that form the basis of any coherent strategic plan. The lack of a plan has been associated with reduced economic performance (Miller, 2001; Woodend, 2009). The analysis in this study shows that farmers with a clear mission and/or vision make greater use of strategic planning tools. There is, however, insufficient data to say whether these farmers are rewarded with better performance.

Good strategic planning requires, however, that farmers look not only at their own performance and practice but at their competitors' performance with a view to improving their business processes. The evidence suggests that, whilst popular, what farmers think of as "benchmarking" is often little more than the comparative analysis of a small number of market indicators (predominantly focussed on prices achieved) which do not have, as a primary concern, a focus on identifying and applying best practice. Best practice can only be attained through seeking to identify what competitors with better "benchmark" positions have done to improve. Indeed even the better quality commercial benchmarking services may need to make more efforts to collect the right data to avoid some of the pitfalls identified by Franks (2009).

This study shows that farmers perceive market uncertainty as the most important barrier to strategic planning and yet, for almost half the respondents, consumer trends did not have even a moderate effect on their decision-making and over one third of respondents rarely or never consulted the end user/ consumer of their produce. But it is only awareness of the "dynamic environment of competition" (Nell and Napier, 2006), combined perhaps with techniques such as scenario planning, which will make any impact on their perception of market uncertainty. Even those who have a clear strategy can fail as a result of "unanticipated market changes" (Sterling, 2003) and they are far more likely to be unanticipated if farmers prefer to look only inward. It is clear that, whilst the problems of market uncertainty have been reported before (Inderhees and Theuvsen, 2006), those without any clear direction may dissipate their opportunities by deferring decisions, engaging in a 'wait and see' rather than a 'go and find out' approach to planning. Failure to engage in information searches and a lack of contingency planning are common pathologies resulting from decision dilemmas in the strategic domain (Wright *et al.*, 2004). Whilst the nature of future changes associated with the ongoing reforms of the Common Agricultural Policy may be unclear, the most successful farm businesses are unlikely to make changes to their business contingent on EU, UK parliament or DEFRA decisions; and very likely will not consider government policy to be a factor important to their success (Duffy and Nanhou, 2002). But for this to be the case farmers will need to see social and consumer trends as being at least as important as the regulatory framework.

Another key barrier to strategic management was lack of time, which was also identified as the single most important resource limitation by the Ontario farmers in Harling and Quail's study (1990). This suggests that if they cannot make time for themselves that they 'buy in' someone else to provide time or skills which are deficient in the business. This may also go some way to reducing "market uncertainty" where advice or research is targeted toward specific needs. Most respondents made little use of economic advisers, preferring mainly the techno-scientific advice of the agronomist. Useful though such knowledge is, it is no substitute for good business management skills. A wide range of professionals in the land-based industries and food supply chain may be able to assist with skills and information, but if farmers do not believe that this advice is trustworthy or valuable (Garforth and Rehman, 2006) they are unlikely to take action to purchase this knowledge. If they prefer to rely on their own judgment (Garforth and Rehman, 2006) they may find that more time spent in the office might have better payoffs than time spent in the field.

If time spent planning their strategy is to be useful, there would likely be benefits for farmers from improving their awareness, understanding and ability to apply strategy tools. Those who have attended college or university may have come across some of these tools but over 50% of UK farmers with low economic performance have no further or higher education and 65% of these farmers were unable to identify any skills gaps (Woodend, 2009). Despite this study's survey respondents being better educated than those of Woodend, they nevertheless showed relatively low awareness of many popular strategy tools. The brief assessment of the content of farm management texts suggests that academia may need to bring more strategy techniques to the attention of land-based students. McElwee (2007) presents views of farming which highlight farmers' reluctance to learn new skills and the cushioning effect of "the subsidy culture". Clearly more needs to be done to assess the usefulness of these techniques if uptake amongst the agricultural community is to be encouraged. The research undertaken in other industries appears to indicate that using strategy tools and more sophisticated planning has a positive effect on financial performance. It would therefore be valuable for more farm management academics to undertake research to assess whether a similar effect is apparent in farming, as such evidence may be instrumental in improving uptake of short courses in strategic management and planning (or else determining that such short courses would provide no benefits to agricultural businesses).

Every farm is unique. Therefore diversity in farm strategies is important to enable farms to remain competitive. Almost half of the respondents said they were always changing. It is unclear whether these changes are the result of attention to detail to ensure the farm remains on course or the result of reactive or whimsical short-termism. Similarly, whilst those in the third of respondents who had a "wait and see" stance may be doing so because they are under-informed and risk averse, it may also be that they already have a strong strategy which is not reliant on government subsidy. Many farmers no doubt already have a thorough understanding of their capabilities and are *prepared* for unexpected opportunities or threats (both within and outside the business) but those who are not in this position may be in danger of squandering what resources they have available.

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REFEREED ARTICLE

COPING WITH THE CREDIT CRUNCH? A FINANCIAL APPRAISAL OF UK FARMING

Jeremy R Franks

The seven sources of finance-related risk outlined by Harrison and Tranter (2989) are brought up-to-date, to conclude that UK farming is better placed now that it was in the late 1980s. However the mismanagement of the global financial markets, and the resulting credit crunch, have created new finance-related risks; (i) payback ability, (ii) adverse movement in land values, (iii) increased counterparty risk, (iv) dependency on increasingly transparent government subsidies, (v) additional exchange rate risk, (vi) threat to diversification and off-farm income streams, and (vii) a new wave of protectionism. The relative financial stability of agriculture may make it a target for a combination of tax increases and spending cuts as government strives to reduce its budgetary deficit.

Keywords: credit crunch, depression, UK agriculture, financial structure, risk, exchange rates

1. Introduction[1]

Despite high risk and uncertainty associated with farming, farm managers need to take decisions, so coping whilst basing actions on insufficient information is commonplace. An appreciation of this is critical to understanding farm-management decisions because each decision is part of a sequence that creates the future, and it is the accumulated effect of repeated choices which may have the most significant impact on overall business performance (Hardaker *et al.* 2004). Agricultural business managers therefore need to identify current sources of risk and how these sources change over time to evaluate how these changes might affect their decisions and coping strategies.

Several studies of the financial structure of UK farming were published in the late 1980s and early 1990s reflecting the downturn in the sector's fortunes at that time (Johnson 1986; Harrison and Tranter 1989; Johnson 1990; Harrison and Tranter 1994; Harrison and Tranter 1995). It is appropriate to return to this area of research as the UK enters the third year of the credit crunch[2] and with UK GDP having contracted by 0.1%, 0.6% and 1.8% in the second, third and fourth quarters of 2008 respectively, and by 2.4%, 0.6% and 0.4% in the first three quarters of 2009[3] (the European Commission forecast an overall decline of 3.8% in 2009). As "the UK economy is now clearly experiencing one of its worst recession in recent history" (Fildes 2009), and with most of the slowdown in economic activity occurring in the last quarter of 2008 and first quarter of 2009, the bulk of the setback in production will

1. This paper was written and finalised in autumn 2009. Inevitably, in the delay between completion and publication, the global economy has moved on. It is necessary to read it with this in mind; sovereign default and the pressure on the Euro, much talked about today, were rarely mentioned until recently. These developments suggest that we are far from over this crisis yet as the new government introduces the first of what is likely to be a series of public spending cuts.
2. The credit crunch is considered by many to have begun on 9th of August 2007 - the day the European Central Bank and the US Federal Reserve injected $90 billion (£45 billion) into financial markets (Elliott 2008).
3. The widely accepted definition of a recession is two consecutive quarters of negative growth in GDP (BusinessDictonary.Com 2010).

only be reflected in the statistics for 2009 (UNCTAD 2009: p 4), in which year UNCTAD predicts a 2.7% fall in global GDP.

The credit crisis poses additional financial risks to all businesses. The collapse of credit supply and financial asset prices in September 2008 meant that commercial banks had to recapitalise their balance sheets. They are doing this by selling toxic assets to government supported programmes or writing them off, by reducing lending and foreclosing on short-term, unsecured loans and recapitalising from current business, in part by failing to pass on low central bank interest rates and in part by increasing the fees charged to customers. This cutback in the provision of credit immediately translated credit risk into liquidity risk: many businesses which relied on short-term credit were forced to consider selling part of their assets in order to meet their short-term liabilities (UNCTAD 2009; Marshall 2009). For some sectors the reduced credit supply exerted additional downward pressure on asset prices, causing a further deterioration in the solvency of borrowers and additional loan foreclosures (UNCTAD 2009: p 14).

To pay back the unprecedented stimulus packages, monetary policy easing and support for ailing financial institutions was introduced by the UK government (ONS 2009). One result of which is that the UK public sector net debt is forecast to keep increasing as a share of national income until 2015-16 whilst the annual public sector budget deficit (PSBD) is halved over the four years from 2010/11 (H M Treasury 2009). Future spending plans are "so tight that all major spending departments are likely to be affected" (IFS 2009 p 182). Under the existing Spending Review, the Department of Environment, Food and Rural Development (DEFRA) received a real cut in spending of about 1.8% (2007/08 to 2010/11). If there is no real growth in total department expenditures other than where automatic stabilisers become effective (such as expenditure to fund rising unemployment), and assuming the financial cut-backs are shared equally, DEFRA will experience a 4% real cut in its departmental expenditure limit (between 2011/12 and 2013/14) (IFS 2009: p 182-183).[4]

This is the macroeconomic context against which the financial performance of the agricultural sector must be assessed. To assess the current financial structure of agriculture, this analysis takes as its starting point an updating of the "seven sources of growing risk in UK agriculture" identified by Harrison and Tranter in 1989, to see which of these remains a concern today. Section three presents seven current and emerging sources of risk to the agriculture sector. Section four concludes.

2.Updating Harrison and Tranter's growing sources or risk in UK agriculture

One approach to determining the current financial status of the UK agricultural sector is to compare current levels and trends in values of selected financial data against their historical level. This is the methodology adopted in this analysis. It takes as its starting point Harrison and Tranter's (1989) seven

4. These forecasts of revenue and expenditure are based on the UK economy growing by 1.25% in 2010 (H M Treasury 2009:p 18).

growing sources of risk, and updates them as far as it is possible to do so, to identify which, if any, are currently sources of risk to UK agriculture.

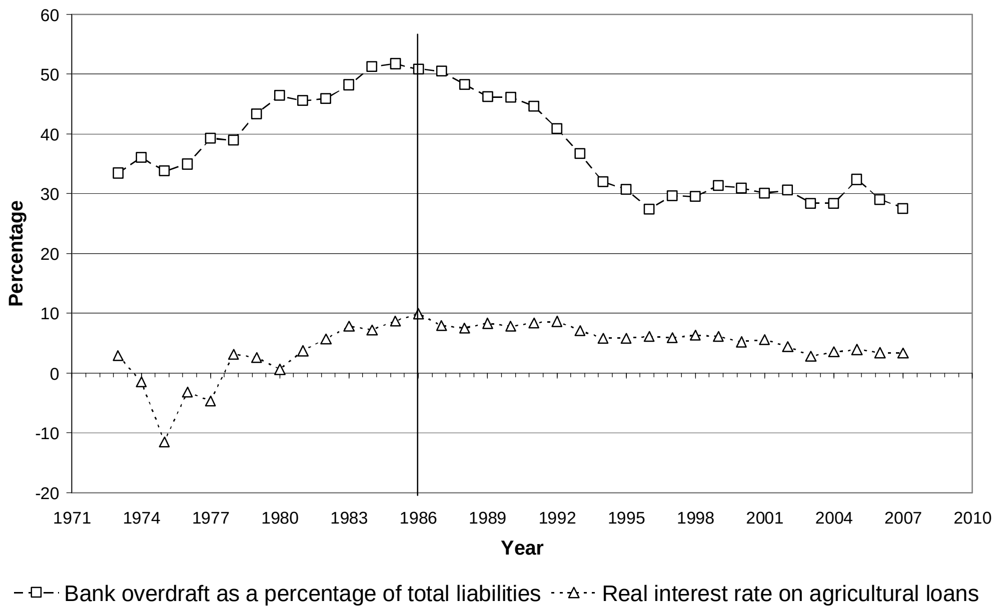
2.1 High interest rates, with a growth in exposure to variable interest rates.

Figure 1 shows the change in the percentage of liabilities held as bank overdraft and the trend in real interest rates. Bank overdrafts are more risky than long-term loans because they are subject to variable rather than fixed interest rates and foreclosure at short notice. The percentage had fallen to 28 in 2007 as farmers rebalanced their debt structure. Although there has been a 22% reduction from the peak in 1985, because total liabilities have increased the value of loans held as bank overdrafts has reduced by only 15%, £543 million from £3.56 billion to £3.06 billion. So a considerable sum of borrowing is still held on short-term, unsecured loans. Therefore, UK agriculture would still be badly affected should banks foreclose on these loans.

Nominal interest rates continued to rise through 1986 until 1990, by which time real interest rates had started to fall. By 2007 the nominal and real cost of borrowing, at 7.6 and 3.3% respectively, represent a long-term low, reducing the debt burden on businesses, whilst still delivering a real return on savers' bank deposits.

Total loans advanced to UK farming increased sharply up to 1985 thereafter they continued to rise but at a slower rate (Figure 2). In 2007 liabilities reached £11.1 billion, an increase of £4,026 billion (57%) over the 1986 level[5]. However, total farm asset values have also increased. In 1986, the

Figure 1 Trends in bank overdrafts and real interest rate.



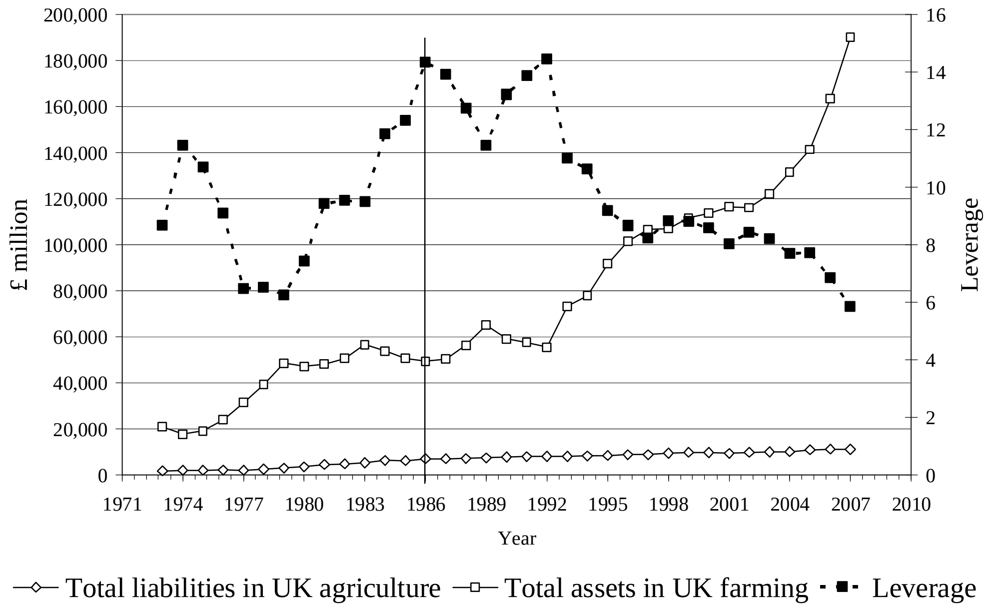
(Source: Table 9.3. Aggregate balance sheets for agriculture: United Kingdom, and Table 9.6 Interest; United Kingdom, both in Agriculture in the UK (DEFRA 2009b)).

5. All data used in this analysis are current values unless stated.

value of assets held by UK farming had remained at about the same level for 7 years, and they had returned to this level by 1992, the year in which leverage (the ratio of total debt to total assets) peaked at 14.5%. Thereafter, asset values increased faster than liabilities, and leverage fell, so that by 2007 total liabilities comprised 5.85% of assets which were estimated to be worth some £190 billion. This relatively strong balance sheet appears to offer some protection against the threats emerging from the macroeconomic environment.

However, much of the increase in asset values arose from the growth in farmland values, little through reinvestment in other farming capital. In the ten years up to 2008 the net stock of capital assets fell by £2,371 billion. Due to this prolonged period of low profitability, depreciation (a positive cash flow item) was largely used to meet living expenses rather than being reinvesting in new equipment and buildings. This trend was reversed in 2007 and 2008, when profits recovered principally because of the commodity price boom, and in 2008 investments raised the net stock of capital assets by £466 million as farmers replaced worn out equipment and dilapidated buildings[6].

Figure 2 Trends in total assets and total liabilities in UK farming, and leverage.



(Source: Table 9.3. Aggregate balance sheets for agriculture: United Kingdom; Agriculture in the UK (DEFRA 2009b)).

2.2 Withdrawal of institutions from land purchase.

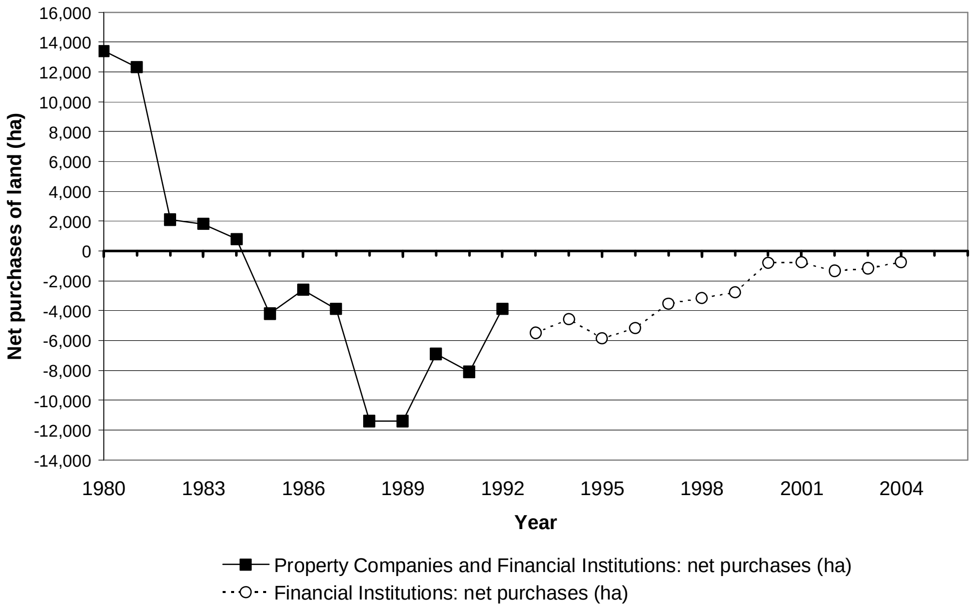
This is a risk to farming because it reduces opportunities “for farmers to sell land and lease it back in order to rid themselves of excessively heavy debt service burdens” (Harrison and Tranter 1989: p 61). Figure 3 shows how this trend has developed since 1986. The rate of disposal of farmland by financial institutions has slowed over the years but they remained net disposers in each

6. In the decade leading up to 1986 net stock of capital increased by £524 million, though in 1986 itself net stock decreased by £337 million (all current prices).

year up to 2004, the last year for which this data series is reported. In that year financial institutions purchased only 67 and sold only 811 ha of land.[7]

Data after 2004 are available from the Royal Institute of Chartered Surveyors (RICS)[8]. In 2007 the largest purchasers of farmland was 'Individual Farmers', their share of all buyers in the second half of 2007, both halves of 2008 and the first half of 2009 was 50%, 56%, 60% and 62% respectively, with a reduction in demand for farmland from life-style buyers as the credit crunch deepened. As farmers purchased land, on the back of a sharp increase in commodity prices and with the continued willingness of banks to lend to agriculture (RICS July-Dec 2008), land values jumped by an average of 24%, from £10,439 to £12,965, in the first half of 2008 (RICS Jan-June 2008)

Figure 3 Net purchases of land (ha) by 'Property Companies and Financial Institutions' (1980-1992) and by Financial Institutions (1993-2004).



(Source: Agricultural Land Sales and Prices in England, (DEFRA 2006), and Royal Institute of Chartered Surveyors (RICS various)).

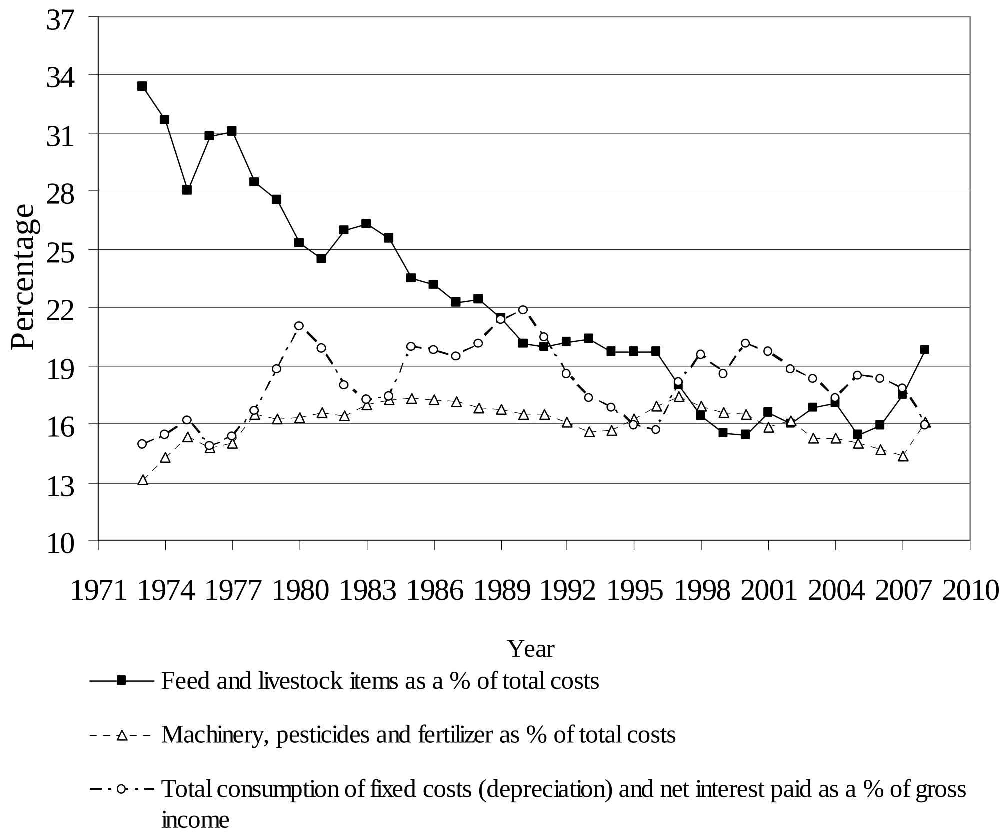
2.3 Increased dependency on purchased inputs and reduced possibilities of substituting family labour for wage labour.

Harrison and Tranter identified three series that showed an increased dependence of agriculture on inputs purchased from the rest of the economy. This they report, makes farming "subject to additional price risks, and farmers are increasingly unable to substitute low-cost family labour inputs for them - the traditional belt tightening exercise associated with family-farming" (p. 63). The evolution of these three series up to and beyond 1986 is shown in Figure

7. This data was collected by the Valuation Office Agency (VOA) and reported by DEFRA.
8. RICS publishes information, initially quarterly but since the second half of 2006 biannually, on land purchasers' background (RICS various).

4. The shift away from feed and livestock enterprises towards crop based ones has continued since 1986. To some degree, this shift is related to the incidences of farm animal diseases; for example the substantial drop in 1996 coincided with reports that BSE could be transmitted to humans by eating infected meat. Other major and costly farm-animal diseases - such as Food and Mouth Disease (outbreaks in 2001 and 2007) and pig diseases - have further reduced livestock numbers[9]. The reversal of this trend in recent years reflects the increase in livestock feed costs as a result of the boom in wheat and barley prices. The evolution of this series since 1986 suggests, from Harrison and Tranter's perspective, an increase the sector's price risk.

Figure 4. Feed and livestock items as a percentage of total costs, machinery, pesticides and fertilizer as a percentage of total costs and depreciation as a percentage of Total Income from Farming.



(Source: Index of the purchase price of the means of agricultural production (United Kingdom), and Index of the producers price of agricultural products; (United Kingdom) Agriculture in the UK (DEFRA 2009b)).

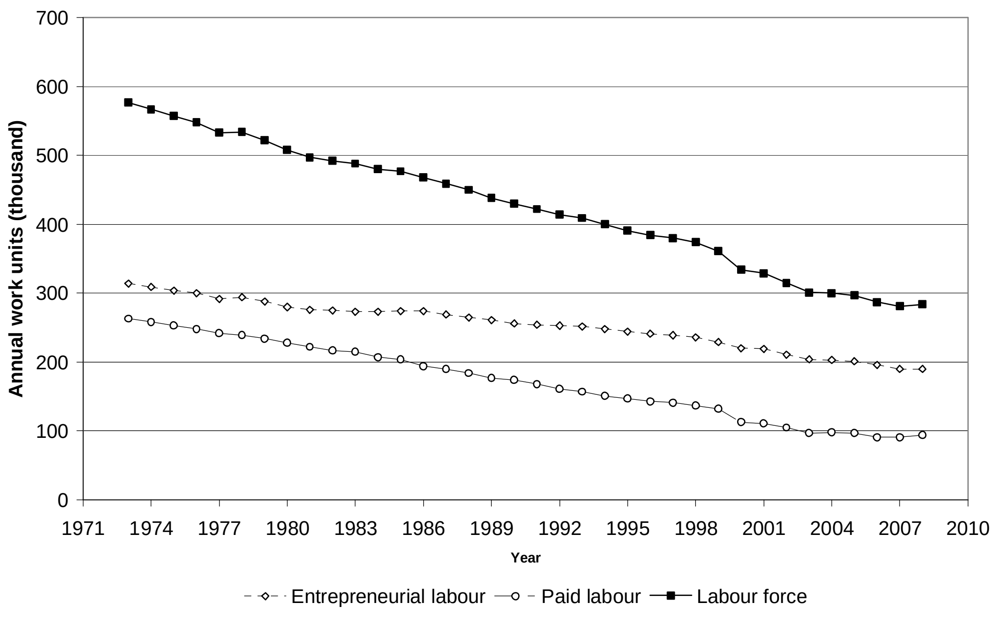
The dependency on mechanical and chemical inputs declined steadily after 1986, increased in the mid 1990s, and then fell once more, to 14.4%, in 2007. This variability is connected to changes in agricultural policy support

9. Particularly porcine postweaning multisystemic wasting syndrome (PMWS) and porcine reproductive and respiratory syndrome (PRRS).

payments, the introduction of agri-environment schemes, set-aside (which removed a variable percentages of arable land from production each year between 1995 and 2007), and will also have been influenced to some extent by the growth in the area of registered organic farmland. Figure 4 also shows the trend in depreciation and net interest payments as a percentage of gross income (defined as the total value of crop and livestock, and all support payments). These continued to increase after 1986 to peak at 21.9% in 1990, the year when net interest payment was at its highest. This series shows some volatility as market output value, support payments and interest repayments varied, but it has declined steadily since 2005 to 15.9% in 2007. The fall in these two series since 1986 indicates a reduction in the sector's risks related to its dependency on inputs purchased from the rest of the economy.

Of particular concern to Harrison and Tranter was farmers' increasing inability to substitute low-cost family labour inputs for waged employment, one of the "traditional belt tightening exercise associated with family-farming" (Harrison and Tranter 1989: p 63). Figure 5 shows the reduction in both family and employed labour in farming has continued after 1986. As the proportion of the workforce with an equity interest in farming increases and wage employment falls, so the ability to substitute between family and waged labour reduces still further. However, this also means that a larger proportion of total labour costs (waged and farmer and spouse, and others with an equity interest in the farm's drawings) is paid to workers who might be more willing to forego payment of their salary to help overcome a short-term liquidity crisis. So the decrease in waged labour is off-set by this additional flexibility.

Figure 5. The reduction in labour use, highlighting the fall in paid labour.



(Source: Table 3.8 Labour force in agriculture, United Kingdom, Agriculture in the UK (DEFRA 2009b)).

2.4 The continuing deterioration in the sector's terms of trade.

Harrison and Tranter (1989) note that in the years leading up to 1986 "inputs are costing more and products are commanding lower prices" (p 63), leading to a deterioration in the sector's terms of trade. Table 1 compares the change in input and output prices and the sector's terms of trade in the four years prior to 1986 and 2008. The earlier period recorded a decline in the terms of trade by 8.5 points as input prices increased faster than output prices to squeeze farm profitability. This compares with the 0.2% change in the four year period leading to 2007, suggesting no cost-price squeeze.

However, during this time input prices increased by 48% and output prices by 46%. These substantial movements suggest the timing of input purchases and sale of product has become more critical putting additional pressure on farmers with limited working capital, whilst farmers with access to savings or credit might benefit by buying inputs before selling outputs if they believe that to be the most beneficial trading strategy.

Table 1. Comparison of input and output indices and terms of trade 1982-1985 and 2005-2008.

	Change in input index	Change in output index	Change in terms of trade	standard deviation	Mean	CV
1982-1985	15	4	-8.5	3.81	97.8	3.89
2005-2008	48.1	46.2	0.2	1.58	96.3	1.64
(Source; Table 9.6 Interest; United Kingdom. Agriculture in the UK (DEFRA 2009b).)						

2.5 Increase variability of farm product prices.

A comparison of the coefficient of variation (standard deviation divided by mean price) of 13 items in each of the two three year periods, 1976-78 and 1984-86, allowed Harrison and Tranter (1989) to conclude "farm product prices are more volatile than they were 8 to 10 years ago" (p. 63). Their analysis revealed that "only 3 product groups (fresh fruit, flowers and plants, and eggs) had a narrower spread of prices in the later period than the earlier" (p. 63-64). However, they found that "quite the opposite appears to have occurred on the factor side" (p. 64), with only energy, fertilisers and seed showing more variable price movements between 1984 and 1986 than between 1978 and 1980. With higher variability in product prices but lower variability of factors, Harrison and Tranter concluded that "the evidence relating to price variability is not clear cut" (p. 64).

Table 2 reproduces their analysis, comparing the coefficient of variation for product and factor input prices for two periods, between 2001 and 2004 and from 2005 to 2008. For nine of eleven product prices the coefficient of variation has increased and the index of "total of all products" has increased from 3.8 to 16.3. Seventeen of the nineteen factor input prices also have increased coefficient of variation and the index of "all means of agricultural production" has increased from 4.04 to 16.33: a similar increase as the "total of all product" index. Fertilizers, animal feeding stuffs and 'energy and lubricants' reported the largest volatility in the most recent period, inputs for which substitutes are not readily available.

The nature of the risks related to terms of trade appears to have changed. Farmers have passed on some of the benefit of higher commodity prices to input suppliers, and though they have avoided the price squeeze of the 1980s they face significant risks related to asymmetric price adjustments: should output prices fall whilst input prices remain high, the sector may experience a sudden and extreme adverse shift in its terms of trade.

2.6 Series that cannot be updated due to lack of comparative data.

Two of the seven sources of growing risk were derived from a large-scale survey of farms, confirmed by bank managers. Similar survey data is not available so it is not possible to compare Harrison and Tranter's findings with current conditions. However, some useful comments and comparisons can be made. The two series are:

(1) a diminishing of within-the-family funding sources increases the splitting-up farms on the death of the owner, and

(2) an increased annual volatility of farm incomes.

2.6.1 Diminishing within-family funding sources

Harrison and Tranter reported that "the years of rapidly rising land values – and of prices generally – caused many members of farming families (often brothers and sisters) who had been left farm assets, under terms which excluded them from equity participation and therefore capital gains on them, to demand that their shares be paid in cash" (Harrison and Tranter 1989: p 61-63). One result of this, they conclude, is that "farmers' debt levels are higher than they would otherwise have been" having "been compelled to borrow from higher cost sources than the low-cost, within-family ones they enjoyed in earlier years, when family ties were stronger and less influenced by narrowly commercial considerations" (p 63).

There are no reasons to believe that motivations of family members who have been left farm assets have changed, and as asset values have increased more rapidly recently than in the early 1980s, these incentives to extract equity most likely remain, and indeed to have increased in recent years. However, easy access to cheap loans characteristic of the 2000s would have decreased the costs to the continuing farmer of paying out family members thus decreasing the impact of this source of risk today.

2.6.2 An increased annual volatility of farm incomes.

Harrison and Tranter's (1989) conclusion that year-to-year variation in farm incomes had become more volatile in the period from 1981 to 85 compared to the period between 1976 and 1980 is based on comparing the coefficient of variation of 150 individual farms. Table 3 examines a related, but by no means identical issue, the change in coefficient of variation of Total

Table 2. Change in coefficient of variation of agricultural product prices and factor inputs (between 2001-2004 and 2005-2008).

Agricultural products

	Total of all products	Crop products	Cereals	Potatoes for Consumption	Animals & animal products	Animals (for slaughter and export)	Cattle	Pigs	Sheep	All Poultry	Milk	Eggs
CV (2001-2004)	3.84	4.23	7.58	20.24	3.79	4.61	5.05	4.79	12.04	1.67	4.94	12.55
CV (2005-2008)	16.31	18.90	34.27	18.27	15.01	13.61	15.84	9.56	10.15	16.04	17.55	16.53
Change in CV	12.47	14.67	26.70	-1.97	11.23	9.00	10.78	4.78	-1.89	14.37	12.62	3.99

Factor inputs

	All means of agricultural production	Goods and services currently consumed	Seeds	Energy and lubricants	Fertilisers and soil improvers	Straight Nitrogen[1]	Triple Super Phosphate	Potassic	Compound Fertiliser	Other Fertiliser
CV (2001-2004)	4.04	4.29	3.97	7.01	7.15	8.89	5.86	4.55	6.00	1.57
CV (2005-2008)	16.33	17.87	18.48	21.53	53.73	42.30	75.37	71.44	65.51	6.04
Change in CV	12.29	13.58	14.52	14.52	46.57	33.41	69.51	66.89	59.51	4.47

	Plant protection products	Animal feedingstuffs	Maintenance and repair of plant	Maintenance and repair of buildings	Veterinary services	Other Goods & Services (General expenses)	Goods & services contributing to investment	Machinery and other equipment	Buildings	Engineering & Soil Improvements
CV (2001-2004)	2.38	3.33	7.00	4.59	3.05	4.66	2.32	0.99	5.73	4.56
CV (2005-2008)	2.81	23.71	6.40	8.27	3.50	3.60	4.24	6.88	7.95	4.89
Change in CV	0.43	20.38	-0.60	3.68	0.45	-1.05	1.93	5.89	2.21	0.33

CV = coefficient of variation (=(standard deviation/mean price)*100)
(Source: DEFRA (2009a) Index of producer prices of agricultural products: UK)

	standard dev	Mean	CV		standard dev	Mean	CV
1982-1985	439.02	1,871	23.4612	1981-1985	326.38	1,618	20.17
2001-2004	500.64	2,335	21.4453	1973-1985	564.62	3,064	18.42
2005-2008	576.21	2,604	22.1320	1995-2007	1202.95	2,277	52.83
(Source: Chart 2.1 Long-term trend in farming incomes in real terms (at 2008 prices), Agriculture in the UK (DEFRA 2009b)).							

Income from Farming and Cash Flow measured at the sector level for three periods; between 1982 and 1985, from 2001 to 2004, and from 2005 to 2008. The comparison shows little difference in the co-efficient of variation in TIFF between the three four year periods, but Cash Flow has a considerably higher coefficient of variation in the most recent period. To a large extent this is due to the difficulties experienced in the first year of the Single Farm Payment Scheme (2005/06) when many farmers had to extend their borrowing facilities to tie themselves over this period. This liquidity problem arose directly from changes to agriculture specific policies but confronting a similar cash shortfall – from whatever source - would pose considerable more problems in today’s economic climate.

Table 3. Coefficient of variation for Total Income from Farming, and Cash Flow.

Total Income from farming				**Cash flow**			
	standard dev	Mean	CV		standard dev	Mean	CV
1982-1985	439.02	1,871	23.4612	1981-1985	326.38	1,618	20.1719
2001-2004	500.64	2,335	21.4453	1973-1985	564.62	3,064	18.4291
2005-2008	576.21	2,604	22.1320	1995-2007	1202.95	2,277	52.8307
(Source: Chart 2.1 Long-term trend in farming incomes in real terms (at 2008 prices), Agriculture in the UK (DEFRA 2009b)).							

2.7 Summary.

Some of the risks identified by Harrison and Tranter in 1986 have reduced, some have altered in ways that make any net change in risk difficult to assessed, and some have increased. Those to have decreased include; (i) a stable and lower interest rate, (ii) the lower percentage and total amount of borrowing held as bank overdraft, (iii) the level of asset values, which means that although total liabilities have increased, leverage at 5.85% is nearly 10 points less than in 1986, and (iv) terms of trade have ceased moving against the sector.

The evidence related to dependency on inputs from outside agriculture is mixed. The decline in the livestock sector represents a reduced opportunities for farmers to add value to the arable enterprises, but the share of purchased chemical and fertilizer inputs to total costs has declined as has total consumption of fixed costs as a percentage of gross income. And the increase in the proportion of the workforce with an equity share in the farm suggests on the one hand less substitution possibilities, but it also means a larger proportion of the workforce might be more willing to forego a proportion of their salary; this net effect of these counter-balancing changes may well may a reduction in farming’s liquidity risk (i.e. a higher proportion of total labour (waged and unwaged) costs can be deferred at least in the short-term).

Some of the series continue to be sources of threat to farming. For example, total borrowing has increased by 57% since 1986, and although lower interest rates have reduced the costs of borrowing, this increase results in the relatively small reduction of interest repayments of £137m (from £762 million in 1986 to £625.2 million in 2008). This is still a substantial sum, and calls into question the ability of the sector to service these loans should the interest rate increase. The data also indicate a continuing absence of financial institutions in the land market. Most land purchasers in recent years have been farmers, and whilst this suggests valuations are based on farmland's contribution to expected farm profitability, the reduction in sale-and-lease-back opportunities removes one route to restructuring farm debt. Whilst the terms of trade has ceased to move against farming, removing this as a source of cost-price squeeze on profits, recent years have seen a steep increase in both input and output prices, increasing liquidity risk. In recent months output prices have returned towards their long-run means, so if input prices remain high or are slow in adjusting downwards, farming will be faced with a sudden adverse movement in its terms of trade. Any pressure on profitability will reduce the sectors debt service possibilities.

These data reflect the influence of events and policies, for example, animal diseases and epidemics. As these are largely unpredictable events and generally beyond the control of individual farmer's, they will act to increase the production and financial risk associated with livestock[10]. As agriculture looks forward it can identify other policy, production and technical changes that may affect its portfolio of risks. For example the recent proposals to ban selected pesticides may increase production risks associated with arable cropping (Rickard 2008).

3. Current finance-related sources of risk in UK Agriculture

The previous sector explored the financial pressures on the agricultural sector in 1986 as interpreted by Harrison and Tranter. This section identifies seven sources, and growing sources of financial risk which are likely to influence the agricultural sector over the next 5 to 10 years. What ties them together is that they are all linked to the credit crunch. Some directly, such as increase in interest charges, and some indirectly, such as growth in land values as money looks for a safe haven. The extent to which each develops as a risk will largely be influenced by the severity of the current financial crisis, for example, the prospect of protectionism is more likely if financial crisis spreads further through the banks and causes countries to default on their national debt[11].

3.1 The growth in land values

An asset bubble occurs when there is trade in high volumes and at prices that are considerably at variance with intrinsic values. It was the easy credit that was partly to blame for the bubble in stock and shares and house prices,

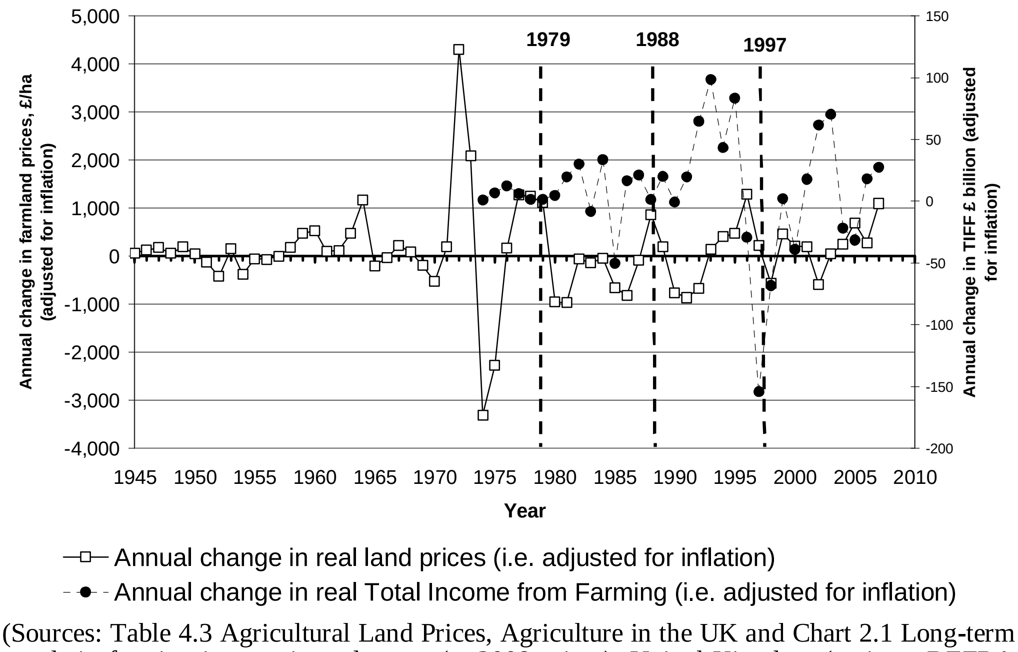
10. At least to the extent that the affected farmers are not fully compensated for their losses.
11. This paper was completed in the autumn of 2009, before the pressures on the Euro arising primarily from the Greek, and to a lesser extent the Spanish and Portuguese, sovereign debt crisis. It therefore has not considered any possible impact of the demise of the Euro as a European currency.

and there must be a danger that the years of easy access to cheap loans have generated a bubble in the farmland market even if the recent preponderance of farmer purchasers suggest that farmland is valued according to profit expectations based on buoyant commodity prices.

Figure 6 shows recent cycles in farmland value, measured as annual change in real farmland prices (£/ha), and the annual change in real Total Income from Farming (TIFF), measured in £ billions. As the majority of farmland purchasers are working farmers, farmland's intrinsic value is best calculated as the present value of the expected future profitability of farming[12]. Figure 6 shows four periods of growth in land price, 1971-3, 1977-9; 1988 and 1994-7, each followed by years of negative growth as the markets readjusted their expectation. The growth in farmland prices between 1993 and 1997 followed several years of high TIFF, the readjustment in 1998 follows a substantial drop in TIFF, evidence of the linkage between farmland prices and farming profitability, which suggests the growth in the preceding years was based on agricultural profitability, and so do not represent asset price bubbles.

The recent increase in land values between 2003 and 2007 also followed several years of increased TIFF, with the slower growth in 2006 reflecting reduced growth of farming profitability. This provides additional evidence that

Figure 6. The annual percentage change in real farmland price and Total Income from Farming.



(Sources: Table 4.3 Agricultural Land Prices, Agriculture in the UK and Chart 2.1 Long-term trends in farming income in real terms (at 2008 prices); United Kingdom (various, DEFRA 2009b)).

12. Traditionally the intrinsic value of land has been considered the expected agricultural net rent. But this is related to the profitability of farming through time lags dictated by agricultural tenancy legislation. As most land is purchased by owner-occupiers, its net value to the farmer is directly related to the expected increase in profitability to the purchaser. So Total Income from Farming (TIFF) is a suitable measure of its expected intrinsic value to the sector.

farmland values over this period have remained linked to farmers' expectations of the profitability of farming. Therefore, any future fall in TIFF would most likely be reflected in a reduced rate of growth, or fall in farmland values.

However, a recent analysis of commodity markets (UNCTAD 2009: p 53-84) suggests the extreme scale of recent changes in primary commodity prices (the price boom between 2002 and mid 2008 was followed by a decline across all major categories of commodities) was largely driven by a major new element in commodity trading over the past few years, namely financial investors treating commodities as an asset class. The speculative activities of financial investors that are active in both financial and commodity markets appear to have influenced price movements to higher or lower levels that those dictated by market fundamentals[13]. If this is the case, then whilst farmland values may be based on expectations of the profitability of farming, because these expectations are in turn based upon a bubble in commodity prices, farmland may be overvalued. It is difficulties such as these that make differentiating between an asset bubble, a bull market and a boom difficult - and often conclusive identification is only possible in retrospect when a sudden drop in prices appears and the market crashes, and the more speculative gains are quickly wiped out.

3.2 Payback (profitability, cash flow and interest charges).

The importance of the debt-to-asset ratio (Figure 2) is clear as it is used in the context of evaluating insolvency. However, Penson (1987), analysing US agriculture, noted that farmers' ability to service their farm debt was deteriorating long before the debt-to-asset ratio began to rise in the 1980s. He concluded that when used by itself this ratio is a "poor indicator of farm cash flow problems before they become insolvency problems" (p 15). He suggests three ratios to use to predict exposure to increased leverage;

- Times Interest Earned ratio (TIE), dividing total earnings before interest and tax (TIFF plus net interest plus rent paid) by total (net) interest payments;

- Financial Leverage Index (FLI), dividing the rate of return (TIFF as a measure of return) on equity capital (sector net worth) by the rate of return on total capital; and

- Debt Burden Ratio (DBR), dividing net cash farm income by total farm debt.

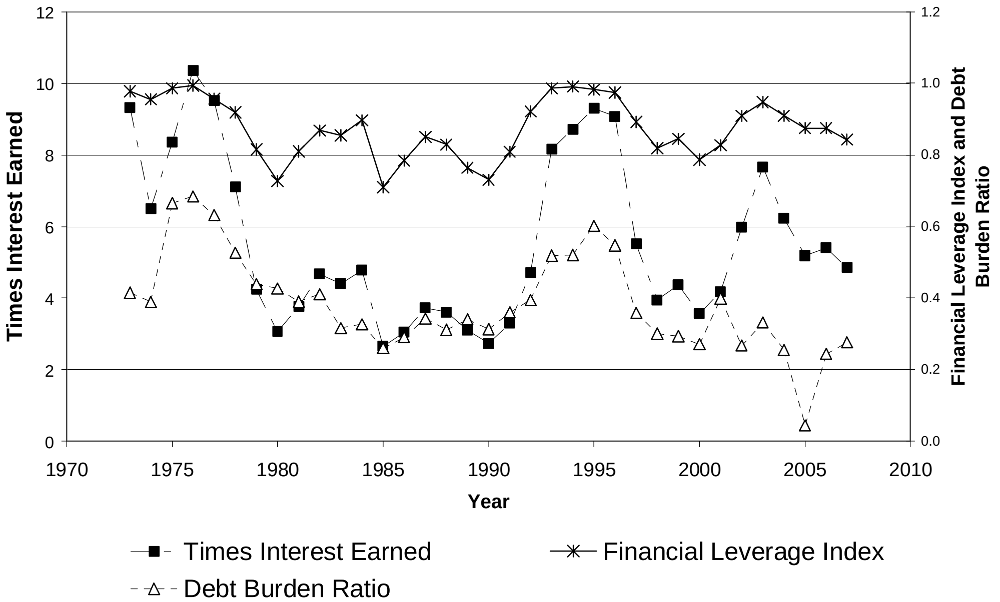
These indices are shown for UK agriculture from 1973 to 2007 in Figure 7. The TIE ratio has fallen from nearly 8 (in 2003) to less than 5 (2007) which shows that interest payments have risen as a proportion of farm sector profit.

13. "The fact that these market participants do not trade on the basis of fundamental supply and demand relationships, and that they hold, on average, very large positions in commodity markets, implies that they can exert considerable influence on commodity price developments" (UNCTAD 2009: p 54).

There has also been a fall in the FLI since the mid 1990s, showing that returns to agricultural assets have fallen in comparison with the costs of borrowing. DBR has also fallen in most years since 2001 (though the 2005 value is an anomaly due to the delay making the first Single Payment Scheme payment), showing the reduced ability of the sector to service its interest payments.

Whilst UK agriculture has substantial equity, the three debt-service ratios in Figure 9 indicate an increasing weakness in its ability to service borrowing from farm profits and cash flow. Though the current Bank of England interest rate is low, these rates have not been entirely passed on to commercial loans as banks seek to recapitalise their balance sheets. These indices therefore, suggest reasons for concern if pay-back becomes even more problematic and for DBR and FLI at least, approach long-term lows. In the event that banks call in more of their short-term loans or interest rates rise (to help the recapitalisation process or to reduce expectations of inflation), farmers may need to sell assets to repay loans and principal, which would most likely reduce the growth in farmland prices.

Figure 7. Trends in leverage and other financial ratios.

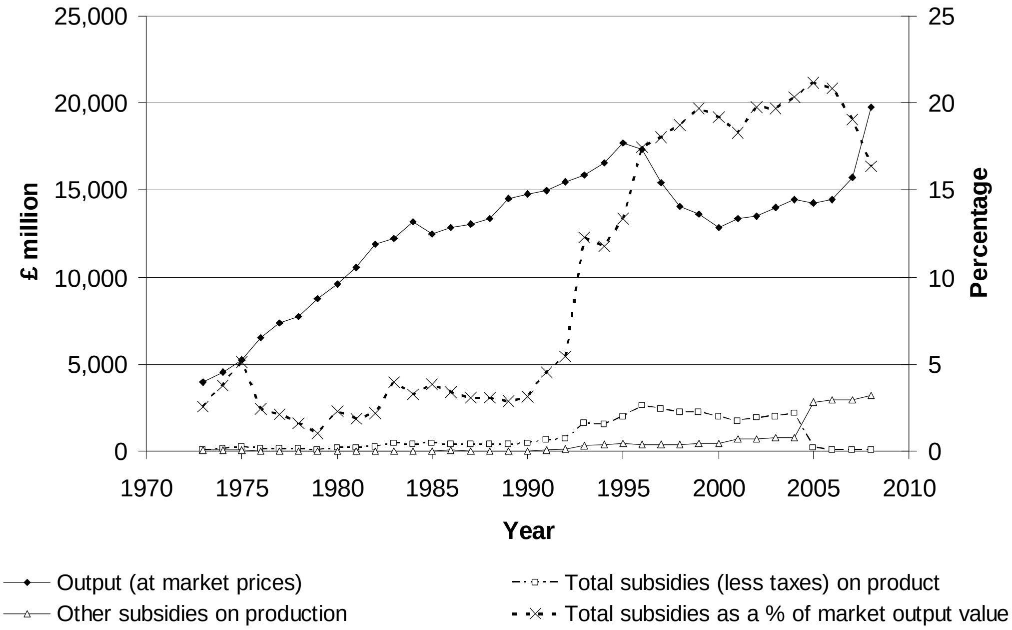


(Source: calculated from various tables reported in Agriculture in the UK (DEFRA 2009b)).

3.3 Agriculture sector policy risk.

Policy affects production and changes in policy have helped empty cereal, butter and skimmed milk intervention stores, as the intervention price was reduced when the Single Payment Scheme (SPS) was introduced. Figure 8 shows the evolution in the dependency of the agriculture sector on government support payments. The substantial decrease in proportion of agricultural commodities and increase in the proportion of subsidy payments after 1992 is explained by MacSharry's reforms, and the shift in 1996 by the BSE crisis. In 2005, the switch to decoupled support payments (the Fischler reforms) moved the bulk of this support into transparent SPS payments (Franks 2006). In 1986 direct support payments represented only some 4% of the total value of farm produce, by 2007-8 it was in excess of 15% (down from its peak of 21% in 2005) (own calculations from Table 10.3 (Costs and volumes of labour engaged in agricultural work (a)); United Kingdom (DEFRA 2009b)). The recent fall is largely a result of the global commodity price boom, and the proportion of support payments to total output is likely to increase when market prices return to their pre-boom long-run average.

Figure 8. Total subsidies paid to agriculture as a percentage of value of agricultural output (at market prices). (Total subsidies (less taxes) on product are payments linked to the production of agricultural products. "Other subsidies on production" include payments not linked to production from which agricultural producers can benefit as a consequence of engaging in agricultural activities e.g. Single Payment Scheme, agri-environment schemes).



(Source: Table 9.3 Aggregate balance sheets for agriculture; (United Kingdom) Agriculture in the UK (DEFRA 2009b)).

The SPS in England sets out future support payments, in Euros, up to 2012. This helps cash flow planning and so reduces financial risk, but there has been an increasing dependency on government subsidies since 1986, and the SPS has, importantly, also introduced a new type of risk to agriculture; because of their transparency, payments made to each farm business can be identified and recorded separately (FarmSubsidy.org 2009). This allows policy makers not only to question the notion that all farm businesses require support, but makes action to, for example, cap the payments made to individual farms, administratively possible. Moreover, the recent switch in DEFRA's preferred measure of on-farm profitability, from Net Farm Income to Farm Business Income, also makes targeting agricultural support payments to households with agricultural incomes below some agreed level easier (Franks 2009a).

3.4 Exposure to exchange rate risk.[14]

SPS payments and commodity intervention support prices are set in Euros (before 1st Jan 1999 in ECUs), so payments in sterling have depended partly on the exchange rate, and partly on agricultural policies, such as agri-monetary compensation, modulation and financial discipline. Figure 9 shows the trends in sterling exchange rate against the Euro and US dollar. After several years of largely stable and slightly rising exchange rates, sterling steadily depreciated against the Euro for two years from mid 2007, thus increasing the value of SPS payments - a 5% shift in the £/Euro is reckoned to change UK total income from farming by £0.3 billion or 15% (Working Group on Risk Management 2003: p 4). However, the recovery in early 2009 suggests at least a temporary end to this windfall benefit. Figure 10 illustrates the impact of variations in exchange rates. It shows the difference in direct payments payable to UK farmers given the strongest and weakest sterling:Euro exchange rate between 1995 and 2008 to be 23.25 p/Euro[15].

3.5 Counterparty risk.

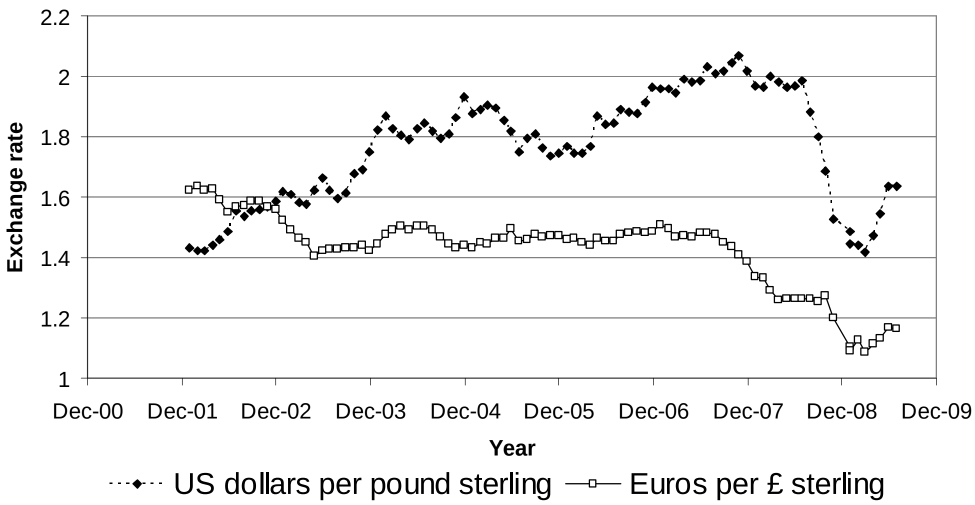
A key reason why liquidity dried up shortly after Lehman Brothers was allowed to go bankrupt in September 2008 was that banks did not know how solvent their customers (which included other banks) were. This risk, which is termed counterparty risk, refers to the danger that the other party in a financial transaction may go bust.

And this was one reason that banks rationed credit to businesses and indeed to one another. By calling in debts and reducing overdraft facilities, banks both reduced their counterparty risk and started to recapitalise their balance sheets. The extent to which this has happened to UK farm businesses is not known, but the increase in lending suggests that the sector as a whole has not been subject to credit rationing. However, farm businesses, like all businesses, face increased counterparty risk, and therefore do need to tighten their credit control and review trading arrangements. The example of the withdrawal of bank funding for the failed farmer owned dairy co-operative, Dairy Farmers of Britain which went bankrupt on 3 June 2009 owing their farmer members an estimated £92 million (DIN 2009: p 9), shows the

14. Exchange rate risk was not identified by Harrison and Tranter as a growing source of risk to UK agriculture. In the mid 1980s the agri-monetary system set the sterling value of European commodity support prices, which at that time were denominated in European Units of Account. The mechanism for setting the green rate changed between 1973 and 1992, in 1986 the green rate was the central market rate times the switchover coefficient. The switchover coefficient changed whenever the spread in monetary compensatory amounts (MCAs) between the strongest and weakest member state's currency exceeded 5 points. The overall effect of this complicated mechanism was to insulate UK agriculture from adverse exchange rate movements in sterling, and to allow it to benefit from revaluations in other member state currencies. The reduction in commodity support prices, and the complete removal of the agri-monetary system, means that UK farming is now more exposed to variations in exchange rates than in 1986 (Ritson and Swinbank 1997).

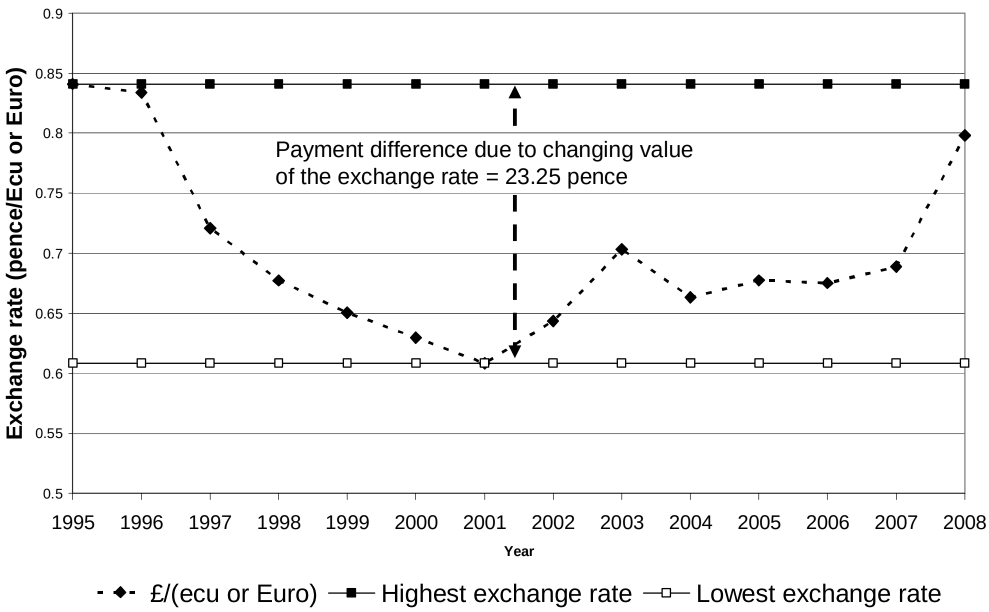
15. The actual payments received depend on other factors, such as agri-monetary compensation and modulation, which introduces an element of sector specific policy risk alongside exchange rate risk.

Figure 9. Exposure to macro-economic policy: exchange rate risk (Euro/£)



(Source: Exchange rates taken from Bank of England website (Bank of England 2009)).

Figure 10. Annual exchange rate used to convert arable area payments and single payment scheme payments from ECU/Euros to sterling (1995-2008: values for 1999, 2001, and between 2005 and 2008 estimated).



(Source: own calculation).

potential losses that can arise from counterparty risk (Pricewaterhouse Coopers 2009).

3.6.1 Economic recession: impacts on farm diversification activities.

Harrison and Tranter (1989: p 22) acknowledged the importance of the increase in income arising from on-farm diversification activities, but lacked information to allow them to assess the risk associated with this trend. But a report on diversification which surveyed 10,000 holdings in England and Wales was published in the same year as the Harrison and Tranter report, by McInerney and Turner (1989). They found that "over 40% had at least one non -farming enterprise, with an estimated one third of all holdings in the UK having diversified in some way" (p i). The general scale of operation was described as "fairly low", with "nearly two thirds of enterprises producing less than £5,000 output and one quarter less than £1,000". A key driver of diversification was found to be insecure farm incomes, "as incomes from farming have seemed less secure many operators of agricultural holdings have been looking to see whether any of the [diversified enterprises] were relevant to their businesses. As a result there has been a noticeable expansion in farm diversification in Britain in the last decade" (McInerney and Turner 1989:p 58). A later study undertaken by Centre of Rural Research (CRR 2003: p 155) arrived at a similar conclusion, whilst noting that the scale and extent of these activities had grown, as agriculture continued to adjust to new opportunities afforded by the developing rural economy. That study concluded that 58% of holdings engaged in some form of diversified activity.

Definitions of farm diversification have changed over time (Ilbery *et al.* 2006; Caron and Cairol 2008), so have sampling frameworks and survey methods, so comparisons between studies are not strictly valid. However, DEFRA has produced a consistently defined time series of diversified activities based on the Farm Business Survey (DEFRA Various)[16] which reported that 51% of farm businesses[17] had some form of diversified activity in 2007/08, a similar percentage to that reported each year since 2003/04. In 2007/08 this activity generated some £400 million of income, 15% of farm aggregate income in that year.[18]

This level of resource deployment out of the farming sector directly exposes agriculture to new risks. The majority of this income was generated through letting buildings for non-farm use (39%), other important activities include processing/retailing of farm produce (7%), sport and recreation (8%), and tourism (3%). Activities such as these have high income elasticity of

16.. The definition used by DEFRA, unlike that used by McInerney and Turner, excludes the provision of agricultural services as a diversification activity.

17. Larger than one half of a Standard Labour Requirement, the size that indicates a full-time or part-time farm business. The Standard Labour Requirement (SLR) for a farm business represents the labour requirement (in full-time equivalents) for all the agricultural activities on the farm, based on standard coefficients for each commodity on the farm. The SLR is representative of labour requirement under typical conditions for enterprises of average size and performance, it may be different from actual labour use on a farm (DEFRA 2010).

18. But there is a wide variation between farms: for 36% of businesses with diversified activities, diversified income accounted for a quarter or more of the total farm income, and for 22% of businesses, the estimated income from diversification exceeded the income from the rest of the farm business (DEFRA 2009c: p 6). Other studies have shown the importance of diversified income to different farming sectors (Franks 2009b)

demand, and this makes them exposed to any economic downturn. Moreover, not all diversification activities are successful, they involve financial risk as investments are made into new uncertain markets, introducing new risks.

3.6.2 Economic recession: impact on off-farm income.

Consistent data is now becoming available about farmer and spouse off-farm employment. In 2003/04 about 24% of farmers (or their spouse's) in England earned off-farm income of, on average, £14,200 (compared to the average income from farming of £17,200). The proportion had increased to 32% in 2007/08 (DEFRA 2009c). With data on diversification activities and off-farm income becoming available it has now become possible to research (i) the impact of the wider economy on diversified and off-farm income, (ii) the degree of risk-balancing undertaken by farmers, that is the extent to which lower risk from a more reliable income streams permit more risk taking in other income-earning enterprises, and (iii) the fungibility[19] of different sources of farm household income.

3.7 Future threats: protectionism.

In the immediate aftermath of September 2008 financial crisis, G20 leaders met in Washington and pledged that they would not lead the world into a new era of protectionism. However, the full impact of the many and varied government responses, many of which have been unconventional, are not known, and unemployment is likely to continue to rise, and politicians find pressure to protect jobs difficult to resist. A report produced by Global Trade Alert (Evenett 2009) believes it likely some of these measures will either intentionally or unintentionally discriminate against trade partners: their investigation of 172 state initiatives introduced by G20 nations since June 2009 found that "121 were found to tilt the playing-field against foreign commercial interests. Only 23 of the 121 discriminatory measures related to the imposition of duties following anti-dumping actions, countervailing duties, and safeguards investigations, implying that resort to other means to close borders has been widespread. These findings imply that, on average, a G20 member has broken the no-protectionism pledge every three days" (Evenett 2009: p 3). The research found that a large majority of these discriminatory measures are in smokestack (low productivity manufacturing), declining industries and in agriculture (Evenett 2009: p 18 and their Table 2.8 (p 24)).

The effect of a raft of protectionist measures is difficult to estimate. Doubtless an increase in protectionism would benefit some farmers and disadvantage others. But any overall benefit would likely be short-lived as relative prices adjusted to the new trading environment. As a high proportion of farm inputs are imported, (perhaps a more important indicator than the value of inputs purchased from the rest of the economy), retaliatory tariffs and duties are likely to increase costs. The timing and overall impact are difficult to assess but protectionism is identified with the worsening of the Great Depression in the 1930s, a period that saw many bankruptcies in farm

19. *fungible:* equivalent and interchangeable, so that a pound income from one source is the same and equivalent to a pound's income from another source *(Ed.)*

businesses in the UK.

3.8 Seven growing sources of risk to UK farming: some implications.

Seven growing sources of risk to UK farming have been identified as:

- The rapid growth in farmland values, following the boom in commodity prices, given the evidence that commodity prices are influenced by trader holding commodities as assets, rather than trading on their underlying supply and demand relationships. If this is so, then it is likely farmland is currently over-valued.

- Measures of payback have moved against the sector, as profitability and cash flow fail to grow at the same rate as interest payments.

- Agriculture's increasing dependency on government subsidies which have at the same time become more transparent, making targeting payments for social rather than agricultural-specific reasons easier.

- Exchange rate risk.

- Counterparty risk.
-
- Impact of recession on;

- (i) incomes from diversification activities that have high income elasticities of demand and
(ii) off-farm employment may reduce as unemployment continues to increase.

- Threats of increased protectionism.

These growing sources of risk mean that farmers need to (i) get the big decisions right and (ii) have sufficient short-term flexibility to cope with different circumstances. Getting the big decisions right (e.g. land purchase, machinery investment) is critical (Pannel *et al.* 2000; Just 2003) is an area that receives less attention than it should. Pannel *et al.* (2000) cite papers to support the statement that the farmers "most likely to be under acute financial strain at any time are those who brought land or machinery at the wrong time or at the wrong price or who made significant and incorrect major adjustments to their farm operations" (p. 72).

Short-term adjustment to farm management can make the most substantial impact to farm profitability because tactical adjustment are generally observed in extreme years, good and bad when optimal management practices may be very different to most years. Due to the impact on increasing profit at a time when other farmers are reporting lower profits, this has important consequences for farm growth and development. However, retaining options means keeping surplus capacity, for example, a wider range of cultivation equipment, which increases farm costs, so identifying the optimum surplus capacity becomes a balance between certain costs and unknown benefits.

This analysis has shown agriculture's conservative attitude to credit, and for this reason it is more likely to be less affected by the credit crunch than other sectors. But does the strength of the sector make agriculture a target for a combination of increased taxation or reduced support payments as government attempts to reduce its budgetary deficit and public sector debt? This is the eight credit crunch related risk, that agriculture could be targeted through loss of preferential tax status, for example the loss of preferential tax rate on red diesel, or the withdrawal of the zero rating of Value Added Tax (VAT) on food, or the introduction of new taxes, such as a farmland property tax. Removal of zero rate on food might raise £11.95 billion (Adam and Browne 2009). A farmland property tax could be introduced along the lines applied in the USA, where farmland is valued on its agricultural use value which is multiplied by a combined county and state property tax rate to raises some $4.9 billion annually (USDA ERS 2009). This might have the additional appeal of expanding the local tax base and so supplement the council tax, the only significant local tax left in the UK (Adam and Browne 2009).

4 Conclusions

Many of the financial trends Harrison and Tranter's identified as growing sources of risk continued to deteriorate into the early 1990s before farmers put into operation the processes of adjustment – leading to the shedding of costs and control of debt. Some farmers, principally the heavily indebted, were forced out as part of this readjustment, as shown by the level of insolvencies in the agricultural sector which reached 500 in 1992, an all time sector high. It is salutary to be reminded of this history as the UK economy enters the third year of the credit crunch and the second year of a recession. But unlike the late 1980s and early 1990s, the agricultural sector in 2007 looks well placed, and certainly better placed than if a similar assessment had been done in for the years leading up to 2004. It has particularly benefited from two years of high commodity prices, which reversed the adverse long-term movement in product prices relative to factor prices, and from a devalued pound. Farmers have used this period of relative prosperity to replace worn-out equipment and to replace short-term bank overdrafts with more secure longer-term loans.

Despite increased borrowings, leverage has fallen below 6% and net equity increased to £178.9 billion (in 2008). Farm asset values have remained buoyant notwithstanding the slump in the housing property market, principally because of a 59% increase in the price of farmland in the 5 years between 2002 and 2007, and prices have continued to rise through to the first half of 2009. But one consequence of the increase in debt and reduced cash flow leading up to 2007 is a reduction in the Debt Burden Ratio and gradual increases to interest rates, from 5.6 in 2003 to 7.6 in 2007 have caused the Financial Leverage Index to fall. Though they are perhaps indicators of trouble ahead, neither DBR nor FLI is out-of-line with historic trends. The increase in interest payments, of 46.4% between 2003 and 2008, has caused the Times

Interest Earned ratio to fall to the lower end of its long-term trend, which indicates some cause for concern as commercial interest rates can be expected to remain high into the foreseeable future. And the credit crunch is a source of further concern in the form of counterparty risk, as poorly financially structured businesses struggle and banks foreclose, forcing bankruptcy and insolvency. The example of Dairy Farmers of Britain, whose bankruptcy appears to have cost dairy farmer members some £92 million is a poignant lesson as total insolvencies in England and Wales exceeded 120,000 in 2006 and 2007, years prior to the seizing up of liquidity in September 2008 and subsequent economic downturn.

Another potential risk is posed by the cumulative effect of changes to agricultural support mechanisms, particularly the increase in transparency of payments. The cumulative effect of regular, largely piecemeal and incremental reforms introduced since 1986 have been to radically change support payments and mechanisms, and this has affected the risks involved in farming. Decoupling support from commodities and coupling it to the area farmed reduces exposure of total revenues to price and yield risk. However these benefits are off-set to some extent by (i) a reduction in commodity price support which increases output price risk, (ii) the increased difficulties of predicting future prices and profitability now markets are increasingly globalised and currently attracting interest from financial investors, (iii) exchange rate risk as only the Euro level of Single Payments made to each farm are known up to 2012, and (iv) that Single Payments are subject to reduction at short notice, through modulation and possibly in the future financial discipline. Therefore, the evidence relating to the net effect of decoupling subsidies from production on risk is not clear cut.

Above all, UK agriculture is now exposed to global price movements. And the globalisation of the financial markets has exposed farming to the financial implications of the large public sector debt. Relatively strong sectors, such as agriculture, which have transparent support mechanisms, risk being easy targets for a combination of cuts to public sector payments, loss of tax benefits and higher taxes. In 2009, trends in global financial and commodity markets together with the UK's fiscal policy and macro-economic management as it seeks to repay debts and balance the annual deficit, have become the most important sources of risk to UK agriculture.

About the author

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REFEREED ARTICLE

CHANGES TO FARM BUSINESS MANAGEMENT UNDER EXTREME WEATHER EVENTS: LIKELIHOOD OF EFFECTS AND OPPORTUNITIES IN THE UK

Graham Tate, Greg Hughes, Mark Temple, David Boothby, Martin Wilkinson

Focus groups were held in the UK to consider the potential adaptation of farming systems to cope with climate change towards the year 2020. The findings were combined with MET office data and the results from a survey of 12000 holdings. It was found that agriculture is neither well prepared nor well informed about climate change. A list of potential adaptations was tested for financial viability using partial budgeting and discounted cash flow techniques. Whilst the impact of climate change typically had a cost implication, the benefits were often qualitative, for example enhancing animal welfare.

Key Words Climate change, extreme weather events, adaptation, partial budgeting, discounted cash flow, financial viability.

Introduction

Warming of the world's climate system is happening largely due to the increased emission of green house gases (GHG) (IPCC 2007). Some of the world's largest polluting countries such as the United States have not been the most active in controlling their emissions, although this is likely to change with the changing administration in the USA (Harris, 2009). The role of the land based industries worldwide in GHG mitigation is acknowledged in the academic literature. This takes a number of forms. The enormous potential offered from the slowing of deforestation, particularly in South America, against the limited potential offered by forestry planting is a familiar issue, although it has been accepted that the likelihood of a deforestation slowdown is low (Fearnside, 2000). The scope for bioenergy for heat and electricity generation would also have some mitigating effect though the plans for this are rather modest in the UK (Taylor, 2008; Defra, 2007). It should also be noted that there is evidence for some potential benefits to the land based industries of increased GHG and associated global warming such as increased growing season and a decline in frost damage to crops and machinery. In applying scenario planning techniques the short and medium term effects on world production of livestock, crop and forestry outputs are all positive, but the impact of associated ozone and ozone precursors such as methane in the long term provides severely negative effects (Reilly *et al*. 2007).

The UK Government is committed to successful adaptation to climate change and as a result has commissioned several studies to examine how this adaptation might happen. This study was prepared by ADAS over a three year time period commencing in 2005 and was the first study to focus on the nature and potential for pro-active adaptation to extreme weather events (ADAS, 2008). There have been several studies that have warned of the need for adjustment (Orson, 1999; Shepherd, 2001; Holman and Loveland, 2002) and the form that this might take (MAFF, 2000; IGER, 2002) but little involving farmers. This Defra funded project was commissioned to remedy this and to develop a consensus across the industry on costed, practical and worthwhile adaptations that would deal with the existing drivers for change.

Selection of Variables of Climatic Extremes and Industry Sectors

Although connected with climate change and global warming, climatic extremes are rather aspects of these phenomena but not the whole story and have their own terminology. Climatic extremes have been defined internationally and principally with extremes being defined as performance that lies outside of the 10^{th} or 90^{th} percentiles (IPCC, 2001). For the purposes of this research this is interpreted as firstly the extreme weather event which in a normal distribution of weather data such as maximum daily temperature is defined as an event outside of the 10^{th} or 90^{th} percentiles. An example would be the maximum daily temperature data for England which reached 38^{o} C in the summer of 2006. The second is the extreme climate event, where a number of extreme weather events happen over time. An example would be the hot summer of 1995 which was 3.4^{o} C warmer than the 1961-90 average. In other areas of the world researching the local impact of global warming, such as the Swiss Alps the interest is in temperature extremes and rainfall extremes. Work done on these harnesses the same IPCC definitions of extremes as used in this project, examining performance that again lies outside of the 10^{th} or 90^{th} percentiles (Beniston, 2007).

The issues for consideration revolved around the potential for adaptive behaviour by farmers in the event of extreme weather events reaching a critical frequency and the possibility of extreme climate events becoming more frequent.

The project was focussed on the relatively short term climate change that is forecast to take place in the next 15-20 years. The years 1995-2005 was the base period under investigation for weather extremes, thus notably the hot summer of 1995, wet autumn/winter of 2001 and the hot summer of 2003 were included as they were inside of the project reference period. These extremes were summarised in Table 1

The objectives of the project were:

1. To assess, using MET Office data and analysis, how the frequency and magnitude of the main extremes may change in the future under climate change to the 2020s and how well such changes may be predicted;
2. To determine with agricultural stakeholders the main extremes that will affect agricultural production;
3. To determine with the industry, how it will adapt to these changes within the context of existing land use change drivers and projections of future socio economic change;
4. To provide a range of costed adaptations to extremes which covers a spread of agricultural sectors, regions and broad soil types;
5. To produce a final report providing examples and a timescale for inclusion of these adaptations into farm business and industry development plans.

Table 1-Summary of the chosen extreme and its definition:

Threshold/extreme	Definition
Heat wave duration/timing	It is defined as the total length of periods of at least 6 days, during either the summer half-year or winter half -year, when the maximum temperature exceeds the 1961-1990 average for that day by at least 3°C and Julian day of start of heat wave.
Frequency of occurrence of maximum temperature exceeding 32°C for >10 days	Number of occurrences of maximum temperature exceeding 32°C for more than 10 days.
Growing season start and end dates	Date of start and end of growing season where the growing season is assumed to start on the 5th consecutive day with a mean temperature of 5°C or greater and end on the 5th consecutive day with a mean temperature of 5°C or less.
Frequency of frost days per month	Number of days with minimum temperature < 0°C.
Duration and timing of dry and wet periods	Greatest number of consecutive days where rainfall < 1mm or rainfall >1 mm and the start date of period.
Simple Daily Intensity Index	Quotient of amount of days where rainfall > 1mm and number of days where rainfall > 1mm.

This article is arranged in a further four main sections. The first of these describes the methodology adopted by the project team to meet the above objectives, the second gives the results arrived at and the third section discusses the findings of the project along with published academic literature. The final section provides some conclusions and implications of the findings of the project.

METHOD

Met Office Analysis

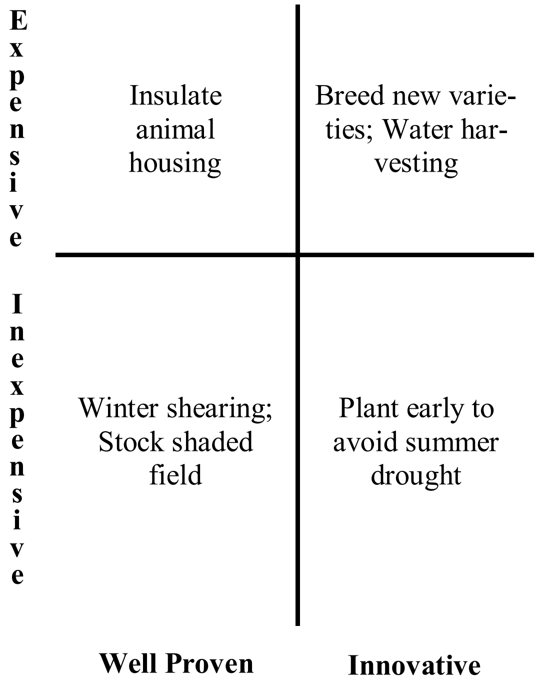
Climatic extremes were projected forwards for the 2020s relative to the 1970s using the Met Office's Hadley Centre Regional Climate Model, HadRM3. This was done by making projections for the 2080s and then by scaling these projections using methods described in Hulme *et al*., (2002).

Several hundred potential adaptations to the MET office forecast climate extremes were identified from sources including expert assessment and from various literature sources. Figure 1 shows the classification of these potential improvements in terms of level of expense and degree of innovation employed.

Farmer Focus Groups

Six focus groups with between six and eight farmers per group were held at regional centres throughout the UK between 26 January and 13 February 2006. The purpose of the focus groups was to consider the types of extreme

Figure 1- Illustration of the range of complexity and expense of adaptations options considered



weather experienced in the period under investigation and the impacts of that weather upon farming practices. The membership of the focus groups was drawn from a range of farm types and enterprises that reflected the regional location of the group.

A summary of 124 adaptations that appeared suitable for a detailed financial evaluation was compiled. These were then put to a second round of six focus group meetings held in March and April 2007 at the same six centres as the previous focus groups. Not all 124 adaptations were considered by all focus group meetings, nevertheless the farmers involved were prepared to consider most of the adaptations should the need arise, which was thought to be between 2 and 5 years of largely consistent weather, operating in an autonomous way.

ADAS Farmers' Voice ™ Survey

A randomly drawn sample of 12,000 holdings is drawn annually from the ADAS Farmers' Voice ™ database of approximately 47,000 holdings and a questionnaire posted out that for the years 2005, 2006 and 2007 included questions addressing issues of climate change. In 2007 2,000 survey forms were returned and as in previous years these were weighted for Government Office Region and farm size and type for each region surveyed, providing a stratified, randomised sample representative of the population of UK farmers.

Costing of Adaptations

A panel of ADAS specialists with many years of business advisory experience was convened to reduce the list of potential adaptations to 28, this being a number that could be assessed quantitatively within the resources allocated to the project. This reduction was carried out by a team that applied a number of criteria to the selection process on the basis of such factors as the importance of farming sectors and being representative of a range of climate extremes.

Information was assembled to enable detailed enterprise costing. This included detailed descriptions of current enterprises, impacts of the respective extreme events on enterprise performance, estimates of capital costs for adaptations and the impact that adoption of the adaptation would have on enterprise performance.

Figure 2-Structure of the partial budgets

Extra costs as a result of the adaptation, as compared to no action	A	Costs saved as a result of the adaptation, as compared to no action	C
Income lost as a result of the adaptation, as compared to no action	B	Extra income as a result of the adaptation, as compared to no action	D
Sub-total	A + B = X	Sub-total	C+D = Y
Impact on Profit	Y – X		

This was then formatted using a partial budgeting layout to show whether the adaptation was profitable or otherwise. This is shown in Figure 2. If Y is less than X then change is profitable, whereas if X is less than Y then the adaptation is unprofitable.

The technique of discounted cash flow was employed to assess the future value of anticipated cash flows resulting from the adaptations. The rate set is said to 'discount' or reduce future cash flows to allow for the cost of capital, or in the case of the Net Present Value (NPV) method the 'discount rate' which in this project has been set at 10%. At the time the work was done in 2006 – 2008, typical borrowing costs for farmers were about 7%. However investments to reduce the impact of extreme events have the associated risk that the event may not occur for several years. It was felt that a discount rate of 10% represented what might be considered a reasonable minimum rate of return given the riskiness of the investment.

Adaptations requiring capital investment were evaluated by the calculation of Internal Rate of Return (IRR), Net Present Value (NPV) and payback period techniques. NPV is a well established technique (Turner and Taylor, 1998; Warren, 1998) that calculates the future value of an investment discounted to the present. The technique has also found favour when applied to measuring the financial effects of climate change (Anda *et al.,* 2009). IRR calculates the rate of return at which NPV is zero, in other words the actual rate of return of the investment. Because the adaptations had different time profiles and quantities of capital invested, using NPV creates problems in comparability.[1]

An assessment had to be made of the frequency with which future extreme weather events would happen as the potentially positive returns to adaptations would only occur in those years, whereas with adaptations requiring capital the costs of that capital investment would also be borne in years when the extreme event did not occur.

Some of the research evidence on adoption and diffusion of innovation leads to the diagnosis of three types of farmers with at least one type, the resigned pragmatists, unlikely to seize upon adaptations to climate change with any degree of zeal (Angell, 1997). For the purposes of this research the process leading to changes in farming systems was assessed on the basis of rational economics - that is simply the impact on profit point as the trigger for adaptation. There are potential limitations to this approach when the wider evidence of farmers' multiple objectives, such as a need for independence particularly amongst the proprietors of smaller farming businesses, are taken account of (Gasson, 1973). However the project team felt that taking a simple profit maximising approach was appropriate in the first instance, although actual farmer behaviour is clearly more complicated.

Selection of Adaptations to be included in the Detailed Costing Exercise

Seven adaptations were selected for more detailed costing. Quotas were set for the number of adaptations involving a single enterprise. Adaptations were selected on the basis of IRR. A few adaptations were rejected for more costing if they were obviously highly profitable since little more would have been learnt. A range of enterprises were represented in the selection of adaptations chosen for detailed costing on the grounds of having chosen enterprises that presented a balanced mix across agriculture in the UK. In this way no significant major enterprise was left out of the assessment. Detailed assessments were undertaken on a basis that allowed for differing regional results to show through the costing methodology, on the grounds of criteria such as climate and soil type.

Return on capital employed was the chosen measure of overall financial viability of the chosen adaptation and this was calculated on one of two bases, depending upon whether or not long term capital investments were made:

If the adaptation involved long term fixed capital investment then IRR was assessed from the Discounted Cash Flow analysis.

If there was no long term fixed capital investment but some extra working capital investment, such as additional spray treatment, then the return to this capital was assessed by a specialist.

In this way 28 adaptations were assessed using this methodology and then sampled again to provide a broad range of possible adaptations that reflected the major enterprises. A short list of nine adaptations was then selected for detailed economic assessment.

1. It has since been suggested to the authors by Philip Lund that a superior approach would be to use the test discount rate to calculate NPVs, divide the NPVs by the capital invested to get £ of NPV per £1,000 invested and rank the adaptations on this basis.

The detailed assessment took into account regional projections on the frequency of occurrence of extreme weather events which was variable for conditions such as the incidence of calf pneumonia. This was achieved by selecting representative regional cells of the Met Office Hadley Centre Regional Climate Model (HadRM 3). The variables required for each adaptation and the thresholds required to trigger an impact, and subsequently an adaptation, were defined from literature and expert opinion. Seven cases were further shortlisted and then subjected to a detailed analysis of background data, climate data and economic impact of the adaptation. Table 2 summarises the variables and thresholds used with the chosen adaptations.

RESULTS

Met Office Analysis

The analysis undertaken by the Met Office compared the occurrence of extreme events in the historic period 1961 – 90 with predictions from their regional climate change model (HadRM3) for the period 2011 – 2030. The extremes examined were for heatwave duration and timing, heatwave frequency, growing season start and end dates, frequency of frost days, duration of dry and wet periods and precipitation intensity.

The principle findings from this aspect of the project were that frost day frequency is predicted to reduce significantly in all areas and that growing season will lengthen, notably in the north of England and Scotland, supporting the findings of the above introduction (Reilly *et al*., 2007). Other findings were that heat wave duration, that is an increased occurrence of six consecutive days when the maximum daily temperature exceeds 32^{o} C within a 10 day period, will increase in the south of England.

Farmer Focus Groups

There were two rounds of farmer focus groups recruited for particular enterprises and held in Wisbech (arable & fruit), Hereford (mixed farming), Coleraine, (mixed livestock and dairy), Aberdeen (cattle and sheep), Barnstaple (mixed grazing livestock) and Malton (poultry & pigs).

The general extreme trends identified by the six focus groups were hot summers, drought, mild wet winters, extreme rainfall, early and late frosts and hail and strong winds. The groups reported their experience of a wide range of weather impacts. For example, the costs of crop drying and loss of outputs such as reduced milk production in hot weather. For the effects of frost and hail the groups' experiences were of yield reductions in arable and horticultural operations, repeat drilling owing to crop failure, a reduced effectiveness of fungicides and an increase in expenditure disposing of slurry/ manure with a reduction in trafficable days in winter.

Changing weather patterns were well recognised by all farmers but did not yet appear to be at a frequency required for farmers to make significant change. To bring about such change extreme weather resulting in yield loss would be necessary in two consecutive years. This potential adaptive response was grounded within the framework of the financial climate facing farmers at

Table 2 – Seven adaptations costed in detail - Summary of the variables and thresholds used to derive the frequency analysis.

Sector	Extreme	Adaptation	Description including Variables and Thresholds
Poultry	Frequency/timing of heat waves; Frequency of extreme heat	Housing redesign - improved permanent ventilation	The poultry crop is affected by heat most during days 30-42 of the crop cycle when the birds are nearly fully grown and space within the poultry house is at a premium. These periods are typically during the summer. More than one crop can be impacted by a heat wave or extreme heat period with losses occurring not only to due to more intense heat but potentially because there are more of them in a year. The analysis defined critical hot days by findings spells of 2 days or more where the Tmax > 30 °C. It was assumed that given the number of operations in any region that at any one time there would be an operation with a flock at the required growth stage. An optimized routine searched all subsequent day 30-42 periods allowing a 7 day window between crops to define the maximum number of crops in a year that may be impacted by heat.
Beef & Sheep	Frequency/timing of heat waves; Frequency/ duration of dry spells	Storage reservoirs/ Water capture	The lack of natural water in streams requiring the provision of water for stock is difficult to model simplistically and using more sophisticated models was beyond the scope of the project. The analysis defined dry days as days on which the available soil moisture was below 10 mm and precipitation was below 1 mm. The number of dry days between July and October were totalled and years where more than 30 such days occurred defined as years in which natural water would be difficult to access.
Arable - Root crops	Frequency/timing of heat waves; Frequency/ duration of dry spells	Irrigation- potatoes	Running a sophisticated water budgeting/irrigation scheduling model like Irriguide for each region was beyond the scope of the project. However, using experience gained from developing/using this model and drawing on 20 years of potato irrigation trial data from the ADAS Gleadthorpe Farm the following parameters were defined. Years in which irrigation would not be sufficient were years in which the soil moisture at the start of the growing season (mm) + precipitation (mm) + 150 mm of irrigation water < 375 mm.
Horticulture - Soft fruit	Frequency/timing of heat waves; Frequency of extreme heat	Investment in cooling and transport temperature control	Soft fruit spoilage is a function of fruit temperature which is affected by maximum temperatures during the daytime and ambient air temperature at night. Days on which this spoilage would take place were defined as days where TMax > 30°C and TMin > 15°C. Years with one or more of these days were determined as well as the average number of spoilage days per year.

Sector	Extreme	Adaptation	Description including Variables and Thresholds
Arable - Cereals	Growing season length; Frequency/timing of frost	Spread risk - grow range of varieties with different flowering dates	Frost days were defined as days where TMin < 0°C during the flowering period, namely, May/June. The number of years in which this would potentially be a problem was determined.
Beef & Dairy	Frequency/timing of heat waves; Frequency/timing of frost	Housing redesign - improved permanent ventilation	The incidence of Enzootic Calf Pneumonia (ECP) in cattle is difficult to model as there are three suites of causative factors with many of these poorly understood, namely etiological agents which include a range of viruses, calf factors which include nutrition and age and environmental factors. This model focuses on the environmental factors as these are the factors addressed within the adaptation. Potential ECP periods were defined as days where TAve > 10°C, RH > 90% and wind speed is < 6.5 km/hr for 3 or more days during the period October to February. Years with one or more of these periods were defined as years in which pneumonia was likely.
Sheep	Frequency/timing of heat waves; Frequency/ duration of wet spells	Increased dipping	The flystrike season length was determined as the first and last five day period where TAve > 8.5°C. Within these seasons the flystrike days were defined for 3 different periods, namely pre-shearing, post-shearing when fleece in adults and lambs is growing and late season when it is fully grown. The fleece length affects the fleece humidity as well as the amount of rainfall required to get the fleece wet. Using the model described by Wall *et al*. (2002) the following parameters were defined: Pre-shearing (until 18 June): TAve > 8.5°C and Precip or Precip + fleece moisture (mm) > 5 mm Post-shearing 1 (19 June till 30 September): TAve > 8.5°C and Precip or Precip + fleece moisture (mm) > 15 mm Post-shearing 2 (30 September till end of season): TAve > 8.5°C and Precip or Precip + fleece moisture (mm) > 5 mm

the time of the focus groups early in 2006. It was felt that such changes would only be seen to be worthwhile if the financial outcomes could be seen to be satisfactory at the time the assessment was made.

Inevitably there was spatial variability in some of the responses to the focus group questions, for example the Northern Irish and Scottish focus group participants did not feel that extreme heat would ever be a problem for them. Many low cost adaptations were already being used by some, such as putting stock in fields with good shade, whilst potentially this might cause another issue in this case as shade for sheep can give rise to fly problems and additional disease. There was agreement that the provision of accurate long range weather forecasts would assist farmers in making the necessary decisions at farm level.

ADAS Farmers' Voice Survey

To draw on a wider body of farmer experience than the members of the farmer focus groups, questions about climate change were included in this large postal self completion survey which has been carried out regularly by ADAS in England and Wales since 1999. Questions were included in the 2005, 2006 and 2007 surveys (1,200, 2,100 and 2,000 respondents respectively). The 2005 survey highlighted that the vast majority of the sample respondents had either not responded to extreme weather (43% in England and 33% in Wales) or had not experienced it (38% in England and 50% in Wales). Some 16% of farmers had made an adaptation to extreme weather. Larger farms showed a slightly greater tendency to adapt than smaller ones and those in the North West region gave the highest positive response at 25%. The proportion of respondents to the 2006 survey intending to react constructively to climate change within five years increased to 46% in England.

Respondents were asked to indicate likely changes to be made and these are shown in Table 3 below.

The average number of changes to be undertaken per holding was 1.9 in England and 1.8 in Wales. Increasing off-farm income or getting out of farming altogether were popular adaptations in both England (41%, and 16% respectively) and Wales (30%, and 12% respectively). However, such behaviour is unlikely to be driven by solely extreme weather patterns. Large farms in England showed a greater tendency towards investment-based responses such as irrigation and livestock housing.

On the matter of the impact of climate change on business performance the 2005 survey found that 71% of respondents took the view that there would be a neutral impact on business performance, or they were unsure what the impact would be. Only 6% of respondents in England and 4% of respondents in Wales felt they were well informed on the issue of climate change. Types of extreme weather that did cause concern were drier summers, wetter winters, intense rainfall and extremely high temperatures, although these results varied with farming sector and region. The horticultural sector was particularly concerned about intense rainfall, unseasonal frost and vagaries in the start and finish of the growing season.

Some linkage between higher levels of concern and adaptive behaviour is

Table 3- Adaptations intended as a result of climate change by region in 2006

Adaptation	North East	North West	Yorks & Hum-ber	East Mids	West Mids	East-ern	Sout h East	South West	Wale s
Replace existing crops/livestock with new varieties	30%	11%	29%	23%	10%	36%	27%	24%	7%
Introduce new types of crops/livestock alongside those cur-rently grown/kept	24%	13%	31%	23%	34%	32%	27%	27%	12%
Increase off farm income sources	46%	31%	44%	51%	40%	50%	36%	40%	30%
Invest in irrigation	4%	8%	2%	3%	5%	12%	17%	1%	3%
Invest in livestock housing	9%	24%	9%	9%	15%	5%	13%	18%	29%
House livestock ear-lier/later in the year	27%	37%	12%	15%	25%	6%	20%	32%	39%
Change timing of sowing/spraying/ fertiliser application	37%	36%	45%	37%	31%	51%	37%	37%	3%
Cut down on stock	0%	18%	0%	11%	0%	5%	3%	0%	12%
Continuous review/ will respond as Required	14%	18%	20%	38%	7%	0%	22%	17%	9%
Energy (bio-crops/ hydro/wind power etc)	0%	4%	36%	11%	8%	30%	0%	14%	0%
Will retire/sell up/ emigrate	18%	18%	17%	0%	23%	30%	10%	15%	12%
Will stop main stream farming/ diversify (unspec)	0%	25%	0%	0%	3%	0%	0%	0%	0%
Reduce energy use	0%	6%	12%	16%	0%	0%	5%	0%	0%
Plant woodland	0%	10%	0%	0%	31%	0%	0%	5%	0%
Change heating (new heaters/lower tem-peratures)	0%	0%	0%	0%	0%	0%	0%	18%	0%
Convert to organic	0%	0%	0%	0%	0%	0%	0%	3%	0%
Let out/lease land	0%	0%	0%	0%	0%	0%	0%	0%	24%
Livestock will stay outside	14%	0%	0%	0%	0%	0%	0%	9%	0%

evident with such behaviour running at between 9 and 14% for the areas of climate change showing greatest concern. Indeed 71% did not indicate that they were adapting to any of the conditions shown. Whilst there appeared to be concern amongst farmers it was a matter for the future rather than the present, although this might be interpreted as a result of not being well informed on the matter. The level of adaptive behaviour was certainly linked to the farming sector represented, for example the pig and poultry sector consistently showed a very low level of interest in adaptive behaviour. The anomaly was that indoor poultry producers contributing to the focus group sessions and pig producers known in the industry had demonstrated some enthusiasm for adaptations in response to climate change. In the livestock sector the adaptations to climate extremes involved a combination of some system change and investment in some additional inputs and production facilities. The welfare of livestock being transported can be adversely affected in very hot weather and attention to the ventilation system coupled with reducing stocking density in transit is the positive adaptation. The environmental consequences of adaptations to heat extremes are generally neutral; however there is a significant positive impact on animal welfare.

Costing of Adaptations

The 28 costed adaptations for each extreme included the forecast of the impact on profit and an investment appraisal and a summary table was produced with a description of the event, enterprise impact and description of the adaptation.

Table 4- Summary of Water Storage - capture

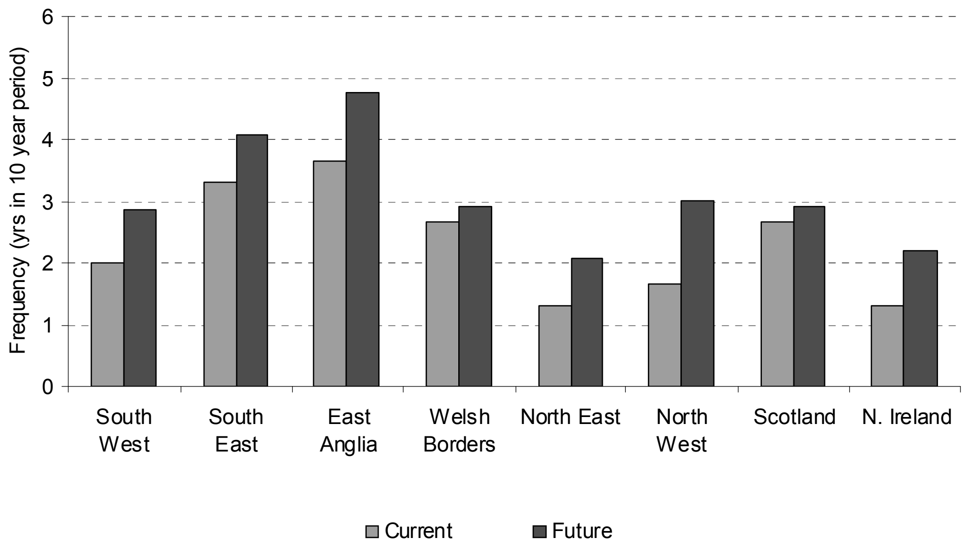
Extreme event	Frequency/timing of heat waves; Frequency/duration of dry spells	Frequency/timing of heat waves; Frequency/duration of dry spells
Adaptation	Irrigation in Top Fruit	Irrigation in Top Fruit
Impact of Extreme	Drought would affect yields and quality of fruit. It would also lead to poor tree growth and affect future years production.	Drought would affect yields and quality of fruit. It would also lead to poor tree growth and affect future years production.
Description of adaptation	Install irrigation system and progressively replace with more drought tolerant varieties.	Install irrigation system and progressively replace with more drought tolerant varieties.
Extreme frequency	2 in 10 years.	
Capital invested	£18,200	
Effect on profit	+£3,159	
NPV	£28,391	
IRR	33%	
Break even frequency	1.1 events in 10 years	1.1 events in 10 years

An example of this is shown below for the irrigation of top fruit. Top fruit yields would be reduced with the occurrence of 14 days without rain combined with temperatures of greater than 32°C. The scenario allows for a 14 hectare apple orchard and the installation of a sprinkler system to apply 25 mm of water per week during spells of high temperature. Table 4 summarises the data and financial outcomes of the adaptation.

One of the seven adaptations costed in depth was improving ventilation by installing electric fans in calf rearing buildings to reduce calf deaths from pneumonia. The cost of pneumonia to cattle farmers is estimated to be about £80 million per year for the UK and includes the cost of treatment, reduced growth, additional work and most significantly, calf deaths. The micro-organisms that cause the disease are found in nearly all cattle herds but pneumonia is only a problem on some farms as a result of the environment and management. There are many factors predisposing calves to pneumonia but a very important one is ventilation. Cold, humid conditions, sudden changes in air temperature and stress due to changes in the environment are associated with pneumonia outbreaks in young calves. This scenario assumes that vaccination is part of current farm practice.

Humid calm heat waves in winter are periods when calf pneumonia may be triggered. These currently occur 2.33 times in a ten year period but by 2020 are predicted to occur 3.1 times in a ten year period.

Figure 3: Frequency of humid, calm winters heat waves, by region (for cattle pneumonia)



The economic impact of spending £4,000 to invest in electric fans in an existing calf rearing building is shown below. Improving the ventilation is assumed to reduce mortality from 8% to 4%.

Table 5. Summary of economic impact of investing £4 000 in electric fans to improve the ventilation in a calf rearing building.

	Effect on Profit £			IRR%		NPV£	
	Current	Future	Change	Current	Future	Current	Current
	£	£	£	%	%	£	£
N. Ireland	-156	989	1145		27	222	5319
Scotland	344	433	89	18	19	2447	2845
North East	-156	120	276		15	222	1451
East Anglia	717	1130	414	23	29	4170	5950
Welsh Borders	344	433	89	18	19	2447	2845
South East	590	866	276	22	25	3543	4771
South West	94	414	321	14	19	1335	2762
North West	-29	474	503		20	787	3028

In three parts of the UK (N. Ireland, the North East and North West) it is not currently worth making the investment but by 2020, due to the increased frequency of these weather events the investment becomes worthwhile.

DISCUSSION

The ability to separate out the effects/impacts of general climate change and climate variability from the impacts of climate extremes has been a distinct difficulty in the more qualitative parts of this project. The impacts from general climate change trends are often amplified within the extremes. Similarly, it has been necessary to disentangle the synergistic and knock on effects of the various extremes with many of them happening at the same time. As an example, increased dry spell duration is usually associated with elevated temperatures and heat waves leading to water resource issues. It has also been necessary to consider the antagonistic effects of the extremes where the benefit of one is negated by another as exemplified by the extended growing season. This may bring opportunities to crop earlier to avoid the mid-summer drought or even the potential for additional cropping. However, earlier cropping can make certain crops particularly vulnerable to late frosts, be offset by an increase in the length of the mid-summer drought or be negated by shorter, wetter autumns. The timing of this synergism/antagonism is often key to whether these combinations are considered detrimental or beneficial and are often sector specific. An example is the synergism of dry and warm conditions -in spring when soil moisture is not a limiting factor to grass growth these conditions are favourable for the sheep sector, however, in the late summer these conditions produce difficult harvesting conditions for the root crop portion of the arable sector.

There is renewed determination internationally to deal with the effects of GHG and global warming (Harris, 2009). This places the subject of the response of the farming industry to these matters further up the farm business agenda. This study has gauged the opinion of a representative sample of farmers drawn from the agricultural industry on how well informed it feels with respect to climate extremes, its experiences of climate extremes, what if anything it has already done to adapt and what if anything it would consider doing to adapt. Most farmers in England and Wales do not feel well informed and farmers that consider themselves to be better informed are more likely to have responded already or to intend to respond over the next 5 years. This highlights as a minimum information dissemination as a key priority. Most farmers have experienced extremes and in some instances have chosen to adapt, while many accept that loss as a result of climate variability is an inherent part of farming. The projections indicate increased frequency and intensity of extremes in the future, even by 2020. Despite this, most farmers state that they are unlikely to adapt in advance of experiencing the changes for themselves with the major drivers for adaptation being current economics and regulation. There is a perception of a need for government action by some researchers in calling for 'a clear strategy of land management' (Taylor, 2008). If enacted this would clearly have an impact on farm business management.

Of all the climate extremes that are predicted, the effects of temperatures and/or low rainfall are considered by all as the aspect of change of greatest concern to the industry. All but one of the climate extremes has a negative effect on the farming system. The potential exception is an opportunity to increase production by including additional crops. However, in the context of climate extremes, additional cropping does not feature well. The climate extreme is, as suggested by the title, an untypical or unexpected event. This differs from climate change which should over time offer greater reliability and potential for adaptive behaviour (Reilly *et al*. 2007).

Perhaps the closest to this is the potential for additional cropping as a result of an extended growing season. Currently this is a technically feasible option for some producers, but not a reliably economic option. The forecasts suggest that the potential will increase with increased frequency of a longer growing season. If greater reliability of production could be achieved, and the supply chain, especially the retailers, could accept UK produce instead of importing potentially lower cost produce, there may be scope to develop this further. Recent developments in the international money markets could affect this balance with the considerable decline in the value of Sterling against many countries that supply our food imports providing an opportunity for production here. The difficulty is that the scenario currently has too many 'ifs and buts' coupled with the retail chains aversion to risk in the context of reliability of supply.

When considering alternative adaptations it is considered vital that the adaptation in no way compromises the relationship between producers and the market place. The quality of the product has to be maintained. In this context quality comprises the whole range of requirements of the process and retail supply chain, from the eating quality to the volume, seasonality and availability of the produce. Within the context of adaptation to climate extremes, the project has not identified potential adaptations that would add value to the produce, or target a niche market. If such adaptations could be identified for other commodities and markets then the financial returns available may encourage producers to consider system changes.

Climate extremes place a greater burden on the livestock sector than arable and horticultural sectors due to the combination of financial and animal welfare effects. Plants do not have any welfare rights and thus financial considerations can dominate decision making. With livestock the white meat sector has greatest exposure to welfare pressures over finance due to the combination of numbers of livestock in a typical enterprise and the modest margin per unit of livestock constraining the opportunity to profit from investment in adaptation. The financial returns from an adaptation may not be sufficient to justify the investment and the response is to accept the loss whenever the climatic extreme occurs.

Welfare requirements place a greater onus on farmers to adapt their production systems. The speed of onset of events also requires livestock producers to seriously consider anticipating adaptation such as investment to militate against extreme heat events. The industry suggestion is, however, that even in situations in which an extreme would compromise the welfare of livestock, producers may well have to experience the impact of an extreme before making an adaptation. Producers generally appear to feel poorly informed about climate change impacts such as extreme events. This finding might change if there was better communication with farmers about climate change. However, given the strategic nature of decisions to be made, the response of the individual farmer will depend, as ever, upon the wider personal and business objectives and not solely on the immediate impact on businesses that the extreme event could cause.

The study has budgeted adaptations to production systems well beyond the normal planning window for most farm businesses as many farms plan one or two years ahead, although some arable units may plan a little further ahead than this. Changes will be brought about by the prospect of changes in the business environment and how this impacts on other existing or potential enterprises. This study has shown that adaptation to climate extremes is currently a low priority amongst farmers who are reacting to shorter timescale pressures that dominate their decision making framework. The last two years have seen wide gyrations in both fuel and fertiliser prices, both of which on most farms are important financial and physical inputs.

The adaptations identified for the climate extremes affecting the arable sector can largely be achieved through changes in working practices, combined with some modest expenditure on pesticides for the control of weeds and slugs, meaning that for most arable enterprises there is no requirement for large capital investment or the need to significantly change the mix of enterprises. The arable sector adaptations to climate extremes do have some positive and negative consequences for the environment. Crops requiring irrigation will have the need met from the positive effect of winter abstraction and storage rather than the negative effect of abstraction during the growing season. However, negative environmental effects can arise from the creation of the storage reservoir and the increased use of fuel to pump water.

Although in the main the adaptations to horticultural enterprises involve greater levels of innovation than in arable or livestock sectors, the generally higher value per unit of outputs has provided greater scope for the adoption of novel and innovative approaches. In the cropping domain it was two arable adaptations that involved potatoes which were again higher value outputs. The three livestock adaptations given detailed analysis dealt with ventilation for poultry in conditions of heat stress, insulation of pig arcs against excessive heat and water harvesting. In these latter cases the driver was as much improved animal welfare as much as the value of the product and the financial return achieved. Welfare requirements place a greater onus on livestock farmers to adapt their production systems and the speed with which these events can occur suggests that early consideration of adaptations would be desirable. Unfortunately this may prove difficult given the low level of readiness to adapt before extreme events are experienced.

Stocking density is also an issue for the management of housed pigs and poultry during heat extremes and action to reduce densities needs to be taken well ahead of such extremes. It would be very inefficient if farmers kept space available and vacant in the event of a weather extreme event. More 'welfare friendly' production systems operated with a retail incentive have reduced stocking density on some farms, but it is too early to say how large a proportion of production might develop in this way, however this adjustment will certainly help to reduce the susceptibility to weather extremes on those farms that have exploited this opportunity.

A further issue for livestock producers is the storage and handling of manure and dirty water on livestock farms. The requirements for Nitrate Vulnerable Zones (NVZs) have resulted in the need for increased storage facilities. Although effluent tanks are sufficient to meet the needs of current regulatory requirements they would be unlikely to provide adequate storage facilities in an intense rainfall extreme.

There is also the wider issue to be considered of the long term efficient and competitive production of food and food security in the UK after the 2020s. The time scale of this project is far too short to consider matters such as the location and potential relocation of food production to avoid an extreme. For example, relocating poultry production to regions that might avoid high temperature extremes could have an effect on the location of the processing capacity and transportation of the poultry themselves.

CONCLUSIONS

The objectives of the study were to identify and budget for the effects of climate change and extreme weather events on agriculture in the UK through to 2020. The outcomes were that agriculture is neither well prepared nor well informed about anticipated changes in extreme weather events at a time when the subject has moved near to the top of the world agenda. Where farmers have adapted or are planning to do so they have done so autonomously and in response to their experience of extreme seasons rather than with the view to adapting their businesses in order to compete in a changed natural environment or purely motivated by profit. The economic costing exercises undertaken in this study were of potential farm level adaptations rather than those that might be undertaken at industry level for such inputs as the development of new plant varieties.

Extreme events, their impacts and adaptation to them have been particularly difficult to forecast. However, what is clear is that extreme heat, increasing dry spell duration and their combined impact on water resources seemed to be of particular concern to the agricultural industry. This is manifested for the livestock sector as potentially extra costs to maintain acceptable conditions of animal welfare whilst with other sectors, notably those with higher value crops such horticulture and potatoes, there might be some possibility for higher returns. The level of awareness of climate extremes was found to be low and variable, as were the levels of existing adaptation. This suggests that readily available and easily digestible information sources, possibly to include a database of options of what has been tried and tested, would be a particularly useful resource.

The environmental consequence of adaptation was generally the input of additional resources of various kinds. Increased variable inputs including such items as pesticides, fertiliser and water whilst other resources might be labour, power or machinery and capital might be consumed in improved facilities and equipment. Whilst the increased consumption of some of these resources does not dictate a negative environmental impact there is more scope for this arising.

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SEMINAR REPORT

FIFTY YEARS OF AGRIBUSINESS TEACHING AT HARVARD BUSINESS SCHOOL[1]

Carl Atkin

January 2010 was a historic moment for the Harvard Business School (HBS), in Boston, Massachusetts. The "Agribusiness Seminar", one of HBS's longest standing leadership and management development programmes, celebrated its fiftieth anniversary. Although the term "agribusiness" has only come into common parlance in Europe over the last ten or fifteen years, the concept of looking at agriculture and food in a whole value chain way was first pioneered by HBS in the 1950s by Ray A Goldberg and John H Davis and discussed in their book *A Concept of Agribusiness* (published 1957). That seminal work traced the complex value-added chain "beginning with the farmer's purchase of seed and livestock and ending with a product fit for the consumer's table". Little more than a decade later, Goldberg followed up with Agribusiness Coordination, another influential volume that applied this method of analysis to the wheat, soybean, and Florida orange industries.

Since initiating the Agribusiness Seminar in the late 1950s, every year around 200 executives from the food industry, agribusiness and farming from all continents meet in Boston to discuss a dozen cases of companies covering all sectors and all levels of the supply chain. Each case is written along the year by a team of Harvard professors and researchers, now led by Professor David Bell (the George M Moffett Professor of Agriculture and Business since 1997) and Mary Shelman (Director of the Agribusiness Programme). Goldberg, the founder of the programme and the first Professor of Agriculture at Harvard Business School (now Professor Emeritus) is still leading sessions and actively contributing to the course, aged some 84 years old. He also teaches food policy and agribusiness at the Kennedy School of Government at Harvard, and remains a very active researcher and thought leader in the agribusiness field.

A traditional Harvard Business School case (a teaching model since copied at many other leading business schools around the world) has around 20 pages; ten pages of text and other ten of annexes (financial and market data). The case reports the historical facts of each company, the current situation, and the major challenges and decisions in the future, in terms of strategic development. In a case discussion event, like the Harvard Seminar, each participant has access to the HBS web, downloads the cases, materials and instructions, and has to read the case in advance. At the Seminar, each case is then previously discussed with a smaller group of 8 participants, to create a more interactive opinion building process. Then the case is finally discussed in a plenary session, and at the end, the CEO of company comes and answers questions interacting with the audience. It is a four-day event full of searching

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questions on both industry issues and specific business strategies and responses.

The cases cover all levels of the value chain and a range of geographies. The cases this year included:

- **GTC Biotherapeutics**: Developing Medicines in the Milk of Goats – an interesting case looking at the changing relationship between traditional agriculture and other industries;
- **Pure Circle** – A large producer of Stevia sweeteners based in Malaysia with an interesting dilemma – how should it compete with sugar and other sweeteners in a complex market?
- **Cosan** – one of the largest producers of sugar and ethanol in Brazil facing a number of challenges as world sugar prices peaked yet the US shows no sign of reducing its tariffs on imported ethanol;
- **Diamond Foods** – a large producer of snack foods in the USA which evolved from a simple farmers co-operative;
- **DaChan** – a large poultry business in China with incredibly sophisticated traceability systems;
- **Ebro Puleva** – the world's largest rice company based in Spain with a strategic dilemma – whether to abandon its historical roots in the dairy sector;
- **Rabobank** – the global food and agribusiness bank based in the Netherlands, with a unique co-operative structure (both a strength and a weakness) and an ambition to become the global specialist in this field;
- **Woolf Farming and Processing** – a large horticultural production and processing business in California facing major challenges of restrictions on water rights and irrigation;
- **Red Tomato** – a local food business in Massachusetts;
- **Hungerit** – a large integrated poultry producer in Hungary;
- **Codevasf** – a public company in Brazil that is promoting 8000 ha of irrigated land to the private sector in a very interesting bid considering sustainable integration;
- **Monsanto** – one of the world's largest biotechnology companies.

Strong common themes were running through most of the cases, which is directly relevant to the long term issues facing UK Agribusiness plc:

1. The agribusiness industry is *increasingly global*. When the course started, 90% of the delegates were from the US. Today the figure is circa 50%. In fifty years time Ray Goldberg predicted it would be less than 5%. Global food systems are increasingly complex and interdependent.

   Local food will remain an important niche, but local is not necessarily more sustainable (and our understanding of what sustainable is will change over time). The local food business and sustainability indicators are clearly less well developed in North America than in Western Europe

2. Agribusiness is *'back in vogue'* as a sector – there was a strong consensus that the outlook for the industry was more positive than at any point over the past decade.

3. The industry environment is *more dynamic* than ever, and this requires the businesses to be much quicker in adapting their strategies. "The companies in the sector that have been successful have changed themselves before someone else changes them" (Ray Goldberg). Often businesses don't have time to think about change, because they are too busy embroiled in the detail of their operations – "in order to have time to think about and manage change you need not to be engrossed in micro management" (David Bell).

   There was a discussion about risk and its management. Professor Bell commented that in the future the world might become *more risky* versus less risky. The reasons for this include information transparency and correlated demand, which causes people across the world to act in concert. An example: with the rapid spread of the low-carbohydrate Atkins diet, the world stopped eating bread. The agribusiness sector needs to understand and manage risk better.

4, Agribusiness is, to some extent, a *quasi-utility* with significant political as well as economic implications. Accordingly, governments affect companies' bottom lines. However, government has finally woken up to the fact it *cannot plan agricultural supply and demand long term by policy* alone – it must work more closely with the market and try to regulate and interfere less.

5. Agribusiness will increasingly *not just be about the production of food*, or indeed the production of energy, but will be about industrial products, chemicals, medicines – there will be a fusion of all of these sectors. To quote Ray Goldberg: "As distinctions between food and medicine fade,

we will see a proliferation of crop-based drugs or 'agriceuticals.' Nor is the blurring of agriculture and pharmaceuticals limited to seeds and plants. Animals are being turned into drug-manufacturing facilities as well."

One particular step in the agribusiness evolutionary process is a transformation that occurred in the past decade. Some industry players have gone from being low-margin commodity producers to higher-margin providers of such "solutions."

"We're much more than a commodity industry; we're a nutrition industry, we're a health industry, we're an energy industry, we're an economic development industry. . . . Our ultimate customer is society as well." - Ray Goldberg

6. Creating shared value in the *supply chain* is critical – how can you work together to make the pie bigger for everyone rather than trying to work against each other. Creating 'win-win' not 'win-lose' is essential to have world class food supply chains of the future.

   Unless you make your customers' customers' customers satisfied, you really aren't going to win very much in this game." - Ray Goldberg

7. *Water* will be a major opportunity and constraint for the industry over the decades ahead. The global governance of water will become the major issue over the coming decades.

8. Public trust in *science and technology* is a key issue to solving the long term food supply challenges. Monsanto have succeeded in shedding a lot of their 'negative press' by transforming themselves into a seed solutions company.

9. There is significant *untapped production potential* in the former transition economies of the Eastern Block and in Latin America. There are infrastructure and logistics challenges, but these will be overcome with time. These offer exciting investment opportunities for American and European companies with sector specific expertise.

I left the seminar very upbeat about the prospects for the agribusiness sector, and in particular for the UK industry, both as a globally competitive producer of many products but more importantly as an intellectual thought leader and provider of solutions to many of these common global challenges.

About the author

Carl Atkin is Partner and Head of Research at Bidwells Agribusiness. He has a first class Honours degree in Agriculture and Farm Business Management and a Masters degree in Business Administration (MBA). He has overall

responsibility for Research for Bidwells Agribusiness, analysing and interpreting the implications of Global, EU and UK agricultural, environmental, food and rural policy on the food and farming industries.
He is a member of the Editorial Committee of this Journal, and Chairman of the Agricultural and Rural Policy Committee of the Institute of Agricultural Management. His business consultancy interests extend across agricultural supply chains and farming and food businesses and he has extensive experience working overseas, especially in Eastern Europe, Former Soviet Union and Africa including studies on agribusiness investment opportunities and working on implementation strategies with local overseas partners. He has recently spoken at conferences in the EU, MENA Region and North America on Food Security and Agri-Investment trends.

Further information on the Harvard Agribusiness Seminar is available at http://www.exed.hbs.edu/programs/agb/

Photograph of Discussion Group

Back Left to Right: Schichi Sato, CEO, Interflour Vietnam Limited, Ho Chi Minh City, Vietnam; Bungaran Saragihm Corporate Advisor, Japfa Cornfeed Indonesia (and Former Minister of Agriculture of Indonesia); myself; David Lenzmeier, Milk Specialties, Minnesota, USA; Luciano Thome e Castro, Lecturer in Agribusiness Marketing, University of Sao Paulo, Brazil

Front Left to Right: Kristin Snapp, Kershaw Companies (Fruit Producers), Seattle, Washington, USA;

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REFEREED PAPER

SIMULATION MODELLING OF THE COST OF PRODUCING AND UTILISING FEEDS FOR RUMINANTS ON IRISH FARMS

E. Finneran, P. Crosson, P. O'Kiely, L. Shalloo, D. Forristal, M. Wallace

A static agro-economic simulation model, the Grange Feed Costing Model (GFCM), was developed to facilitate the rapid calculation of feed costs and to aid in explaining the interaction of variables influencing the cost of providing fifty three distinct feed crops to ruminants on Irish farms.
The GFCM was used to quantify the impact of changing biological, management and market variables on the cost of producing and utilising eight of the most common feed crops grown in Ireland. While grazed perennial ryegrass was found to be the cheapest feed, a wide range of feeds were shown to be cost competitive with grass silage as winter feed options.

Keywords: Crop cost, feed cost, GFCM, simulation model, winter feeds

1. Introduction

Irish agriculture is dominated by ruminant production systems with 95% of Irish farmers describing their farming systems as either 'mainly cattle' (beef and dairy), 'mainly sheep', or 'mixed crops and livestock' (DAF, 2008). Feed cost accounts for over 75% of total variable costs on these livestock farms (Connolly *et al*., 2010) and can therefore have a significant impact on farm profitability. Ramsey *et al*. (2005) demonstrated a clear inverse relationship between feed cost and farm profitability on beef rearing farms in the USA, while McCall and Clark (1999) found similar results using data from dairy farms in the USA and New Zealand. Several other authors have highlighted the need for optimisation of feed sources as a means of improving farm profitability (Groen and Korver, 1989; O'Kiely *et al*., 1997; Shalloo *et al*., 2004).

Agricultural input and output commodity price peaks and troughs have impacted on livestock farm profitability in recent years. The considerable increases in the price of oil and oil-derived products (e.g. fuel, fertiliser, polythene and pesticides) during 2008 contributed to a significant fall in farm incomes. Similarly, the sizable drop in milk prices in 2008/2009 had a negative impact on dairy farm margins (Connolly *et al*., 2010). As a result of the removal of agricultural commodity support structures in the EU, farmers are increasingly exposed to world commodity price fluctuations. In this context, low cost production systems are more likely to remain sustainable in the longer term. As feed cost constitutes such a large proportion of total variable costs, it is clear that prudent management of feed costs can significantly impact on the profitability and sustainability of ruminant production systems.

Selecting the most appropriate feeding programme has become a more complex task for Irish farmers in recent decades. New legislative environmental constraints such as 'The Nitrates Directive' (SI 378 – DAF, 2006), voluntary schemes such as the Rural Environmental Protection Scheme (REPS) and changes in the Common Agricultural Policy (CAP) have had implications for optimal farm systems (Crosson *et al.*, 2006). New developments in agronomic and feeding technologies have resulted in increased production of whole-crop maize silage, whole-crop cereal silages, high moisture grains and grazed brassicas as alternative feeds (CSO, 2010). The wider choice of alternative, home-grown feeds, the changing regulatory environment and greater input cost variability have demanded a more fluid decision-making process of Irish farmers seeking to optimise nutrient supply to ruminant production systems. A number of authors (Walker, 2002; Newman *et al.*, 2000) identified the need for a computerised tool to aid the understanding of such complex decision-making environments on farms.

Simulation modelling has been used for many years to aid in explaining, understanding and improving the performance of farm systems (Qureshi *et al.*, 1999). Crosson *et al.* (2006) and Shalloo *et al.* (2004) developed systems models to analyse the economic impact of changes in the technical, environmental and policy environment on Irish beef and dairy farm systems, respectively. There have been numerous agronomic models developed to describe the impact of management and environmental variables on crop production (Dobos *et al.*, 2004; McCown *et al.*, 1996; Brisson *et al.*, 2003). However, the number of models developed to simulate the economics of feed crop production and utilisation is low. O'Kiely *et al.* (1997) is one of very few published studies to have examined the costs of producing and utilising a range of feeds for ruminants while none have examined the impact of a range of fluctuating variables on feed cost.

To address the aforementioned set of complexities impacting on feed cost the Grange Feed Costing Model (GFCM) was developed. The objective was to develop a research tool which would consistently quantify the costs and values of changing feed cropping options and management practices in the production and utilisation of a comprehensive range of feed crops for ruminants on Irish farms. The GFCM was targeted for use by specialist advisory and agricultural systems researchers who could disseminate the results generated by the model to the ultimate beneficiary, the ruminant livestock farmer.

The modelling approach used permitted simulation of a much broader range of alternative feed crops and technologies employed by Irish farmers than previously studied by O'Kiely *et al.* (1997). Research by both McGee (2000) and O'Kiely *et al.* (1997) identified the problem of partial costing approaches to costing feed crops and the consequent "grossly misinforming conclusions" which could be derived from such approaches. Thus, developing a standardised 'full-costing' methodology across all feed crops within the model design was prioritised.

The objective of this paper is to describe the structure of the GFCM and to demonstrate its application by investigating the impact of biological, management and market changes on the cost of producing and utilising ruminant feed crops on Irish farms.

2. Model specifications and costing conventions

2.1 Model structure

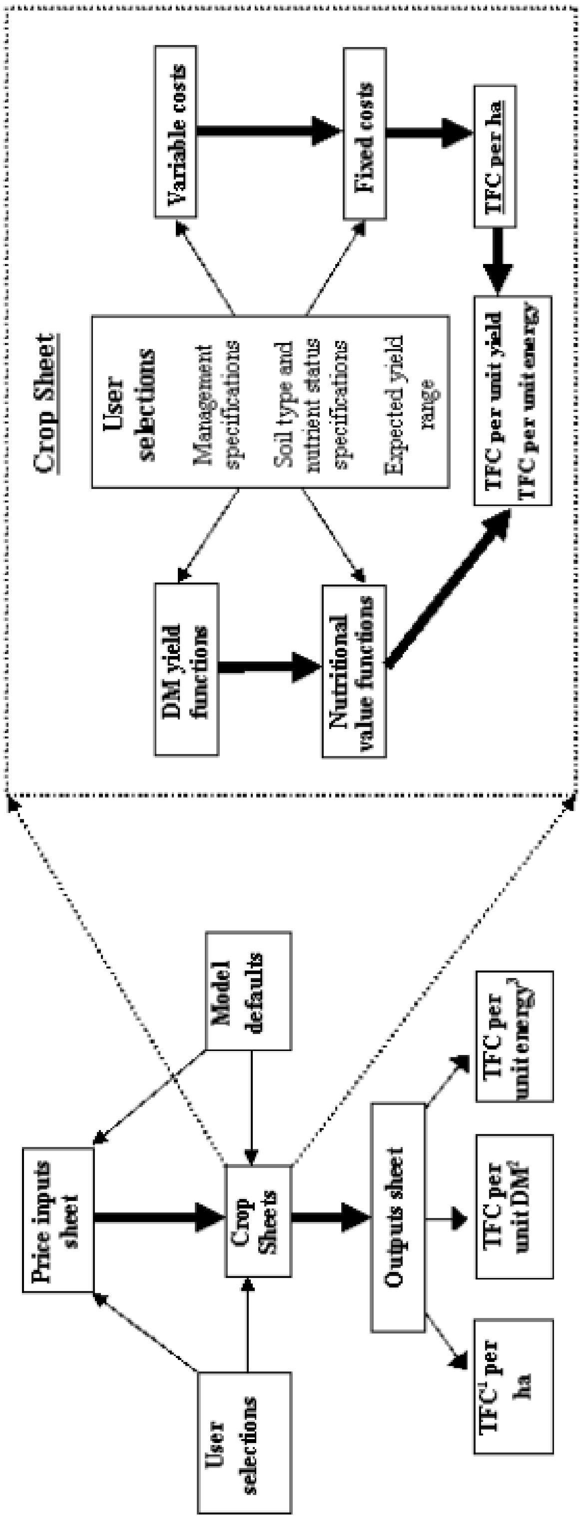
The GFCM is a static, spreadsheet-based, agro-economic simulation model for evaluation of the physical and financial performance of alternative feed crop production and utilisation options in Ireland. It employs a single-year, deterministic approach to modelling feed crop cost. Agronomic defaults in terms of sowing dates, field operations, and harvest and utilisation options are relevant to Irish conditions (Coulter and Lalor, 2008; O'Kiely, 2001; O'Mahony, 2009; O'Riordan *et al*., 1998). Deterministic crop yields, based on specified biological and management factors, are calculated rather than simulating growth rates. The economics are based on annual input costs at prevailing 2009 prices (unless otherwise specified) and long term capital costs. Fifty three distinct feed crop production and utilisation options are modelled in the GFCM (Table 1) and are categorised as grass/legumes, cereals, brassicas and beet.

Table 1. GFCM feed crop production and utilisation options

Feed crop category	**Feed crop**	**Sowing options**	**Grazing options**	**Silage *(whole-crop)* options**	**Other harvest options**	**Post harvest/ Conservation options**
Grasses/ Legumes	Perennial ryegrass	User defined re-seeding interval	1[1]	4	2[2]	-
	Perennial ryegrass & white clover		1	-	-	-
	Perennial ryegrass & red clover		1[3]	4	-	-
Cereals	Wheat	Winter/ Spring	-	*(2)*	2[4]	4
	Barley		-	*(2)*	2	4
	Oats		-	*(2)*	2	4
	Triticale		-	*(2)*	2	4
	Maize	Mulch/ No Mulch	-	*(1)*	-	-
Brassicas	Kale	Multiple sowing date options	1	-	-	-
	Swedes		1	-	-	-
	Stubble turnips		1	-	-	-
	Fodder rape		1	-	-	-
Beet	Fodder beet	April sown	1	-	1[5]	-
	Sugar beet		0	-	1[5]	-

Grass may be rotationally grazed over a full grazing season or grazed before or after silage harvest; [2]Hay – early or late harvest; [3]Ryegrass/ red clover swards may be grazed following either the second or third silage harvest; [4]Small grain cereals may be harvested as HMG or 'dry' (> 80% DM) grain; [5]Beet tops may be grazed *in situ*.

Figure 1. Schematic of GFCM model structure



1.TFC = Total Feed Cost 2. DM grown or DM utilised (UDM) 3. Metabolisable Energy (ME) or net energy (NE)

In the GFCM and for the purposes of this paper "feed crop production" refers to all processes from land preparation, sowing and crop management through to the point of grazing or harvest. "Utilisation" refers to all processes from immediately prior to harvest through to the point of ingestion by an animal, including grazing or harvesting, processing, conservation, storage and feed-out. The model allows considerable usability and flexibility for the model -user as it was designed as a computer spreadsheet (MS Excel) incorporating drop-down menu options and clearly marked data input cells. It employs a comprehensive input price sheet which allows the user to model the impact of input price fluctuations across all of the feeds (Figure 1).

The GFCM contains individual "crop sheets" for each feed crop where a number of environmental and management variables must be specified by the user. Yield and nutritional value is computed by means of a series of inbuilt functions derived from long term experimental data measured under Irish conditions. Fixed and variable costs associated with the feed crop are detailed in tabular format in the crop sheet. Soil type and nutrient status affects feed crop fertiliser requirements and consequently feed cost. Management specifications such as stocking rate (for the grazed crops), sowing and harvest dates, and harvest and conservation technologies must also be defined by the model user in the crop sheets. The various management, biological and input price variables may be altered either simultaneously or sequentially by means of the data input cells in order to model the impact of different cropping scenarios on feed crop cost.

2.2 Feed crop yields

The model quantifies feed crop yield in a range of measures; dry matter grown per feed crop hectare (DM ha^{-1}), dry matter utilised per feed crop hectare (UDM ha^{-1}), digestible dry matter per feed crop hectare (DDM ha^{-1}), metabolisable energy per feed crop hectare (ME ha^{-1}), and net energy per feed crop hectare (NE ha^{-1}), which can be compared across all feed crops. Yield data were obtained from published Irish sources for feed crops grown in productive soils under good management (Butler, 2006; CSO, 2010; O'Kiely, 2001). In the absence of published data, yield data from Teagasc research farms were used to derive default values.

Nutritional value is expressed as follows;

1. Digestibility; dry matter digestibility (DMD) and organic matter digestibility (OMD for cereals); g kg DM-
2. Metabolisable energy; MJ kg DM^{-1}
3. Net energy; UFL kg DM^{-1} (Unité fourragère lait – Feed unit for milk production) and UFV kg DM^{-1} (Unité fourragère viande – Feed unit for meat production) (Jarrige, 1989).

2.3 Costing convention

The GFCM employs a full-costing approach in calculating the TFC (total feed cost) of each feed. TFC is equivalent to the 'economic cost' described by Kay and Edwards (1994) as the opportunity cost of the resources plus the 'accounting cost'. The accounting cost includes all production (land preparation, sowing and crop management) and utilisation (processing, storage, labour and feed-out) costs associated with the feed; in addition to non-cash costs such as depreciation of fixed assets (see Appendix A).

Labour is often included as an opportunity cost in the costing of feed crops but is treated as a cash cost in the TFC within the agricultural contractor charges which are applied for all feed crop production and utilisation operations (See Appendix A). The opportunity cost of the land is included as a 'land charge' (assumed as equivalent to the current annual market price for rental land) in the TFC to give the full economic cost of the feed.

TFC is expressed as Euro (€) per unit of feed crop yield; on net energy (NE), metabolisable energy (ME), dry matter grown/harvestable (DM), dry matter utilised – i.e. ingested by the animal - (UDM) and digestible dry matter (DDM) bases. The cost of balancing a feed crop for energy, protein, fibre or minerals in order to meet particular dietary requirements is not included in TFC. A facility is provided in the GFCM to benchmark home-produced feeds against the cost of purchased alternatives (including storage and feed-out losses and costs) such as rolled barley.

2.4 Model validation

In order to ensure that model outputs would provide a reasonable representation of reality a validation process was undertaken to assess the functionality of the model and the appropriateness of data sources used and assumptions made. In the absence of a broad and robust dataset of yields and input rates for feed crops grown on Irish farms, an assessment of "face validity" of the GFCM by "knowledgeable individuals" was conducted as described by Qureshi *et al.* (1999). Two separate group meetings of specialist agricultural advisors and crop and ruminant researchers were held to validate the GFCM development and functionality. Following thorough examination of the individual yield and nutritional value functions, input prices and scenario analysis it was deemed that the GFCM provided an appropriate model of the interactions influencing feed crop cost on Irish farms.

3. Model applications

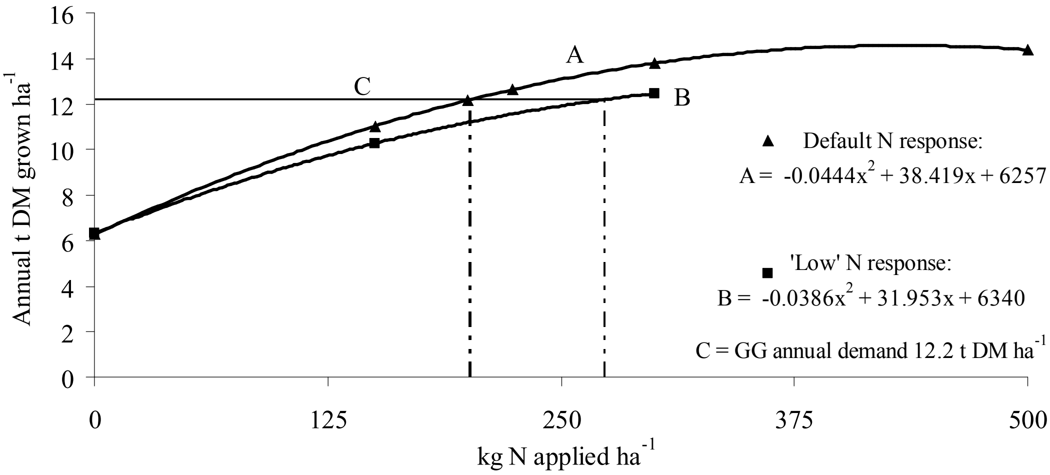
This section describes how the GFCM was used to analyse and compare feed crop production and utilisation scenarios and input price fluctuations. The following model applications demonstrate the capability of the model to simulate feed production and utilisation options and provide economic indicators to assist the user in evaluating the viability of these options.

3.1 Impact of biological factors: Nitrogen response of perennial ryegrass

A comparison of two annual nitrogen (N) response curves for a grazed perennial ryegrass sward was conducted using the GFCM to examine the impact of a non-management (biological) factor on the cost of producing a grazed grass crop (GG).

The N response curves for the default and 'low' N response rate scenarios are presented in Figure 2. The default N response curve is based on the work of Butler (2006) which used multi-year data from two Teagasc sites, Moorepark (in the south of Ireland, 52° 9' N, 8° 15' W) and Grange (in the east of Ireland, 53° 31'N, 6° 39'W).

Figure 2. Nitrogen response curves for grazed perennial ryegrass and annual DM demand for a beef cow plus calf to beef system used to model the economic implications of nitrogen response in the GFCM



A = Default annual perennial ryegrass nitrogen response curve; combined multi-year nitrogen response curve for Teagasc, Grange and Teagasc, Moorepark (Butler, 2006).
B = 'low' annual nitrogen response curve; nitrogen response for perennial ryegrass sward grazed at Tegasc Grange (O'Riordan, 1997).

The 'low' N response curve used in this analysis was derived from O'Riordan (1997), and is taken from a perennial ryegrass sward grazed on a 28 day rotation at Teagasc, Grange. The gley soil of the Ashbourne series prevailing at Grange contains 470 g N kg^{-1} organic matter in the upper 18 cm (An Foras Talúntais, 1983), while the acid brown earth soil at Moorepark contains 210 g N kg^{-1} organic matter in the upper 20 cm (O'Connell *et al.*, 2003). This difference in N content of soil organic matter contributes to the higher grass DM production observed at low or zero N application rates at Grange relative to Moorepark. At higher N application rates perennial ryegrass swards at Grange exhibit lower grass DM production relative to Moorepark.

To compare grazed grass production costs of both N response curves, a target annual yield of 12.2 t DM ha^{-1} was set. This yield is representative of the annual grazing season demand for a suckler beef farm stocked at 2.5 cow plus calf units ha^{-1} (Drennan and McGee, 2008). N was applied according to the requirements for this target yield specified by the specific N response curve. Phosphorous (P) and potassium (K) were applied in the form of inorganic compounds as per the recommended rates of Coulter and Lalor (2008).

3.1.1 Nitrogen response of perennial ryegrass: Results and discussion

The mean response over the grazing season at the default N response was 26.2 kg grass DM kg N^{-1} (Table 2). At the 'low' N response curve the mean response over the grazing season was 21.4 kg grass DM kg N^{-1}.

The additional 4.8 kg grass DM kg N^{-1} grown in the default scenario equated to a 23% greater response than that of the 'low' N response scenario. This resulted in a 10% difference in TFC due to the higher rate of N application required in the low N response scenario.

Table 2. Impact on fertiliser application and total feed cost (TFC) modelled using GFCM for two nitrogen response curves

	Mean nitrogen response	**Nitrogen applied**	**Yield**	**Fertiliser cost**		**TFC**	
	Kg DM kg N^{-1}	*Kg ha^{-1}*	*Kg DM ha^{-1}*	*€ ha^{-1}*	*€ t UDM^{-1}**	*€ t UDM^{-1}*	*€ GJ ME^{-1}***
Default N response	26.2	201	12,182	248	27.14	80	7.26
Low N response	21.4	273	12,182	320	35.02	88	7.98

* € per tonne of utilised dry matter
** € per gigajoule of metabolisable energy

As expected, this result indicates that increasing N application in order to increase the yield of grass DM per hectare under a low N response scenario will result in a greater feed cost relative to under a higher N response scenario. The real value of this model application is that a definitive quantification of this higher feed cost can be established. This information could be used by farmers to determine the N response at which point it becomes less expensive to purchase alternative feeds rather than to apply additional N fertiliser to a grass sward. Efficiency gains can also be realised by taking steps to improve the response of a grass sward to applied N. For example, reseeding with more productive grass varieties can increase the N response of a sward containing a low proportion of perennial ryegrass. In order to make most efficient use of N fertiliser, farmers should be cognisant of the N response status of the different soil types on their farms.

3.2 Impact of management factors: Grass silage and spring grazing

The impact of altering closing and harvest dates on DM yield, DMD, ME and consequently cost of a single harvest grass silage crop was modelled. The crop was assumed to be a 5 year old (mid-point of a 10 year re-seeding interval) perennial ryegrass sward. The crop was grown in a loam soil, in a field which was grazed during the previous year; hence it had an N requirement of 100 kg N ha^{-1} (Coulter and Lalor, 2008). P application was linked to expected DM yield and constrained by statutory limits (DAF 2006); i.e. 16 kg P ha^{-1} for crops yielding less than 5.5 t DM ha^{-1} and 20 kg P ha^{-1} for all greater yields. K was applied proportionately to expected DM yield.

There were three separate spring closing dates (i.e. the date of final sward defoliation prior to harvest) modelled, and a fourth scenario where there was no spring grazing, but where the sward was grazed to a residual of less than 4 cm in the previous November. The spring closing dates were 15-March, 31-March and 15-April. All inorganic fertiliser was assumed to be applied on the closing date or on 15-March for the 'not spring grazed' crop. Crop yields were modelled for a series of ten harvest dates for each of the four closing date scenarios. Yield and DMD values for the 'not spring grazed' crops were derived from five years of data for perennial ryegrass swards at Grange (O'Kiely, 2001). The harvest dates were at weekly intervals from 1-May to 3-July. The yields for each of the spring grazed crops were calculated using a co-efficient for the impact of spring grazing on subsequent grass silage yield derived from O'Riordan *et al*. (1998). Similarly, the DMD values at harvest for each of the spring grazed crops were predicted using a co-efficient derived from Humphreys and O'Kiely (2006) and O'Neill *et al*. (2000). Default DMD loss during conservation was 20 g kg^{-1}, while total DM losses during harvesting, conservation and feed-out amounted to 150 g kg DM^{-1} (O'Kiely *et al*., 1997). Average DM content at ensiling was 217g kg DM^{-1}. All silage crops were harvested using a precision chop harvester and stored in a walled concrete bunker silo.

Common (shared between multiple feed crops) annual fixed costs (i.e. fencing and roadways) were allocated to the grass silage crops in the same proportion as the land charge as described in Appendix A. The entire proportion of the fixed costs associated directly with the conservation of the crop (i.e. the silo and effluent tank) was allocated to the grass silage crop.

3.2.1 Grass silage and spring grazing: Results and discussion

Spring grazing of a grass silage sward in March had a modest impact on the UDM yield of grass silage from harvests after 22-May (Table 3). Although yield from these later harvests was slightly depressed by March grazing, DDM and ME yield was similar to the sward that was not spring grazed, due to higher digestibility of the harvested grass. Delaying closing date in the spring beyond late March had a more pronounced impact on silage yield, particularly for the earlier silage harvest dates.

Figure 3 shows how UDM yield of the 'not spring grazed' sward increases almost linearly from 2 t ha^{-1} on 1-May to 8 t ha^{-1} by 1-July. However as the DMD of the sward falls in an approximately inverse linearity to the DM yield, total ME yield peaks by mid-June. This decline in DMD and ME concentrations results in TFC per unit of ME beginning to rise again in the last week of June, despite the increasing DM yield.

Grazing of a silage sward after March depressed subsequent silage yields to the extent that it substantially increased the cost of the silage harvested before early June (Figure 4). However, grazing up until the 15-March resulted in a slightly lower TFC (on an ME basis) from harvests after 22-May relative to a 'not spring grazed' sward. This is because the increase in DMD at any given silage harvest date as a result of March grazing (Humphreys & O'Kiely, 2006) offsets the DM yield loss arising from such management. In addition to

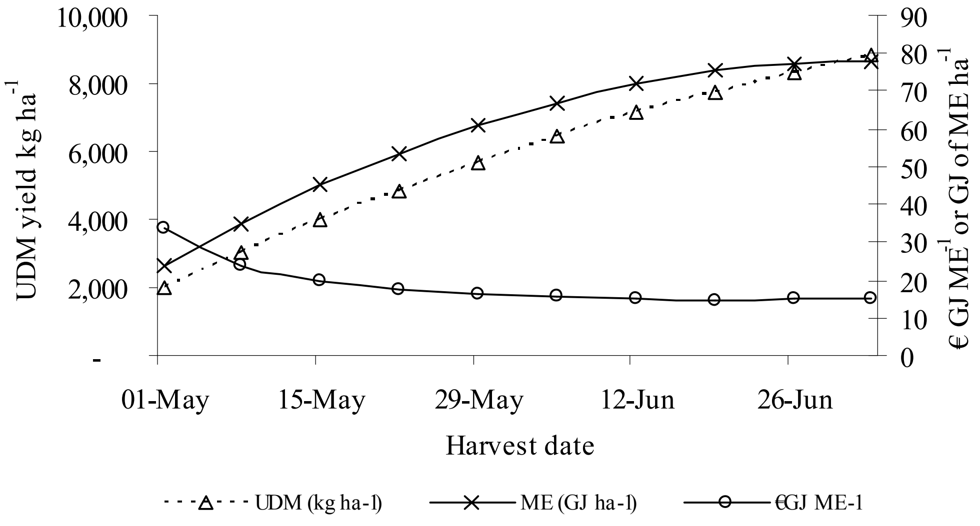
Table 3. Yields of grass silage dependant on spring grazing and silage harvest date for a range of closing and harvest dates as modelled using GFCM

	Closing date							
	Not spring grazed		**15 Mar**		**31 Mar**		**15 Apr**	
Harvest date			As proportion of 'not spring grazed' sward					
	Kg UDM[*] ha-1	*Kg DDM[**] ha-1*	*UDM ha-1*	*DDM ha-1*	*UDM ha-1*	*DDM ha-1*	*UDM ha-1*	*DDM ha-1*
01-May	2,015	1,600	0.75	0.76	0.55	0.56	0.38	0.39
08-May	3,024	2,372	0.78	0.79	0.60	0.61	0.42	0.43
15-May	3,970	3,066	0.81	0.82	0.65	0.66	0.47	0.48
22-May	4,854	3,674	0.85	0.86	0.70	0.71	0.52	0.53
29-May	5,675	4,194	0.89	0.90	0.75	0.76	0.58	0.59
05-Jun	6,434	4,621	0.93	0.94	0.80	0.81	0.64	0.65
12-Jun	7,131	4,953	0.98	0.98	0.83	0.84	0.67	0.68
19-Jun	7,765	5,189	1.00	1.00	0.87	0.87	0.70	0.71
26-Jun	8,336	5,329	1.01	1.01	0.89	0.89	0.72	0.72
03-Jul	8,845	5,372	1.00	1.00	0.92	0.92	0.74	0.74

* Utilised dry matter
** Digestible dry matter

examining the TFC, there is a need to take into account the farm silage requirement and the desired fill value (Jarrige, 1989) and DMD of silage for the chosen livestock system when deciding closing and harvest dates for grass silage swards. The effect on the cost of resultant additional grazing or grazing

Figure 3. Yield and total feed cost (TFC) of a single harvest grass silage crop (not spring grazed) for ten consecutive harvest dates as modelled by the GFCM

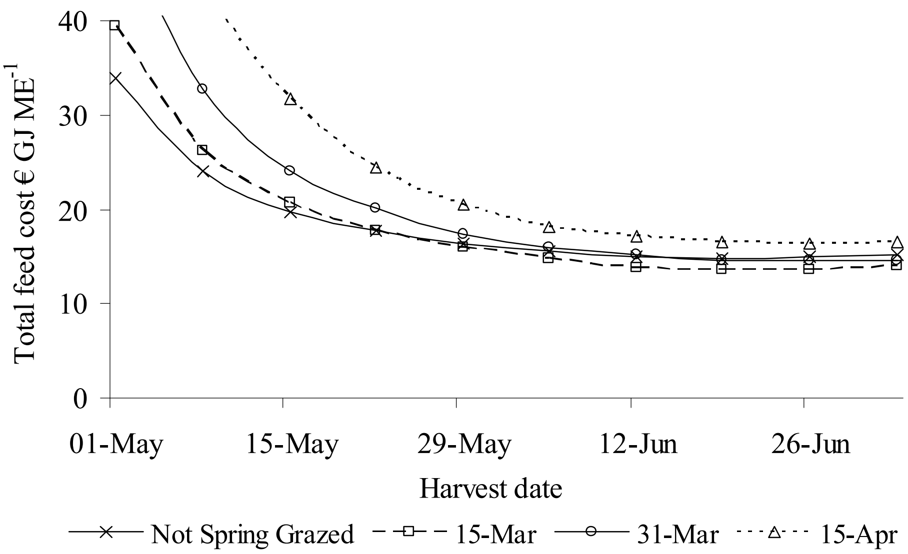


forgone and the balancing of feed supply and feed demand at a given time-point in the spring or summer will also impact on this management decision. Ongoing development of the GFCM will address this issue of costing a grass sward both grazed and conserved over the course of the farming year.

3.3 Impact of market factor: Fertiliser cost

The GFCM was used to calculate TFC for eight feed crops commonly fed

Figure 4. Impact of spring grazing and harvest date on total feed cost (TFC) of a single harvest grass silage crop(€ GJ ME^{-1}) for 10 consecutive harvest dates as modelled by the GFCM



on Irish cattle farms; grazed grass (GG), a single harvest grass silage crop (GS1), a double harvest grass silage crop (GS2), a single harvest baled grass silage crop (GSB), whole-crop maize silage (WCM), whole-crop fermented wheat silage (WCW), grazed kale (Kale) and harvested fodder beet (FBH). Input price sensitivity analysis was conducted using the GFCM to examine the impact of the increase in chemical fertiliser cost between 2007 and 2008 on the cost of producing and utilising each of the eight feed crops. Mean monthly fertiliser prices were used for each year (CSO 2010). All other input prices and yield values remained constant in this analysis.

Each feed crop was assumed to be grown in a loam soil with P and K indices of 3 (Coulter and Lalor, 2008). All harvested crops were assumed to be grown on land from which grass silage had been harvested the previous year (therefore index 2 for N; Coulter & Lalor, 2008). The kale crop was sown after grazed grass; i.e. in a field already fenced for grazing.

The full fertiliser requirement for each feed crop was provided by means of inorganic fertiliser application. Fertiliser was applied in a combination of compound and single nutrient inorganic fertiliser based on crop nutrient requirements (Coulter & Lalor, 2008) and constrained by statutory limits (DAF, 2006). Total fertiliser applied and the costs of this fertiliser (including spreading cost) are shown in Table 4.

Table 4. Quantities of fertiliser applied and their cost as modelled using GFCM for assessing the impact of market factors on total feed cost (TFC)

Feed crop	Macronutrients applied (kg ha^{-1})			Fertiliser cost[9] (€ ha^{-1})	
	N	P	K	2007	2008
GG[1]	201	10	15	175	248
GS1[2]	100	20	168	202	332
GS2[3]	185	30	205	317	513
GSB[4]	100	20	168	202	332
WCM[5]	140	40	190	274	445
WCW[6]	160	25	100	253	409
Kale[7]	80	30	170	218	363
FBH[8]	179	40	160	310	491

[1]Grazed perennial ryegrass; [2]Single harvest grass silage system; [3]Double harvest grass silage system; [4]Single harvest grass silage– baled; [5]Whole-crop maize silage; [6]Whole-crop winter wheat silage; [7]Grazed kale; [8]Fodder beet – harvested; [9]CSO (2009).

Table 5. Yield and quality data for eight feed crops modelled using the GFCM

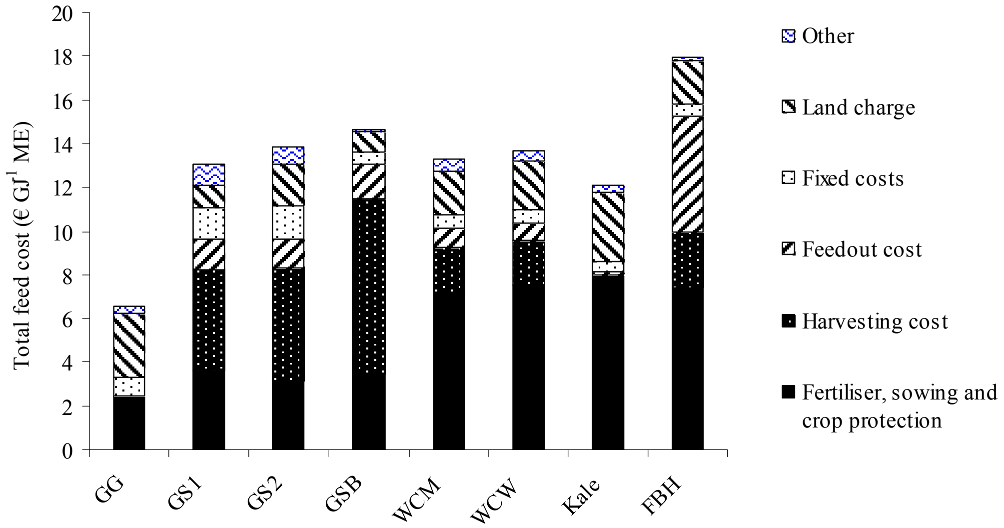
Feed crop	Harvest date	Crop yield (kg DM ha^{-1})	Utilised yield (kg DM ha^{-1})	DMD[1] at feed-out (g kg^{-1})	ME[2] at feed-out (GJ. kg DM^{-1})
GG[3]	Mar-Nov	12,182	9,137	780	11.00
GS1	12-Jun	6,934	5,918	700	10.15
GS2	22 May 24 Jul	11,996	10,240	722[4]	10.50
GSB	12-Jun	6,934	6,192	700	10.15
WCM	20-Oct	16,010	14,193	701	10.50
WCW	20-Aug	14,827	13,144	689	10.43
Kale	Nov-Jan	10,125	8,100	722	11.76
FBH	01-Nov	15,000[5]	14,400	851	12.40

[1]Dry matter digestibility; [2]Metabolisable energy; [3]Feed crop codes as per Table 4; [4]Weighted mean DMD of two harvests; [5]5,000 kg DM of beet tops and leaves by-product not included in yield

3.3.1 Fertiliser cost: Results and discussion

Table 5 shows the harvest dates and yields of the eight feed crops on DM and UDM bases. It also shows the DMD and ME concentrations of the feed crops at feed-out. These are the key default yield and nutritional values for these feed crops in the GFCM. Figure 5 shows the TFC of the eight crops using 2007 fertiliser prices. It also illustrates the breakdown of TFC into six key cost components to demonstrate the differing structure of total feed cost between the feed crops.

Figure 5. Total feed cost (TFC) categorised for eight feed crops[1] as modelled by the GFCM using 2007 fertiliser prices

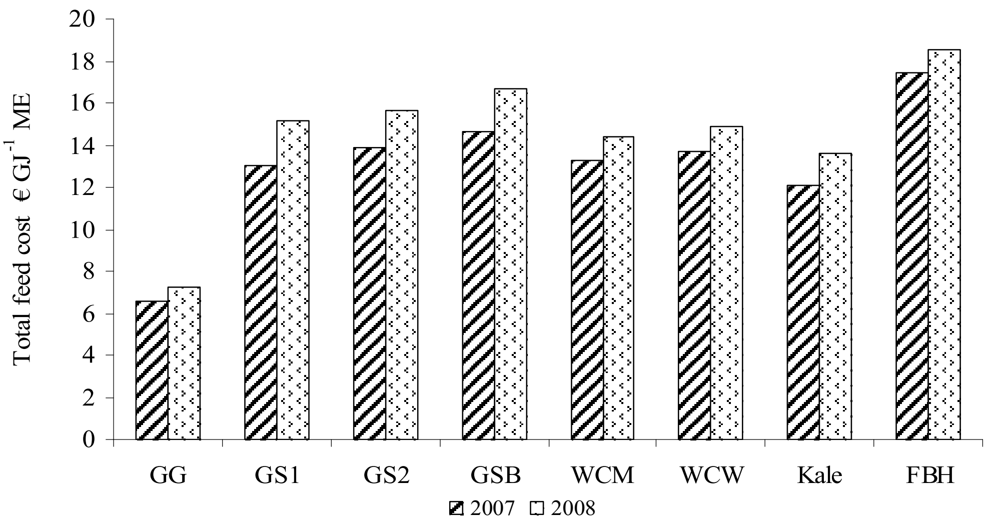


[1]Feed crop codes as per Table 4;
[2]Other costs include the cost of working capital and repair and maintenance costs of fixed assets;
[3]Annual land charge €300 ha^{-1}, or appropriate proportion of annual charge on a feed crop rotation interval time basis;
[4]For grass crops, crop establishment is included as a fixed cost depreciated over 10 and 14 years for the grazed and silage swards respectively;
[5]Feed-out work rates as per Forristal (1993).

On an ME cost basis the feed crops ranked (from lowest to highest) GG, Kale, GS1, WCM, WCW, GS2, GSB and FBH. The cost of the other seven feed crops relative to grazed grass emphasises its importance as the primary ruminant feed in Ireland during the months of March to November. In terms of cost relative to GS1, the most common winter feed for ruminants in Ireland, all winter feed crops with the exception of FBH could be produced and utilised at similar cost (on an ME basis) using 2007 fertiliser prices (Figure 5). While in these results kale ranks as the cheapest alternative to grazed grass, cognisance must be taken of the fact that environmental regulatory compliance costs such as a land charge for a "run-back area" (a grassland area of 1 ha accessible to each livestock unit grazed on the feed crop as required by EU legislation) may need to be included in TFC for brassica crops.

Fodder beet is the most expensive of the eight feed crops in this analysis at €18.52 GJ ME^{-1}. However a large proportion of this cost (29%) is accounted for by the labour and machinery intensive nature of the cleaning, chopping and feed-out operation for fodder beet. Figure 6 demonstrates the impact of the increase in fertiliser cost from 2007 to 2008.

Figure 6. Total feed cost (TFC) of eight feed crops calculated using 2007 and 2008 fertiliser prices as modelled by the GFCM



On an ME basis the increase in the cost of fertiliser between 2007 and 2008 resulted in an increased TFC of between 6% (FBH) and 17% (GS1). The greatest impact on TFC was observed in the feed crops where fertiliser cost comprised a greater proportion of TFC (i.e. the grass silages). Because of this, GS1 became more expensive relative to WCW, WCM and kale in 2008. P and K prices rose at a greater rate (+85% and +95%, respectively) than N prices (Calcium Ammonium Nitrate +57% and Urea +38%) between 2007 and 2008. Therefore the impact of the fertiliser price rise was greater for feed crops with greater P or K requirements. As the fertiliser requirement for the GG feed crop was mainly N, the impact of the fertiliser price rise was not as great as for some of the harvested feeds which had a proportionally greater P and K requirement. Determining the relative impact of such fertiliser price changes would be beneficial to a farmer deciding for example whether to replace a GS2 system with a WCW crop.

These results highlight the importance of making more efficient use of organic manures to meet crop nutrient requirements, particularly during periods of high inorganic fertiliser prices. In practice farmers tend to respond to high P and K prices by reducing application rates. Lalor *et al.*, (2010) found that inorganic P and K fertiliser usage in Ireland reduced by 29% and 25%, respectively between 2006 and 2008; a large proportion of this decrease can be attributed to the substantial price increases. Soil P and K levels are depleted over time when application rates are consistently below crop requirements and therefore this solution cannot continue indefinitely. More sustainable cost abatement options farmers could undertake include regular testing of soil nutrient status; using soil test results to match fertiliser application to the requirements for optimal yield, returning winter produced organic manures to fields from where winter feed was harvested, and as far as possible limiting the growing of harvested crops to fields where high levels of soil P and K prevail.

4. Conclusions

A computerised tool, the GCFM has been developed and applied to simulate the effects of market, management and biological factors on feed cost. The GFCM fulfils a recognised requirement of providing a standardised methodology to economically quantify the impacts of changing production and utilisation scenarios for a wide range of ruminant feed crops. The flexible structure of the GFCM permits analysis of changing input prices and changing feed crop production variables. The applications of the model outlined in this paper have quantified the considerable impact these highly variable factors can have on the economics of producing and utilising certain feeds. This GFCM could facilitate economic analysis of new feed crop research data relating to production or utilisation responses.

This study confirms and quantifies the substantial cost advantage of grazed grass relative to alternative feed crops in Ireland. In the default scenario TFC of feeds typically offered to ruminants outside of the grazing season ranged from 1.88 (kale) to 2.55 (fodder beet) times the cost of grazed grass on an ME basis (Figure 5). Yield is the primary factor influencing TFC. However, additional costs addressed in the GFCM, many which have not been widely quantified previously, including feed-out costs, storage and feed-out losses, and the cost of storage facilities for feeds can also have a considerable impact on TFC.

The analysis shows that there is a wide range of feed crops which can be cost competitive with grass silage as winter feeds for Irish ruminants. However, given that permanent pasture forms the majority of land used for ruminant production in Ireland, grass silage, as an integrated part of a grass-based production system, remains the primary winter feed option for cattle and sheep farmers. In addition, as yield is the key driver of TFC, if grass silage cannot be economically produced on a given farm due to site or soil factors, then it is unlikely that any of the alternatives could be economically produced on such a farm either. The significant seedbed preparation and feed crop establishment costs associated with annually sown feed crops tend to reduce their economic attractiveness when compared with perennial feed crops such as ryegrass. For livestock systems requiring high-energy diets (such as beef finishing or winter milk production) these alternative feed crops may play a valuable role as part of a grassland reseeding programme or in situations where a portion of the land area cannot be easily integrated into the grazing system; i.e. an 'out-farm' situated a long distance from the main farm unit. While this study examined the deterministic costs of the most common feed crops grown in Ireland, further development of the GFCM will allow valuable stochastic analysis of the effect of fluctuating yields and input prices on TFC.

The process of developing the GFCM highlighted the recognised requirement for more quantitative and qualitative data permitting more robust estimation of production functions for feed crops on commercial farms. Moreover, given the cost advantages of grazed pasture coupled with its role as the predominant ruminant feed crop in Ireland, there is a continued need for research focussed on improving grazed grass production and utilisation. These data are required to enhance understanding of DM production responses and utilisation rates, particularly in relation to factors such as weather, grazing strategy, soil-type, sward composition and age.

About the authors

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APPENDIX A: METHODOLOGY OF TFC CALCULATION IN THE GFCM

Resource constraints

This appendix describes how the GFCM applies a cost to all of the resources employed in the production of feed crops as illustrated in Figure A. In addition to production cost and yield factors, a farmer must also consider the farm resource constraints when selecting the optimal feed crop production and utilisation option from a range of alternatives (O'Kiely et al., 1997). If any of the resources required to produce or utilise a certain feed crop are limiting, then the decision to select such feed crops is also limited.

A.1 Land

Land as a finite resource is one of the most limiting resource constraints. An opportunity cost of land is included in TFC by means of an annual land charge, or portion thereof, depending on the typical time interval between seedbed preparation for the feed crop being costed and seedbed preparation for the subsequent land use. Land charge for grass silage is apportioned to the feed based on the length of time between the date of final defoliation prior to harvest (closing date) and harvest date; calculated as:

[Equation 1]

$$A = \frac{H - C}{365} * LC$$

Where A = Land charge apportioned to the silage crop (€ ha^{-1}), H = harvest date, C = closing date (set as 1st Jan for 'not spring grazed' crops), LC = Annual land charge (€ ha^{-1}).

A.2 Labour

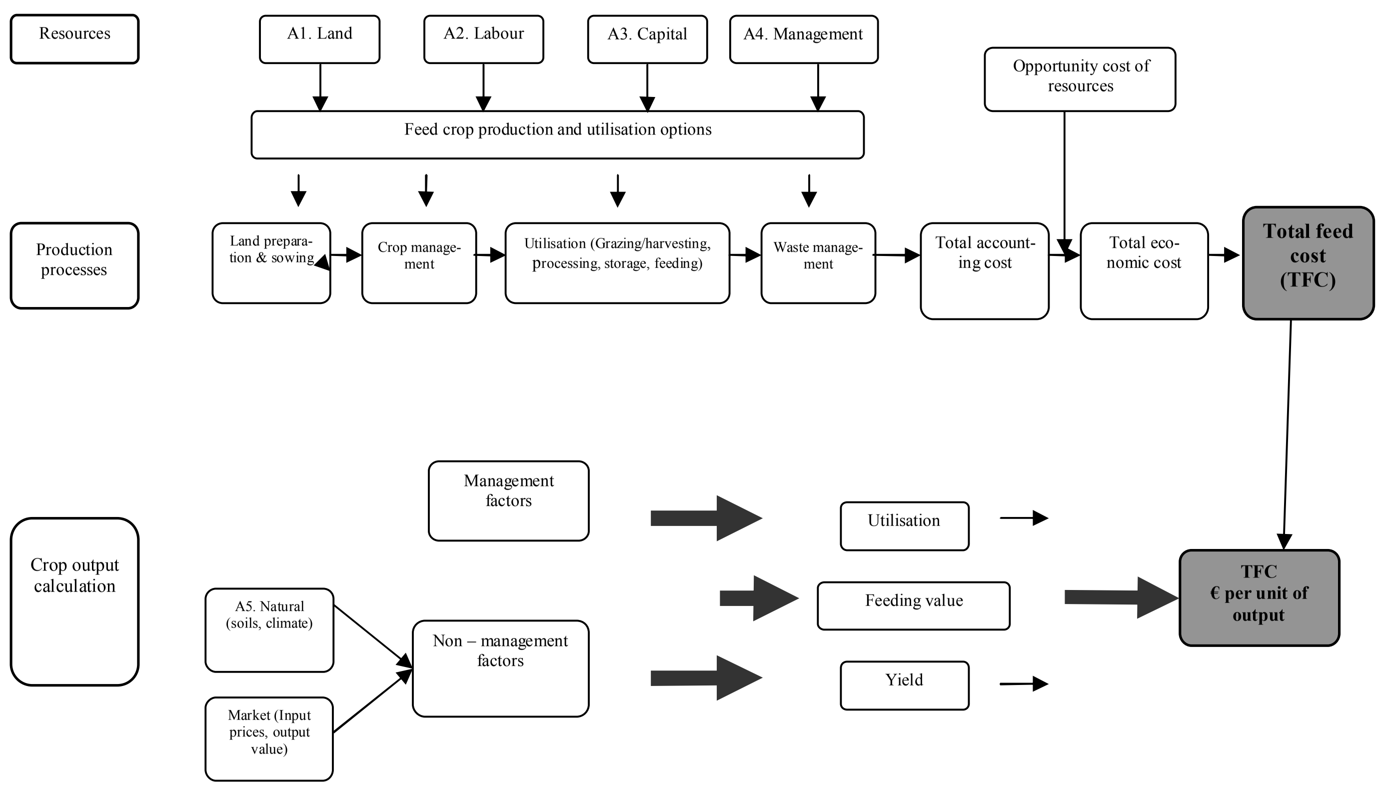
The labour, time and machinery costs involved in producing and utilising each feed are considered in the GFCM by assuming commercial agricultural contractor costs (Teagasc, 2008) and published work rates for all crop production and feed-out operations; e.g. tilling, sowing, fertilising, spraying, harvesting, processing and feed-out. This approach removes the requirement for complex machinery depreciation (which would depend on assumptions about the type and age of machinery) and labour opportunity cost functions within TFC. Labour for non-machinery related operations such as herding (moving of rotationally grazed animals and fences etc.) is costed per hour at average hourly agricultural wages for 2009 (CSO, 2010).

A.3 Capital

Fixed assets are also limiting factors in terms of feed crop selection. If a permanent facility or structure is required to produce, store or utilise the feed crop (such as a concrete silo or grain store) then a medium to long term investment decision must be made before deciding to produce the feed crop. This factor is integrated into TFC in the GFCM by including the cost of constructing and maintaining such fixed facilities as fencing, roadways, silos and grain stores. The required facilities for the particular feed crop, the associated construction/ installation cost and the age of the facilities must be specified by the user. Fixed assets are valued at their replacement cost based on the costings of the Irish Department of Agriculture and Food (DAF, 2007). Silos and buildings are depreciated over a specified period (typically 20 years), using the declining balance method. The age of the asset determines the depreciation and interest cost for the specified year. If use of a fixed asset is shared between two or more feed crops then the cost is also attributed to these feed crops in the same proportion as their usage (on a volume by time basis) of that asset. The cost of annual maintenance and repair of these fixed assets is charged at 1% of the construction cost per year within the variable cost fraction of TFC.

The interest cost on borrowed investment capital is accounted for in the GFCM by assigning an asset age, loan duration and interest rate to each asset. The total capital cost is the sum of interest payable and any depreciation costs arising. The user must specify the source of capital funding and the annual interest rate. In the GFCM default scenario annual interest on borrowing for construction of fixed assets is charged at 8%.

Figure A: Schematic of calculation of total feed cost (TFC) in the GFCM



Working capital is the capital required to finance the day-to-day operation of a farm business. Working capital is accounted for as an interest charge on savings foregone (O'Mahony, 2009) and calculated as follows:

$$WC = V * (P / 365) * 1/2$$

[Equation 2]

Where WC = Working capital cost (€ ha^{-1}), V = total variable costs (€ ha^{-1}) and P = length of the feed crop production period in days; i.e. the sowing to harvest time interval in the case of cereal crops, the closing date to feed-out interval in the case of grass silages and the grazing season duration in the case of grazed crops.

A.4 Management

Management input is the only resource not specifically accounted for as a financial cost in TFC. Some feed crops may require greatly differing crop management skills to others. Because of the difficulties of quantifying such a non-market variable as management input, this cost is not quantified in the TFC for the purposes of this paper. In order to allow consistent comparisons, a high standard of management is assumed in the default scenario across all feed crops in the GFCM.

A.5 Climate and soil

Local climate and soil factors can be major constraints on the range of feed crops that can be grown on a particular farm. Variability of feed crop yields, nutritional values and utilisation rates due to regional soil or climate factors is provided for within the model and these crop production variables may be changed to reflect location-specific values based on historical data.

Note: The Grange Feed Costing Model spreadsheet may be inspected on request to Eoghan Finneran (eoghan.finneran@teagasc.ie). Teagasc retains full intellectual property rights in the model.

REFEREED PAPER

LIVESTOCK AND PUBLIC ACCESS : WHY DOES STRICT LIABILITY EXIST AS A LEGAL PRINCIPLE, WHAT IS 'REASONABLE' CARE, AND SHOULD LIVESTOCK KEEPERS BE CONCERNED ABOUT RECENT COURT DECISIONS?

Carrie de Silva

McKaskie v Cameron [2009] concerned a farmer's liability for serious personal injury caused by animals when on a public right of way across farm land.

There have been towards 20 fatalities in such circumstances over the past 15 years (according to HSE statistics), with additional serious injuries. Negligence, occupiers' liability and the Animals Act 1971 were applied, with reference to the potential criminal liability under the Health and Safety at Work etc. Act 1974.

This paper summarises the case and the relevant law and reviews the matter in the context of rural risk management and the development of good working practices, i.e. what livestock keepers can do to avoid / mitigate damage and legal exposure.

Key words Public access, right of way, liability, injury, livestock. Shirley McKaskie v John Cameron (2009)

The case of McKaskie v Cameron[1] was brought after a walker, out with her dog, suffered severe personal injury caused by the defendant's cattle when on a public right of way across farm land. After an award to the injured party in the County Court in the order of £1 million, leave to appeal was not taken up by the defendant and an out of court settlement was reached in January 2010.[2]

Clearly, public access over private land gives rise to risks, physical and legal, for both owners, occupiers and the public. This case explores the legal issues in some detail and points towards the management of those risks.

1 THE CASE

C (the Claimant) had lived in Greystoke Gill, Cumbria since 2002 and often walked with her Jack Russell terrier along a nearby public footpath. The accident in respect of which the case was brought took place in May 2003 on or near the public footbath which links Greystoke to the hamlet of Greystoke Gill. The footpath in question crosses three of D's (the Defendant's) fields in Millrigg Farm - Sealby's Field, Bank Field and Far Bank Field. C did not make a claim until almost three years after the accident.

1.1 The Farm

D had farmed At Millrigg since 1965. Since 1991 the business was beef and sheep. Grazing in Sealby's and Bank Fields were 20 cows (7 Simmentals,

This article is based on a paper presented at the ROOTS Conference 2010, but substantially revised with the help of advice from two anonymous reviewers.

11 Simmental cross, one Aberdeen Angus cross and one Limousin cross). D held one Simmental bull so some calves were Simmental, most were cross (with some Friesian but predominantly Simmental). The calves at the time of the accident were between 5 and 9 months old.

The Wildlife and Countryside Act 1981 prohibits bulls of recognised dairy breeds from being kept in fields with public access.[3] Simmentals are not such a breed.[4]

Sealby's and Bank Fields were used for the grazing of cows and autumn born calves and Far Bank Field for silage. Some fields on the farm changed usage periodically. Others had usage constrained by condition, e.g. too wet or steep for machinery. There were several other footpaths crossing various areas of the farm.

1.2 The Route of the Footpath

The path leaves the garden of a Gallery by a stile leading into Sealby's Field. At the other side of the field is an opening in a dry stone wall (an 'ever open gate') by which to enter the next field. There is a track, which D unsuccessfully tried to establish was made by sheep, which would indicate to a walker to go straight from the stile to the ever open gate. This would be an incorrect route according to OS[5] map which has the path following the field boundary and leading to a stile (rather than the ever open gap in the wall). That second stile was not visible from the first stile on entering Sealby's Field. Again, in Bank Field the OS map has the path following the boundary until reaching a third stile leading from Bank Field to Far Bank Field.

There were footpath indicators with a notice 'Farmland - please close gates - please keep your dog on a lead - Thank You' between the Gallery and Sealy's Field. There was conflicting evidence as to when these signs were erected. There were no other signs over the farmland.

When C and her partner were first told about the footpath by locals, they were directed towards the ever open gate. They used the route at least, and probably more than, 20 times and were not challenged about taking the unofficial route.

1.3 Farming Practice

Calves born in the autumn and winter were wintered indoors and turned out to graze with their mothers in late April or early May after de-horning and castration. There were two creep feeders for calves (not accessible by fully grown cattle) in Bank Field and water was provided by a stream.

The May turnout had been customary since 1991 with no apparent accidents. There had been an incident in 1990 or 1992, the facts of which are unclear. On first turning out, the cows and calves would be frisky for an hour or so but soon settle down to graze.

1.4 The Accident

C had only used the footpath since December 2002 and was on holiday in early May 2003, thus had not seen cattle in the field before - only sheep. Having dropped her partner at the pub and done some chores, C planned to walk down the footpath to the pub, with her dog, to join him. Only C witnessed the accident and the judgment indicates that her recollection must, in part, be inaccurate.

The accident was discovered by D who went to investigate on his quad bike on hearing the cows making a commotion. D's wife made the HSE report from her husband's account - great weight was put on this account. D recovered C, who was being 'thrown about' by the cows. He brought C to the farm house, dialled 999, tried to make her comfortable on cushions in the yard and got neighbours to help. C was discharged from hospital in July 2004, over a year after the accident.

C was found some 50 yards from the designated footpath. D's wife noted that she believed that if C had been on the route of the footpath she would have been able to get away from the cows.[6] She also noted that it was known that people did use the 'short cut'. D was cross examined on the HSE report and confirmed his wife's statement. D expressed horror at seeing his cows throwing C around and had not seen anything like it before, considering that C was lucky to have survived.

Although it is acknowledged that there was no attempt to deceive by D, in the very open HSE report and other statements, it was notably criticised by the judge that D's legal advisers were misguided in leaving out certain aspects of evidence from an edited version of a witness statement in an attempt to strengthen D's case.

D indicated that he found C in the middle of Bank Field. C said she was attacked by the cattle in Sealby's Field. This cannot be correct unless the cattle pushed C up some considerable length of slope, pushed her through the ever open gate and then on up across Bank Field. Evidence from C's partner is that in Bank Field they habitually walked on a route which followed the OS designated footpath. D asserted that as C was found in the middle of the field she was taking a short cut. The court considered that on the balance of probabilities she had been following her usual route but had veered from it as the cows moved in.

1.5 Claimant's Route

C believed she was following the correct footpath route, as described to her by locals. Only when the original defence was served was a query as to the route of the path, and C's route, raised.

Photographs, of various dates but not at the time of the accident, show high nettles and other growth which would indicate that following the correct route might have been difficult.

1.6 Farming Decisions

D, as would any competent farmer, acknowledged the danger of cows with calves at foot, particularly in the presence of dogs. But he stressed that this is more with very young calves, i.e. spring born, which he consciously grazes in fields not crossed by public footpaths. His autumn born calves are indoors at this stage. The court accepted the decision making behind the positioning of spring born calves. It was not persuaded that such risk assessment was operative with autumn born calves where the convenience of available land seemed to be a higher priority to D. He stated that otherwise the cattle would have to be in three separate (rather than abutting) fields and would be more difficult to manage.

2 THE LAW

Possible Causes of Action

Occupiers' Liability Act 1957
Occupiers' Liability Act 1984
negligence
Animals Act 1971
Health and Safety at Work, etc. Act 1974

2.1 Occupiers' Liability Act 1957

The Occupiers' Liability Act 1957 imposes a duty[7] on the occupiers of premises to take such care as is reasonable to see that lawful visitors are reasonably safe for the purposes for which he is permitted on the premises. This duty does not extend to risks willingly accepted by the visitor[8].

Lawful visitors are those who either have express permission or, as with users of a public footpath, a legal right to be there[9]. As C was found some considerable distance from the line of the path, was she a trespasser and so outside the protection of the 1957 Act?

Readers may be aware that injuries sustained by users of public rights of way[10] generally do not have the protection of the 1957 Act.[11] That exemption indicates that there is normally no duty owed in respect of *non*-feasance,[12] e.g. not filling in a hole, but there remains a duty for *mis*--feasance. Thus, where injury is sustained due to something the occupier has actively done, in this case introducing livestock, then the basic statutory principles still apply.

2.1.2 Occupiers' Liability Act 1984

A duty is owed to persons *other than visitors* [13](within the meaning of the 1957 Act). The duty applies to those who enter land without authority and are therefore technically trespassers, and also to those who enter without permission but with lawful authority, e.g. persons entering land subject to an access agreement [14]or order in force under the National Parks and Access to the Countryside Act 1949 [15]and persons exercising a private right of way. The provisions follow the Law Commission's recommendations in their *Report on Liability for Damage or Injury to Trespassers and Related Questions of Occupiers' Liability* [16]which ascribes liability where the occupier is aware of the danger (or has reasonable grounds to believe that it exists), *and* they know (or have reasonable grounds to believe) that C would come into the vicinity of the danger *and* the risk is one against which D may reasonably be expected to offer some protection.[17] Where a duty arises under this Act that duty is to take reasonable care to ensure that persons do not suffer injury on the premises by reason of the danger.[18] This duty *may* be discharged by warning, although a warning does not *necessarily* discharge the duty[19]. It will be a matter of fact in the individual circumstances.[20]

So on the footpath D had a duty to keep C reasonably safe. Off the footpath D had a duty to take reasonable steps to protect C against injury arising from things done or omitted to be done on the land on or near the footpath, if he knew or ought reasonably to have known of the danger.

2.1.3 Which Act applies? Establishing Status of Claimant

Prima facie C was not on the footpath so must have been a trespasser, albeit unintentional. While most trespasses to land are intentional, trespass can also be committed negligently[21] or accidentally.[22] C followed the route explained to her by locals and also apparent to any observer due to the wearing of a path in the field. D and his wife were aware, as evidenced by their witness statements to the HSE, that walkers used this alternative route. There were no signs to indicate the correct route. It was successfully argued that D's implied consent, or lack of objection, to walkers using the alternative route prevented him from asserting that C was a trespasser. D later said he only rarely saw people using the short cut and on each occasion objected with those concerned. This did not appear to align with the earlier HSE Report.

Taking into account the apparently habitual use of the unofficial route, the appearance of the track in the field, the lack of signage, that anyone without an OS map would take the unofficial route, the knowledge of D that the short cut was used the court found the requisite degree of acquiescence such that D was estopped from claiming C was a trespasser.

As there was some evidence raised that there might have been some obstruction of the right of way, the judge went on to consider the right to deviate when a right of way was obstructed with particular reference to private rights of way.[23] *Halsbury's Law of England* [24]indicates the right to deviate from the public highway onto open land where the usual route is 'founderous and impassable'.[25]

So :Was D under a duty to keep footpath in good repair and passable?

The general right of repair is at public expense [26] and the court found no duty on D to repair the footpath.

Was there good reason for C to deviate?

It is likely that there were nettles in front of the stile and that the obvious alternative would be through the ever open gate. It was noted that the right to deviate is a matter of fact. It is irrelevant whether or not C knew the correct route and had consciously deviated.

2.1.4 What care would have been required if C had been a trespasser?

To take the three stage test in the Occupiers' Liability Act 1984,[27] D clearly knew of the danger, knew of the presence of walkers and the judge found that it was a danger against which D should reasonably be expected to offer some protection.

Due to the absence of signs, many people would be likely to trespass without meaning to do so, which D knew, and many walkers would not appreciate the danger of cows with calves. The danger, given a cow's size and weight, would be likely to be severe.

Although not tested in court, it might be that signs alone *would* offer an adequate defence against a claim by trespassers in a situation where there was not suggestion of public access.

2.2 Negligence

The basic principles of negligence need not be set out in detail here. Suffice it to note that there is a three stage test such that it must be established that D owes C a duty of care, that this duty of care has been breached, and that the damage claimed for resulted from that breach and was of a broadly foreseeable nature. In fulfilling a duty of care D must take 'reasonable' care,[28] a measure of which would be industry good practice.[29] In this case, the point in question was that of breach and, in this respect, a number of claims were made. In ascertaining whether D had taken reasonable care it was asserted that

a. He failed to consider that cows with calves are more likely to react to dogs;
b. He failed to post adequate warning signs such that C could make an informed decision;
c. Allowing a Simmental bull materially increased the risk of unpredictable behaviour in the cows and calves - both veterinary experts disagreed with this point;
d. The likelihood of walkers taking short cut, with the attendant increased need for accurate signage, was not considered.

2.2.1 Duty of care

Given that C has been found to be a lawful visitor, it needed to be established that D had taken 'reasonable 'care' A number of cases were considered which underlined the point that there is *no* duty to warn or protect against 'obvious risk'.[30] The court felt that walking across a field with cattle grazing, even with a dog, was *not* an 'obvious risk' to the average citizen with no specialist agricultural knowledge, thus some warning or protection should have been given.

2.2.2 Did C consent to the risk?

She did not know there were cattle in the field on entering. C did, actually, come from a farming family and she knew cows could be dangerous but did not appear to know of the additional danger of calves at foot, especially when faced with a dog.[31]

2.2.3 Contributory negligence

Not unexpectedly, the defence raised arguments of contributory negligence,[32] i.e. the principle that the claimant's own lack of care directly caused or contributed to her injuries :

Claim - C did not try to escape over stream or in creep feeder. This was found to be impractical and/or ineffectual and was rejected.

Claim - If she followed the footpath she would have been less vulnerable The veracity of this was rejected on expert evidence.

Claim - C should have retraced her steps once realising cattle were there. It was found that (a) her position would make this unfeasible, (b) she did not know that cows with calves were a danger.

Claim - the dog was on an extended lead and not under complete control. This was rejected.

2.2.4 What should D have done to comply with his duty under OLA 1957?

Clearly, following the published NFU and HSE guidance which warns against putting cows with calves in fields with public access, would be key. In short, either put up temporary fencing or use other fields. The dangers of walkers with dogs might be rare but leave a farmer vulnerable if a walker is injured. The situation is susceptible to the most sensitive animal in the herd, who others will follow if it becomes agitated.

Warning signs - helpful, indicators of good practice but not the only answer.

Fencing - ideal, but likely to be impractical for reasons of time and expense in many instances.

Other fields - relatively easy to arrange on this farm, but that will obviously not be the case universally.

It might be noted that there have been other cases in recent years where a farmer has been found to be negligent for lack of due care when managing livestock in a way which most industry observers would consider to be good practice. In the Court of Appeal it was decided in *Wilson v Donaldson* [2004][33] that a farmer, who had good fencing and regularly checked stock, should have had self-closing gates due to the possibility of walkers leaving gates open, leaving him liable when the cattle got onto the public highway. There is clearly room for concern as to what the courts will see as negligence in a farming context.

2.3 Animals Act 1971

The Animals Act ascribes liability, in certain circumstances, in the absence of fault. Under this Act (to take the relevant elements) it must be established that damage, if caused, is likely to be severe.[34] Clearly this is the case with cattle, due to their size, weight, potential speed, the likely use of their heads as a weapon and their habit of trampling.

It must then be established that the likelihood of damage is either due to known characteristics of the animal in question (e.g. it has a history of aggression) or is due to characteristics found at particular times or in particular circumstances,[35] e.g. with calves at foot. This accords with the view taken in *Mirvahedy v Henley* [2003].

Were those characteristics known to D? Yes (or should have been).

Do any of the s5 defences offer D any protection?

(1) Was the injury wholly due to C's fault?
(2) Had C voluntarily accepted the risk?

In *Cummings v Granger* [1977],[36] it was held that to prove someone has voluntarily accepted the risk it must be shown (1) that they fully appreciate the risk, and (2) that they, thus, voluntarily exposed themselves to it. it was held that C did *not*, and cannot have been expected, on an objective standard, to have appreciated the risk.

There have been other cases where the s5 defence of voluntary acceptance of risk has succeeded (e.g. *Freeman v Higher Park Farm* [2008][37]) but in the *McKaskie* case the judge found that s2(2) of the Act was satisfied and none of the s5 defences to be operable.

2.3.1 In the absence of lack of care, can Animals Act strict liability be justified?[38]

The underlying reasoning behind civil actions for damage caused by animals has classical Roman roots in Ulpian's:[39] man should not use his own property so as to hurt another.[40]

Although, as was heavily reported in the press following *Mirvahedy*, it perhaps seems *prima facie* to be 'unfair' to ascribe liability without fault when there is every evidence of due care, this was specifically explored in the thinking behind the Animals Act in a number of preceding reports and papers.[41] In short, although the defendant may not be at fault, the claimant certainly is not [42]and, on balance, with whom should liability and the insurance burden lie?

The law had long imposed strict liability in cases of cattle trespass, i.e. where certain kinds of animals stray on to the land of another. Under the old doctrine of scienter,[43] strict liability also arose in regard to injury caused by a domesticated animal where it could be established that the defendant knew that the animal had a vicious or mischievous propensity. This tort of strict liability was referred to in *Rylands v Fletcher* [44] and although that rule would only embrace animals of a dangerous species,[45] not those of a domesticated species with a dangerous disposition, the thread of legal reasoning is clear : reflecting the reciprocity theory of tort, if one takes risks or actions (e.g. by animal keeping), one must bear the burden of resultant damage.[46]

There have been several attempts either to remove [47] or temper the strict liability element of the Animals Act. Defra consulted with industry on the matter in 2009.[48] This retained strict liability for claims involving animals which are known to show characteristics 'unusual' to their type, i.e. that are particularly vicious. The revised provisions contain a classification of ‘conditional’ characteristics. These are those characteristics generally shared by the species but only in particular circumstances. There would be strict liability here *unless* the keeper can shown that there was no particular reason to expect the particular circumstances that provoked the conditional characteristic would arise at that time. In March 2010 a response was published, which indicated that there was no clear support for the new revision. The conclusion is that Defra will prepared a revised Legislative Reform Order [49]and seek further views from respondents to the original consultation in order ‘…it is hoped, agreement, on an acceptable way forward.[50]

Suffice is to say that the proposals as they stand would not have helped the defendant in *McKaskie v Cameron* (disregarding any lack of due care) once the behaviour of cows with older calves was accepted, in that it *would* be expected that cows with calves could be aggressively protective and it *would* be expected that walkers with dogs might be on a public footpath.

2.4 Health and Safety at Work etc. Act 1974

The Health and Safety Executive (HSE) Inspector considered the duty, subject to criminal charges, of D under the Health and Safety at Work etc. Act 1974 [51]to ensure that third parties are not put at risk from their work activities. He stressed that his discussions with D and his wife revealed their ‘extensive knowledge’ of farm health and safety. He concluded that D recognised where the risks lay in keeping cattle in fields and had taken reasonable practicable steps to manage the risk. The HSE decided not, therefore, to pursue a criminal action under the Health and Safety at Work etc. Act. The court noted that the lack of eye witnesses would have been detrimental to the criminal standard of proof [52] required for such an action.

Given both the different standard of proof in the civil court and the solely persuasive value of the HSE Inspector’s report, the court noted that it was not bound in its consideration of other areas of law by the HSE’s apparent preference for the defence case.

It may be noted that the HSE investigations of similar incidents were referred to in the case, the vast majority of which involved cows with calves and walkers with dogs.

3 RISK MANAGEMENT AND GOOD PRACTICE

The court considered industry guidance and the opinions from expert witnesses (farm management and veterinary). Their views and conclusions point towards general good practice and risk management in this area.

3.1 Cattle and Public Access in England and Wales [53]

Produced by the HSE, this leaflet stresses the potential dangers of all large animals and, regarding the decision to put cattle in fields with public access it advises :

consider whether cattle should be in fields with public access at all, based on both the nature of the cattle and the level and nature of public use;

consider whether animals are generally placid;

assess whether young calves will affect cattle behaviour;

consider whether temporary fencing would be practicable.

If the decision *is* made to put cattle in a field with public access suggested precautions include :

check fences, stiles and gates;

check that paths are clearly marked;

check cattle at least once a day;

it is good practice to display signs;[54]

remove or cover inappropriate signs (e.g. 'bull' signs left simply to deter public use).

3.2 Livestock on Rights of Way : A Guide to the Law[55]

The NFU document was produced in 2002. The advice is against putting cows with calves in fields with public access without some suggested precautions, in the light of the *Mirvahedy v Henley* [2003] Animals Act 1971 judgment.[56]

The advice was :

where particular animals are known to be aggressive or there is a general risk of aggression, e.g. cows with calves, then either have the herd away from public footpath or erect temporary fencing;

also consider placing signs at all entrances:

it is not acceptable for signs to indicate that people enter at their own risk;

signs should be removed as soon as they become redundant;

it advises they check wording with the HSE agricultural specialists at Stoneleigh;[57]

the HSE document noted above is recommended.

The guidance makes the point that if signs indicate that an animal is aggressive or dangerous it should not be in the field anyway. Misleading or intimidating signs are not permissible.

3.3 Farming Management and Practice Experts

Both expert witnesses on farming management and practice agreed on :

the mix of livestock that were in the field;

that cows and calves bellow constantly for a few days after separation;

that the bull was not involved in the accident;

that continental breeds are less reliable and docile than native breeds;

in suckler herds, the breed is less important to temperament than management and handling;

that cows can be unapproachable for the first month after birth.

The main disagreement was at what point the cow and calf bond reduces such that there is little behaviour danger in the relationship.

3.3.1 Farming Expert for C - Mr Marshall

The expert for the C, Mr Marshall, noted that it was incumbent upon cattle keepers to assess their particular cattle and to take into account that most footpath users will have no specialist knowledge of livestock. He suggested that mothers will defend young well over 12 months of age, quoting examples of how cows separated from older calves still bellow on separation, and a cow separated at six months still allowed it to suckle when they were re-united when the heifer was two years old. He also mentioned the well publicised availability of signs available from agricultural suppliers such as 'Caution – farm livestock and young'. He noted that D knew :

continental cattle are known to be less placid than native breeds;[58]

cows were out with calves;

walkers could have dogs with them.

He also knew, or ought to have known, about the NFU and HSE leaflets about keeping livestock in fields crossed by public footpaths. He expressed surprise at the HSE decision. He felt that, although not implicated in the accident, the presence of the bull with no warning signs evidenced a lack of proper risk assessment. If, which was not the position in this case, there was no possible alternative fields for the cattle then Mr Marshall would have expected warning signs regarding the cattle, signage for the footpath route and a check that stiles were usable, even if temporary fencing was not practicable, concluding that D had not acted in a way which would have been expected from an experienced and prudent farmer.

Mr Marshall answered questions that clearly had the Animals Act in mind to the effect that statements about the cows tossing and head butting C were in character with cows in such a situation and that injury from such an attack was likely to be severe, given the weight of cows being around 650kg – 750kg and speed being up to 25 miles per hour over short bursts.[59] He indicated that such behaviour was not normal in cows but was normal in particular times and/or particular circumstances,[60] i.e. the circumstance of having calves and C having a dog. Mr Marshall found D to be a competent farmer of many years experience who had received formal training at agricultural college and who understood good stockmanship. It was thus concluded that he would have known of the HSE and NFU advisory leaflets.

3.3.2 Farming Expert for D - Mr Pitchford

Part of Mr Pitchford's evidence was that the farm was typical of Lake District farms. The judge doubted the application of statistics in reaching this conclusion. He also doubted the relevance of the statement that the relationship between the many visitors to the Lake District and farmers normally works well. As a matter of fact, most farming in the area was upland sheep – lowland cattle were *not* typical of the area.[61] The statement that a stream formed a natural barrier to keep the bull and other cattle out was also discarded – in the light of Mr Marshall's statement that cattle could easily cross the stream, the judge found 'something strange' about Mr Pitchford's assertion. Mr Pitchford said that the considered decision to put older calves with cows, and a bull, was a reasonable one. He also stated that there was no statutory obligation to erect signs and that a reasonably prudent farmer would not think signs to be necessary. Mr Pitchford was cross examined on the prudence of signs and his responses, such that there was never a need for signs as anything particularly dangerous should not be in a public access field, was discarded. The judge was concerned as to whether Mr Pitchford understood that his duty as an expert witness was to the *court* rather than one or other of the parties.[62]

In cross examination Mr Pitchford could not but agree that there were heightened risks in various aspects of the situation which have already been explored, i.e. calves at foot and walkers with dogs

After hearing the experts the judge considered how likely danger had to be before preventative measures were required within the OLA 1957 requirements of reasonable care.

3.4 Veterinary Experts

The two veterinary expert witnesses agreed in certain areas set out in a joint report, most of which has been covered above :

even placid cattle can be aggressive in certain circumstances;

cattle can cause serious injury due to their size, even if not intentional;

increased handling tends to make animals more docile;

beef animals tend to be handled less and are less docile than dairy breeds;[63]

continental breeds tend to be less docile;[64]

suckling enforces the cow-calf bond;

dogs are a predator species to cattle and their reaction, even to a well behaved dog, is hard to predict;

almost all HSE data on death or injury to walkers across fields caused by cattle involved dogs and Continental breeds of cattle.

3.4.1 Veterinary Expert for C - Mr Dobbs

In addition to the above agreed points, Mr Dobbs stressed that behaviour as exhibited by D's cattle in the accident was not uncommon for Continental breeds. He recommended that cows with calves not be kept in fields with public access and he noted the disturbing effect of dogs on cows with calves. The vet spent some considerable time explaining the strong bond between cow and calf, often re-established after some considerable period apart. He asserted that this bond was as strong with a 5 – 7 month old calf as with one of less than one month old. He said, under examination, that the bond was very strong until weaning - up to 12 months of age.

When posed with a threat in the form of a walker and, more particularly, a dog, in the confined space of a field with calves at foot the normal response to the 'flight or fight' instinct would be to fight.

Mr Dobbs concluded that the behaviour of D's cattle was not unusual for this breed in the given circumstances. He noted that tossing a body around was not 'normal' but was not an unusual form of aggressive behaviour in the face of stress. Clearly, given a cow's size and weight, injuries caused were likely to be severe. Mr Dobbs particularly noted the effect of the cattle being in a new field - they had only been let out to graze, after over-wintering indoors, 8 days earlier and there would have been an additional element of stress due to the recent castration of the calves. He also stated that the physiological effects of castration and disbudding can last for some weeks.

Mr Dobbs was particularly firm on the fact that whilst the cow-calf bond changed over time, it did not diminish.

3.4.2 Veterinary Expert for D - Dr Andrews

Dr Andrews, in discussing the temperament of various breeds found that the Simmental does not have a negative reputation. He did *not* agree with Mr Dobbs and others that all Continental breeds are more difficult than native breeds. He indicated that breeding, rearing, handling and the situation all have an effect. Dr Andrews felt that the cow-calf bond *did* reduce after the calf was a month old. The court doubted Dr Andrews' basis for this statement which seemed largely to be a study of Japanese Black cattle - a different breed and with no evidence of a dog. He acknowledged the effect of the presence of a dog.

The court commented that Dr Andrews referred to D and other witness statements (of parties not called for cross-examination). This was not veterinary evidence.

Dr Andrews disagreed with Mr Dobbs in that he felt that if C had walked on the designated path, round the edge of the field, she would have been less likely to have got into difficulties.

The judge, in commenting of Dr Andrews' representations about the dog appeared to discount the possibility of the dog having barked or otherwise disturbed the cattle, even if well behaved and on a lead.

Although the expert's understanding of their role was referred to by the judge with reference to Mr Pitchford, he made a far more overt statement of disquiet regarding Dr Andrews : 'I have to ask how independent a witness is Dr Andrews?'[65] As well as denouncing Dr Andrews' attempt to consider 'what may or may not have occurred [66] he finds that Dr Andrews is 'plainly wrong' in the conclusions he draws from photographs regarding what C could see on entering the fields, and also regarding the possible safety of the stream or entering a creep feeder. The court also rejected a hypothesis of Dr Andrews that the cows approached in a curious, rather than aggressive manner, and the injury was caused by C losing her footing. He felt that this was not consistent with the 'fight or flight' instinct.

The judge seemed very ready to reject the idea that cattle might be boisterously curious rather than making a direct attack.

Dr Andrews particular stressed that the cow-calf bond at this age should not have been strong and that there was no indication of why D should not have put his cattle in these fields. This does not take into account HSE guidance on precautions. The nub of Dr Andrews' opinion is the strength of the cow-calf bond in animals of 5 months or more.

In answer to some of the particulars of negligence (as amended) Dr Andrews' view was:

> D failed to have adequate signage allowing C to make and *informed* decision.
>
> Dr Andrews felt that to put such a sign would be to admit animals are dangerous.
>
> D kept a Simmental bull in the field which C claimed materially increased the risk of the cattle's behaviour being unpredictable.
>
> Dr Andrews asserted that the presence of a bull would have a calming effect on the cattle.

> The court agreed with the vets' joint report that the bull had no relevance to the accident.

D, having decided to keep cow with calves and a bull in a field with public access, did not appreciate the risk of walkers going across the worn track in the middle of the field rather than keeping to the proper route round the edge.

Mr Dobbs felt that the route was irrelevant, that the cattle would have reacted in the same way to a walker with a dog on the field margin.

Dr Andrews felt that they would have been more prominent on the correct footpath - which seems somewhat odd.[67]

Dr Andrews referred to C's statement about the animals 'trotting' towards her, which he felt indicated curiosity rather than the 'fight' instinct. The court noted that her statement said 'trotting towards her with a purpose' which were felt not to be inconsistent with aggression rather than mere curiosity.

Dr Andrews felt that D's description of what he saw did not indicate aggression - the court felt that a description of something being thrown about 'like a rag doll' did indicate aggression.

Dr Andrews acknowledged that a suckler herd grazing in a field with public access posed a risk, in comparison with a dairy herd, but that the risk reduced as the calves got older, although still present at the time of the accident. The dog would also be a risk factor. He stated that although not all cows and/or calves would react badly to a walker with dog, if some reacted then the others might well join in.

3.4.3 Judge's conclusions on expert evidence

The court favoured Mr Marshall as agricultural expert.

The court favoured Mr Dobbs as veterinary expert.

The court noted that three of the experts felt that continental breeds are less reliable than native breeds whereas Dr Andrews did not. The judge also criticised Dr Andrews for ruling out the possibility of the cattle aggressively instigating the accident (rather than the dog setting them off). Dr Andrews appeared to ignore witness statements of those who had previously encountered the cattle behaving aggressively.

The judge preferred Mr Dobbs evidence that whether the walker was on the field edge or middle made no difference to the situation. Dr Andrews said the walker would have been worse on the correct path.

On the cow-calf bond, the judge, favouring Mr Marshall and Mr Dobbs, felt that the bond lasted at least 7 months and that this should be the consideration in respect of the OLA 1957.

3.5 Knowledge and understanding of the farmer

Evidence from the HSE and the NFU about the circulation of risk assessments and instructional leaflets and documents available as a result of membership, together with the HSE Inspector's opinion as to the general level of agricultural education and managerial competence of D, indicated that D was highly likely to have seen such documents.

A general knowledge of such incidents to be gained from the press was not imputed as most such accidents were reported after the incident in question.

3.6 Warning Notices

What wording would protect D from liability, given the potential legal exposure which a sign could engender? There are a number of contra-indications regarding the wording of signs :

- Animals known to be dangerous (whether as a type, such as dairy bulls, or as individuals) should not be in a field with public access so a notice would not offer legal protection.[68]
- Wording should not be so dramatic as to discourage public access.[69]
- Wording should not be so vague as to offer no real purpose.[70]
- Members of the public with little knowledge of agriculture would not ascribe a meaning of warning to a sign indicating 'livestock with young'.

C said she would have chosen a different route if there had been *any* suggestion of a problem with the stock.

Following the reports of the case in the summer of 2009, the NFU introduced signs indicating : 'Your dog can scare or harm farm animals - Keep it on a lead around livestock, but let go if chased by cattle.[71] Reviewing the wording with a consideration of the above issues indicates that the signs seem to fulfil the purpose intended, of warning the public of dangers and avoiding unnecessary risk, without further legal exposure.

4 CONCLUSION

4.1 The judge's concluding remarks

The judge made some unhelpfully vague comments (which he stressed did not form part of the judgment) on the conflict of interest where a footpath crosses grazing land, between the public and the land owner/occupier, with there being a balance between farmers' and walkers' interests such that farmers should not keep cows with calves in fields when walkers wanted to use them - which, given the nature of public rights of way, seems to be all but meaningless. He ignored existing provisions regarding the right to plough up footpaths, subject to reinstatement.[72] On balance, he felt that the publics' rights should prevail.

4.2 Practical Implications

For those with farm management responsibilities, it is clear that industry guidance from the NFU and the HSE provides the basis for managing stock in land with public access. The NFU signs give wording which would appear to fulfil both their intended purpose of protecting the public and fulfilling the occupiers' duty of care. The *McKaskie* case, and others discussed above, do give a clear view of what might be considered 'reasonable' care in terms of the age and breeds of cattle. The conclusion of the length of time a cow-calf bond persists might be a concerning view for farm managers but more evidence is needed if it is to be rebutted as future courts will doubtless consider this case. The Animals Act continues to play a part and any proposed changes are not likely to have a major impact on situations such as were found in this case.

The judge's conclusions are certainly not universally accepted and many were hoping that there would be an appeal to hear the arguments reviewed, but for that we await another case, as Ms McKaskie settled out of court.

About the author

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Civil Procedure Rules
Countryside and Rights of Way Act 2000
Health and Safety at Work etc. Act 1974
Health and Safety (Safety Signs and Signals) Regulations 1996
Highways Act 1980
Law Reform (Contributory Negligence) Act 1945
Legislative and Regulatory Reform Act 2006.
National Parks and Access to Countryside Act 1949
Occupiers' Liability Act 1957
Occupiers' Liability Act 1984
Rights of Way Act 1990
Wildlife and Countryside Act 1981

Notes

1. 1st July 2009, Blackpool County Court, claim no. 6NE04848.
2. Cumberland and Westmorland Herald, 29th January 2010.
3. s59. Bulls under 10 months old or not of a recognized dairy breed, or if with cows or heifers, are permitted.
4. s59 (4) 'Recognised dairy breeds' are Ayrshire, British Holstein, British Friesian, Dairy Shorthorn, Guernsey, Jersey or Kerry.
5. OS ref. x344605, y529609.
6. Doubted, as a matter of fact, in argument in response to claims that C in some way caused or exacerbated her injuries.
7. s2(2).
8' s2(5).
9. s1(2).
10. And, indeed, access land granted under s13 of the Countryside and Rights of Way Act 2000 or land set aside under the Access to the Countryside (Dedication of Land) (England) Regulations 2000 .
11. *Gautret v Egerton* (1867) LR 2 CP 371, *Greenhalgh v British Railways Board* [1969] 2 QB 286, *McGeown v Northern Ireland Housing Executive* [1994] 1 WLR 187,
12. See de Smith, S A (1949) 'Misfeasance and Non-Feasance.' *The*

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13. s 1(1)(a).
14. Under Countryside and Rights of Way Act 2002, see section 13.
15. s 60(1).
16. 1973, Cmnd 6428, which followed upon the modification of case law in *British Railways Board v Herrington* [1972] AC 877, [1972] 1 All ER 749, HL.
17. s1(3).
18. s1(4).
19. s1(5).
20 Wulff, Helge 'Recreational Access to Agricultural Land: The European Experience.' *24 Independent Law Review* 1641 (1990-1991).
21. *League Against Cruel Sports v Scott* [1985] 2 All ER 489.
22. *River Wear Commissioners v Adamson* (1877) 2 App Cas 743.
23. See Gaunt, Jonathan and Morgan, Pau l eds. (2008) *Gale on Easements* 18th ed. London : Sweet and Maxwell; *Stacey v Sherrin* (1913) 29 TLR 555, *Selby v Nettleford* (1873) 9 Ch. App. 111.
24. *The Right Honourable Lord*, ed. (2004) London : LexisNexis Butterworths at para. 208.
25. See *Arnold v Holbrook* (1873) LR 8 QB 96.
26. *Halsbury's Law of England*, paras 97 and 621.
27. Section 1(3).
28. *Blyth v Birmingham Waterworks* (1856) 11 Exch 781; *Donaghue v Stevenson* [1932] AC 562, [1932] All ER 1.
29. See HSE and NFU guidance under 'Evidence' below.
30. *Staples v West Dorset District* Council [1995] PIQR 439*; Trustees of Portsmouth Youth Activities Committee v Poppleton* [2008] EWCA Civ 646.
31. Kilgour, R and Dalton, **C** (2006) *Livestock Behaviour : a practical guide.* Oxford : CAB International.
32. Under the Law Reform (Contributory Negligence) Act 1945.
33. EWCA Civ 972.
34. s2(a).
35. s2(b).
36. [*1977*] QB 397, [1977] 1 All ER 104.
37. [*2008*] EWCA Civ 1185.
38. See the Law Reform Commission / An Coimisiún Um Athchóiriú An Dlí (1982) *Report on Civil Liability for Animals* (Dublin) for an

excellent review of the common law relating to animals.

39. Dometius Ulpianius (170 - c224 AD) was a Roman lawyer whose writings comprise about two-fifths of Justinian's *Digest* which formed the core of European legal education.
40. **Honoré, Tony** (2002) *Ulpian : Pioneer of Human Rights*. Oxford : Oxford University Press.
41. Law Commission Report on the Civil Liability for Animals (1967, Cmd 13), Lord Goddard's Report of the Committee on the Law of Civil Liability for Damage Done by Animals (1953, Cmd 8746), Report of the Law Reform Committee for Scotland (1963, Cmnd 2185) and Williams, Glanville (1939) *Liability for Animals.* Cambridge : Cambridge University Press.
42. Or if he / she is, that is adequately dealt with by the defence available in s.5(1) : 'A person is not liable under sections 2 to 4 of this Act for any damage which is due wholly to the fault of the person suffering it.'
43. Jackson, Bernard S (1978) 'On the Origins of Scienter'. *The Law Quarterly Review.* 94 (1978), p.85.
44. (1868) LR 3 HL 330
45. I.e. animals which would not be a 'natural' use of land, as is required for liability under the rules in the rules in *Rylands v Fletcher*.
46. Fletcher¸ George P 'Fairness and Utility in Tort Theory.' (1972) 85 *Harvard Law Review*, 537; Epstein, Richard A (1973) 'Theory of Strict Liability.' *The Journal of Legal Studies*, Vol. 2, No. 1 Jan, 1973,
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48. June 2009 Defra sought response to consultation document on amendment Bill, see www.defra.gov.uk/corporate/consult/animals-act/index.htm .
49. The mechanism for Ministers to amend existing legislation under the Legislative and Regulatory Reform Act 2006.
50. Defra (2010) 'Consultation on changes to the Animals Act 1971 to clarify the application of strict liability to the keepers of animals : full consultation response. March 2010. www.defra.gov.uk/corporate/consult/animals-act/summary-responses.pdf .
51. s 3(2).
52. *R v Majid* [2009] EWCA Crim 2563 and Keogh, Andrew (2009) *Crown Court Bench Book* : *Specimen Directions for Crown Court Cases*. Wigan : CrimeLine Publishing. ch 2, 'Burden and standard of proof.'

53. Agricultural Information Sheet no. 17EW (a similar sheet is available for Scotland - Agricultural Information Sheet no. 17S).
54. Refer to BS 5378, European equivalent and, where appropriate, Health and Safety (Safety Signs and Signals) Regulations 1996.
55. The court noted that as 'A Guide to the Law' it is of persuasive authority only. The guide was updated in May 2009 and the NFU have released further guidance notes for members, such as a briefing on the *McKaskie* case, 7th July 2009.
56. [2003] UKHL 16, [2003] 2 All ER 401.
57. But, as of September 2008, this branch no longer exists.
58. Although this was stressed as far more significant by the claimant's expert, and is not without controversy.
59. See www.britishsimmental.co.uk .
60. Animals Act 1971, s2(2).
61. See Defra (2009) *Agriculture in the UK 2008*, https://statistics.defra.gov.uk/esg/publications/auk/ . Released annually.
62. Civil Procedure Rules, Part 35.3 (as supported by Practice Direction 'Experts and Assessors') Experts – overriding duty to the court : (1) It is the duty of experts to help the court on matters within their expertise; (2) This duty overrides any obligation to the person from whom experts have received instructions or by whom they are paid. www.justice.gov.uk/civil/procrules_fin/ .
63. Simmental being large a beef breed, particularly in the UK : www.britishsimmental.co.uk/breed/.
64. See Grandin, Temple ed. (2007) *Livestock Handling and Transport*. 3rd ed. Oxford : CAB International and Stricklin, W R, Hesler, C E and Wilson L L (1980) 'Heritability of Temperament in Beef Cattle.'*Journal of Animal Science* 51 (Supp. 1) 109.
65. Para. 236.
66. Para. 238 - a job for the court not the expert witness.
67. Comment - could it possibly be that Dr Andrews is referring to the worn middle field path as 'the Footpath'?
68. This would constitute negligence and almost certainly strict liability under s2(2) Animals Act 1971.
69. Contravention of the National Parks and Access to Countryside Act 1949, s57.
70. Probably negligent.
71. Available in English or Welsh from NFU CallFirst on 0870 8458458.
72. Section 1(3) Rights of Way Act 1990, amending s134 Highways Act 1980.

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CONFERENCE PAPER[1]

WILL THE DIVERSITY OF RURAL ESTATES IN ENGLAND ENSURE FUTURE FINANCIAL SUCCESS?[2]

Ian Bailey

Primary research of over 200 rural estates in England and Scotland covering more than one million acres offers an in-depth insight into the resourcefulness of land managers. Rural estates are in themselves diverse property portfolios offering opportunities. However, there are constraints, such as location, and threats which include regulation.

The information derived from our ongoing research enables estates to benchmark themselves against the industry average. However, the benchmark report also includes sufficient physical information to enable managers to identify those aspects of the business which can be managed and those beyond the control of the business.

This paper reviews the historic data and explores the future trends for the key income streams, notably agricultural, residential, commercial and leisure in England. Ultimately an understanding of economic dynamics of the 'average estate' will enable areas of best practice to be identified.

Key Words Forecasts, gross income, rural estates, benchmark, income streams, land managers, diversity, financial success

1. Introduction

Warren Buffett said that it is only when the financial tide goes out that you discover who has been swimming naked. In contrast to banks and other highly leveraged businesses that have been savaged over the past two years, the recession has revealed most rural estates to have been well-clothed. The long-term thinking which lies behind the running of estates has served their owners well in straitened times. Will this continue?

The research for this paper is drawn from the Savills Rural Estate Benchmarking Survey. We believe our Estate Benchmarking Survey, which has around 200 participating estates, covering more than one million acres of land across Great Britain, is the largest and most comprehensive in the industry. It reports on the financial (income, expenditure and return on capital) and physical aspects of the estate business and covers the main business streams typical to rural estates – agriculture, residential and commercial/ leisure, analysing the let sectors in detail. The survey reports separately for England and Scotland.

1.This paper was originally presented at the ROOTS Conference 2010 – The Annual RICS Rural Research Conference – 13-14th April 2010, at Plumpton College, Sussex. It is reprinted by kind permission of the Royal Institution of Chartered Surveyors and the author.

2. In accordance with normal professional practice, this article is for general informative purposes only and does not constitute a formal valuation, appraisal or recommendation. It is only for the use of the persons to whom it is addressed and no responsibility can be accepted to any third party for the whole or any part of its contents. It may not be used as a basis for any contract, prospectus, agreement or other document without prior consent from Savills, which will not be unreasonably withheld. The findings are based on the assumptions given. As is customary with market studies, the findings should be regarded as valid for a limited period of time and should be subject to examination at regular intervals. Whilst every effort has been made to ensure that the data contained in it is correct, no responsibility can be taken for omissions or erroneous data provided by a third party or due to information being unavailable or inaccessible during the research period. The estimates and conclusions contained in this article have been conscientiously prepared in the light of our experience in the property market and information that we were able to collect, but their accuracy is in no way guaranteed.

The results of our 2009 survey show another rise in incomes despite the current economic climate. The diversity of rural estates and the resilience of agriculture to recessionary pressure has been a contributory factor, but the skills and resourcefulness of those who manage rural estates has also played a part.

The main objectives of estate owners, as recorded by the survey, are the long term retention of the core estate and income generation. These are closely followed by maximising the return on capital and then environmental stewardship. To this end this paper specifically looks at the sources of income generated on rural estates in England with the analysis concentrated on the three key sectors – agriculture, residential and commercial/leisure and for the years 2002 to 2009. Reference will be made to estate expenditure, net incomes and investment performance as these are essential elements of benchmarking.

Methodolgy

The survey is well established having commenced in 1996 and collects data each year analysing performance of the property assets of participating rural estates. Each year the survey analyses the results of participating estates with financial year ends in the 12 months to 5th April. The survey is essentially a management tool and participants are encouraged to use management accounts.

We believe that timely results are paramount to ensure businesses have the information required to respond to changing market conditions. To this end the main data submission period is March to May with reports distributed in the second half of July, meaning they are available for use at board or trustee meetings to review the year's performance.

All information is ring fenced within our research department, which has an established track record of preserving the confidentiality of participant data.

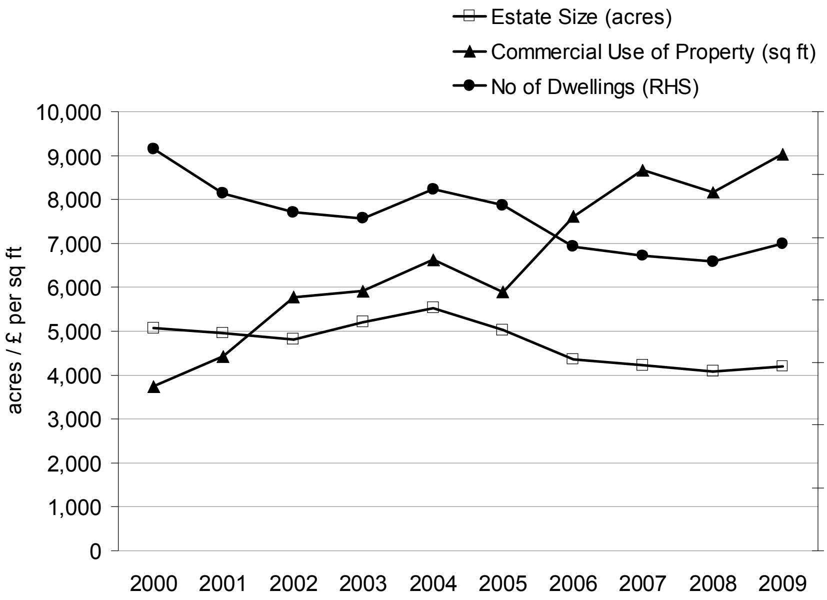
Since 2000 the average annual area participating in the survey across England has been over 650,000 acres and has a robust mix of private (70%) versus institutionally (30%) owned estates. Data is collected from over 7,000 residential properties and just under a million square feet of commercial workspace per year.

2. Estate structure

The average estate structure is illustrated Graph 1. The overall area of the average estate was relatively static at around 5,000 acres until 2005 since when there was some consolidation to around 4,200 acres. The total number of houses has also seen some contraction since 2000 although this has slowed since 2002 and in 2009 averaged around 50 houses per estate. In contrast, the average area of commercial workspace has significantly increased since 2000; reaching about 9,000 sq ft in 2009 although the rate of this increase has declined during the past few years.

The survey has recorded a shift in movement from the more regulated tenancy types to those which are more market orientated. In the agricultural sector the area let as Farm Business Tenancies (FBTs) has increased from around 20% of the let agricultural area to over 35% and similarly the

Graph 1. Average estate structure



Source: Savills Research

proportion of AST tenancies in the residential sector has increased from under 40% of all houses to around 48%.

3. Investment performance

Understanding the performance of an estate's property assets and how they compare with other assets (property or otherwise) is most important particularly in the current economic climate. Although agriculture and the rural economy generally tend to be more resilient to recessionary pressure than other sectors, knowing the return from capital invested is useful for strategic analysis of funds; especially for estates where there are also alternative investments.

The survey shows that the performance of all assets on rural estates came under pressure during 2009 recording a total return for 'All Let Property' of just 2.4% compared with 19% in 2008. However, when compared to other

Table 1. Total returns of comparable asset

12 months to:	Dec 2008	Dec 2009
All Let Residential	-13%	-7.3%
Urban Commercial	-22%	2.2%
Equities	-30%	30.0%
Gilts	15%	-0.3%
Forestry	7%	7% (est.)

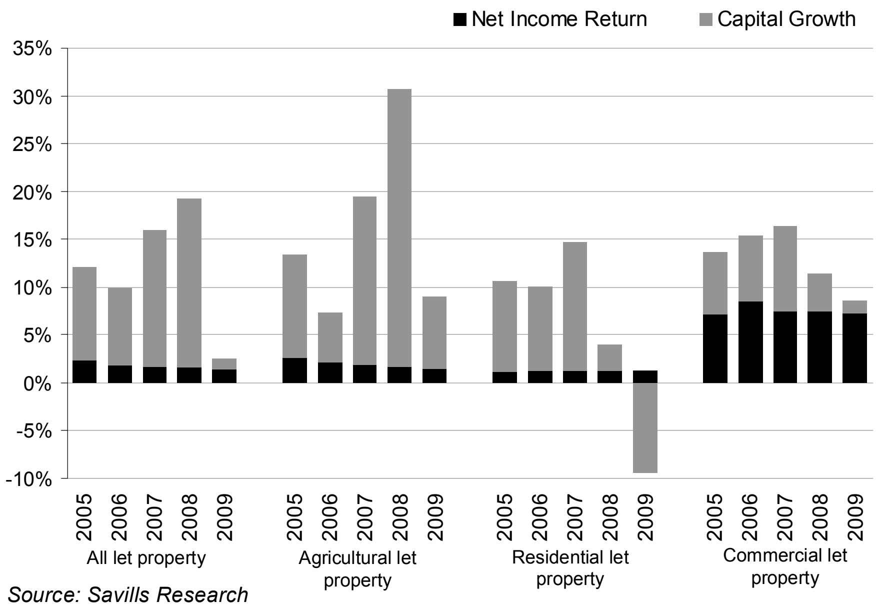
Source: IPD & Savills Research

asset classes, especially mainstream residential and commercial investments, and also equities the performance of rural estates was reasonable and at least remained in positive territory.

Graph 2 illustrates the performance of the let sectors analysed in our benchmarking survey. Let agricultural property recorded a healthy 9% return in 2009 although the softening of land values reduced this from the 30% recorded in 2008.

Commercial assets on rural estates also performed well with a total return of 8.6% in 2009 although, in contrast to agriculture, the performance was supported by income rather than capital growth.

Graph 2. Mixed assets on rural estates support performance



Source: Savills Research

Rural residential property however gave a total return of -8.2% as a result of capital growth falling by -9.4%, however, these results are better than for mainstream residential property.

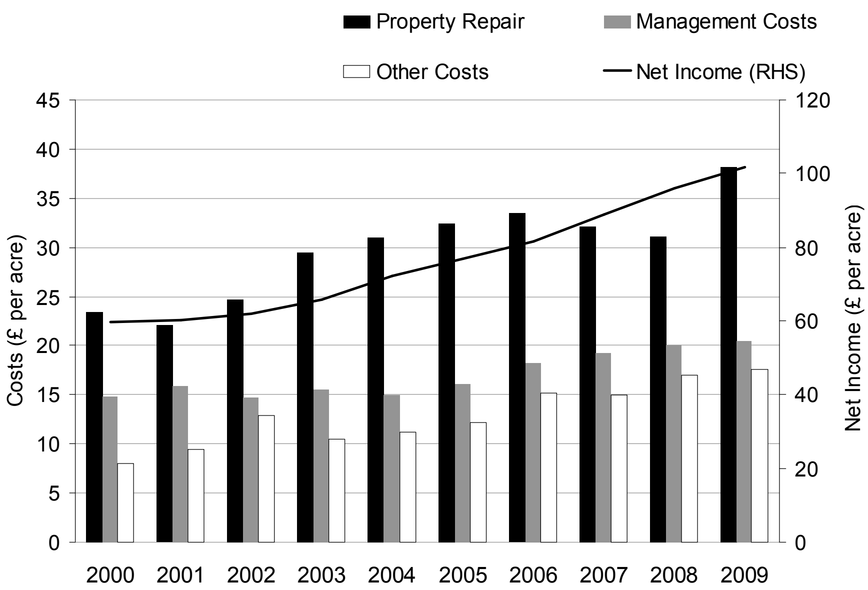
Diverse property types on rural estates and the resilience of farmland values to recessionary pressure have maintained investment performance above levels recorded in mainstream sectors. We expect the investment performance to be similar in the next 12 months as lower annual growth in farmland values is balanced by some improvement in residential values. Therefore the performance of rural estates will again be comparable to alternative assets as shown in Table 1.

4. Net Income

Our survey results show that the average net income (before depreciation, finance, drawings and tax) increased by 6% during 2009 to £102 per acre continuing the robust upward trend of the past decade. Net incomes across the regions show a similar pattern to gross incomes.

The rise in net income was due to an 8.3% increase in gross income but was tempered by a significant increase in property repair costs (see Graph 3).

Graph 3. Net income and expenditure



This resulted in an 11.6% increase in total expenditure on all estates during 2009 to over £76 per acre. This increase was significantly above the annualised increase of 4.5% recorded over the past three years.

Effective cost management and attention to detail to maintain income streams, as discussed later, will help ensure net income continues the upwards trend.

5. Expenditure

Property repairs increased significantly (22.5%) in 2009 to over £38 per acre. This was anticipated as the buoyant agricultural sector increased the willingness of estates to again invest in their farms. This is also confirmed by a substantial rise (30%) in the money spent on capital improvements amounting to £24 per acre in 2009.

Repairs to agricultural property increased by 65% in 2009 to £7.65 per acre compared with repairs to residential property, which increased 24% to £23.06 per acre. The agricultural property repairs were spread across all farm types but the predominantly dairy estates recorded the highest sums spent. These amounted to almost £24 per acre and were more than double those spent in 2008. In addition, estates with dairy farms spent another £20 per acre on capital improvements in 2009, up 26% on that spent in 2008. Pressure to upgrade slurry storage to comply with Nitrate Vulnerable Zones (NVZs) will no doubt have been a factor. The proportion of estates in the survey which are predominantly dairy has remained relatively static.

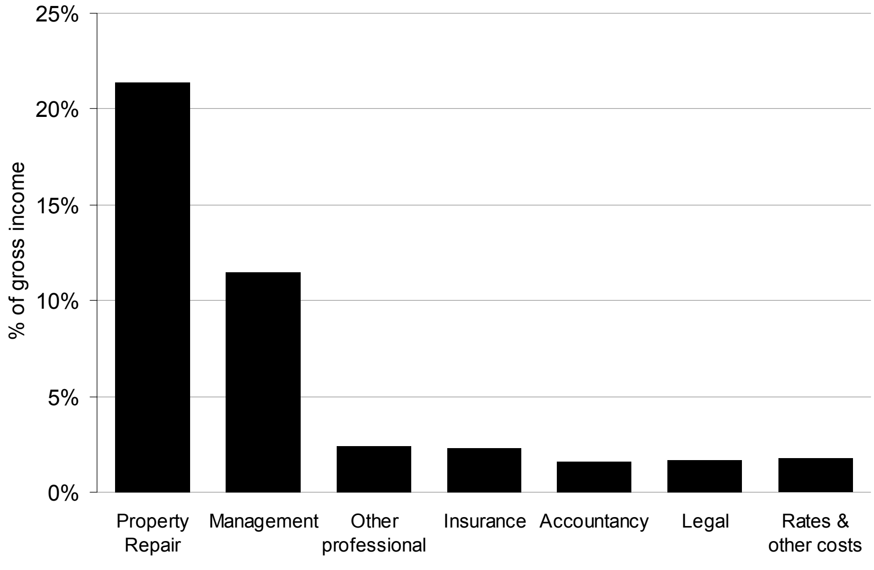
It is likely that the 2010 results will show repair costs falling back to around £32 per acre as recorded in the previous few years, which will slow the rate of increase of the rolling five year average. The five year rolling average takes out the annual volatility and records an annualised increase since 2000 of 4.9%.

Total management costs (cost of estate office plus management fees) continued to increase but were capped below inflation, rising 1.8% in 2009 on the average estate to £20.44 per acre. Our research suggests that savings are being made on management fees, which fell by 4% during 2009 compared with a substantial 10% increase in the cost of running estate offices. Outsourcing this facility may be worth consideration.

Other estate costs increased 3.4% to £17.58 per acre in 2009.

Graph 4 shows the key areas of estate expenditure and their proportion of gross income. Although expenditure, other than repairs and management, may be relatively small individually, collectively they add up to another 10% of

Graph 4. Expenditure as a proportion of gross income in 2009



Source: Savills Research

gross income.

6. Source of income

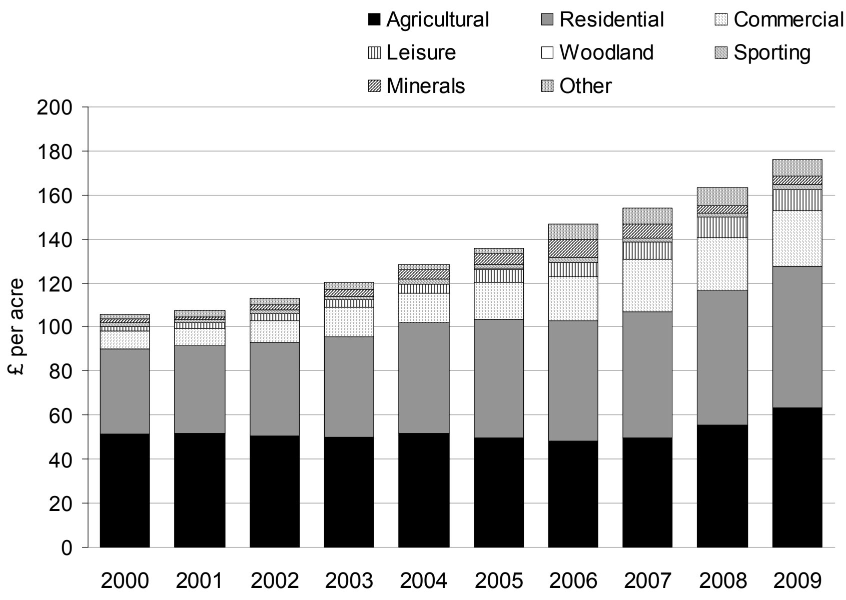
Our research shows that the financial performance of rural estates has remained buoyant and relatively unscathed by the recession (see Graph 5).

Average gross income on 'All Estates' increased by 8.3% in 2009 to £178 per acre. Increases were recorded across all income streams during 2009 but agriculture was the star performer.

Agriculture contributed 36% of gross income putting it back up to the proportion recorded in 2005, having slipped to under 32% in 2007. The contribution from residential assets slipped slightly to 36% with the proportion of income generated from commercial assets slipping below 15% for the first time in the past two years (since 2007).

Our analysis clearly illustrates the diversity of rural estates. This diversity largely stems from the various property assets which constitute a 'rural estate' and which offer the opportunity to extend income streams beyond those in agriculture. However, it should be noted that each individual estate is unique and the key is to identify all the resources available to the estate and then to exploit each one to generate income within the constraints of location, capital and management skills.

Graph 5. Source of income

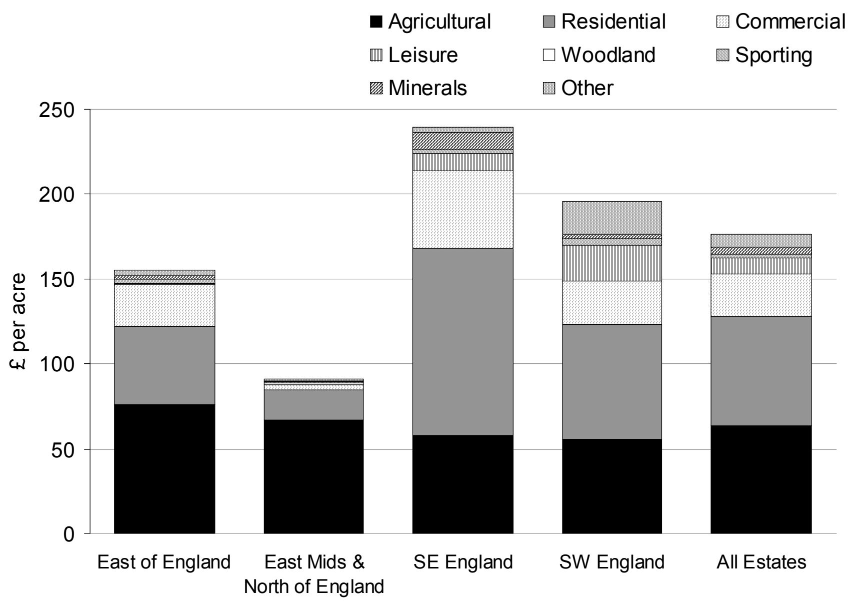


Source: Savills Research

Location is often a factor which boosts the potential of some income streams but limits others. Our research shows, as illustrated in Graph 6, that the opportunities outside of agriculture in the southern counties of England enable rural estates to outperform the average.

In the South East of England average gross income in 2009 was almost £238 per acre, a third higher than that recorded for 'All estates'. Greater levels of rental income derived from residential and commercial lettings were the key differences. In the South West of England tourism helped boost income in the leisure sector. This sector contributed significantly to the South West estates' gross income, pushing it up by 9% above the 'All estates' average.

Graph 5. Source of income by region



Source: Savills Research

In contrast, the greater reliance on agriculture and the fewer and more disparate areas of high population density in the eastern and northern counties limited gross income.

Although our survey has data going back to 1996 this paper will concentrate on the data collected since 2000 when commercial and leisure income data was reported separately as illustrated in Graph 5. A correlation analysis of this data (see Table 2) shows that there are three key areas of positive correlation.

1. Those very positively correlated i.e. 0.98 and above. Here the analysis shows an excellent correlation between residential and commercial income streams suggesting that the same skills and best practice can be rolled between these two assets – both require attention to detail with respect to repairs and capital expenditure, planning, marketing and interpersonal skills to maximise occupancy and rental levels. This suggests that as we move forward these two income streams will remain closely linked especially from a management perspective. Although tenant demand may differ between them.
2. Those with a strong correlation i.e. between 0.85 and 0.92. Here we see a strong relationship between residential, commercial and leisure

income streams with 'other' income suggesting, as in 1 above, that the entrepreneurial flair that drives more income from built property assets will also be looking for opportunities from all resources.

3. Those with a reasonable correlation i.e. between 0.60 and 0.66. Sporting enterprises often tend to be linked with the agricultural activities on the estates and a reasonable correlation would be expected. However, the tendency for activity in the mineral sector to be somewhat correlated to residential, commercial and leisure activities suggests that this may be linked to the core skills of the estate manager. Redundant quarries often open up new leisure opportunities, especially those that are water based.

Table 2. Income stream correlation (2000 to 2009)

	Agricultural	Residential	Commercial	Leisure	Woodland	Sporting	Minerals	Other
Agricultural	1							
Residential	0.52	1						
Commercial	0.45	0.98	1					
Leisure	0.53	0.98	0.99	1				
Woodland	-0.42	-0.15	-0.16	-0.17	1			
Sporting	0.65	0.44	0.32	0.38	-0.28	1		
Minerals	-0.24	0.64	0.66	0.60	0.21	0.20	1	
Other	0.46	0.85	0.90	0.92	-0.29	0.33	0.56	1

6.1 Agricultural Income

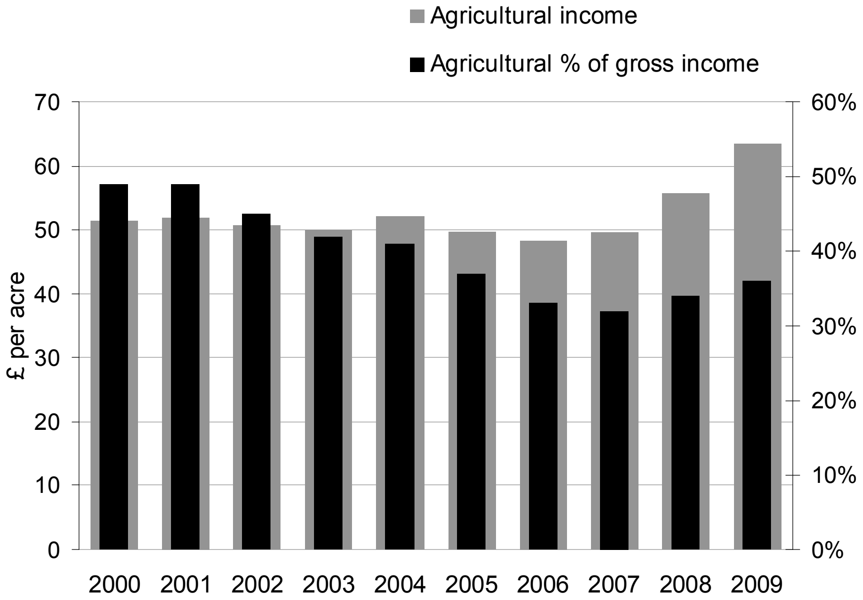
The survey shows that Agricultural Holding Act Tenancies (AHA) increased by 16% on all estates during 2009 to £75 per acre (£185 per ha) following an increase of 11% the previous year. The majority of this uplift was in the arable sector where average AHA rents increased 20% to £83 per acre (£205 per ha). We expect a further but smaller increase in average AHA rents in the next survey year.

Farm Business Tenancy (FBT) rents increased 4.7% in 2009 to £95 per acre (£234 per ha). The FBT area, as a proportion of the let agricultural area, increased again in 2009 to over 35%.

Average in-hand farm incomes (net income after deduction of property repairs, insurance, third party rents and interest on borrowed working capital) increased for the third year in a row to £110 per acre (£272 per ha). They now exceed both AHA and FBT rents for the first time in ten years. It is unlikely that this position will be maintained as profitability comes under pressure from falling commodity prices and rising input costs, but there are benefits from farming in-hand rather than letting out the land. These must however be balanced with the risk and the additional capital requirement. In-hand farming does give the estate more control and this might make new opportunities easier to implement.

Farmland is the core asset of the rural estate and provides a fundamental base to gross income. Our research shows that this sector has contributed around £50 per acre to gross income since 2000 although the upturn in agriculture pushed this up to £55 and £63 per acre in 2008 and 2009 respectively (see Graph 7). However, as also illustrated in Graph 7, agriculture now only contributes around 36% of gross income compared with almost 50% at the beginning of the decade.

Graph 7. Agriculture's contribution



Source: Savills Research

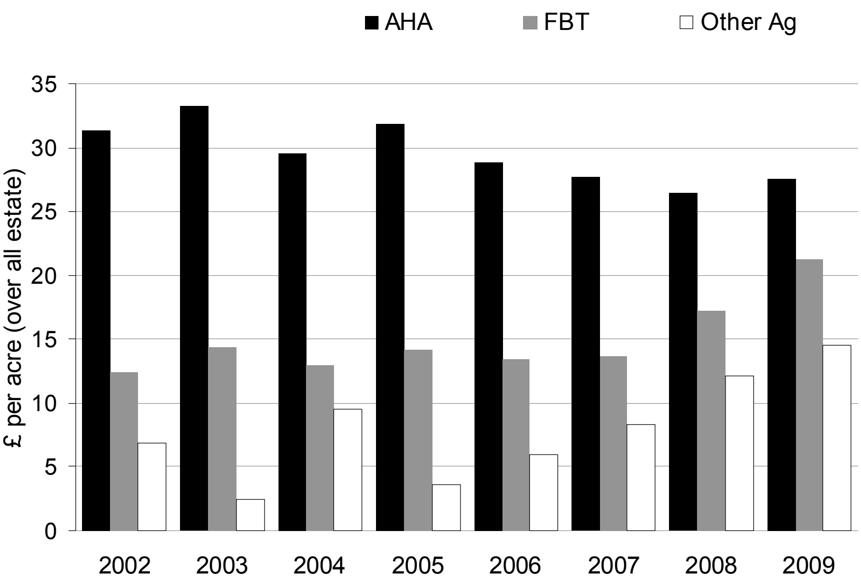
A very significant part of the agricultural income is derived from let farmland which principally includes AHA and FBT tenancies, and in-hand farming enterprises. Graph 8 shows that AHA tenancies are the main stay of the agricultural portfolio although this is changing with a shift to FBT tenancies and a more flexible approach to managing this part of the estate.

Income from AHA tenancies has fallen from over 60% of all agricultural income in 2002 to 43% in 2009. The slight increase in 2009 was due to a significant (16%) increase in AHA rents. In contrast, FBT income, which represented only a quarter of the agricultural income now represents over a third. The pattern has been similar for the FBT area as a proportion of the let agricultural area – moving from 21% in 2002 to 35% in 2009. Defra's June Census data for England confirms this trend with the total FBT area of England representing 33% of the total area rented in 2009 - up from 24% in 2002. The reversion of AHA tenancies is key to further enhancing the income potential of the agricultural sector of an estate.

6.2 Residential Income

Residential income continued to increase at a steady annualised rate of 4.1% per year during the three years to 2009. The average rental income, including 5.2% voids, from Assured Shorthold Tenancies (ASTs) was £7,428 per dwelling in 2009. Regulated rental incomes increased by 7% in 2009 to £4,278 per dwelling.

Graph 8. Contribution by tancy type



Source: Savills Research

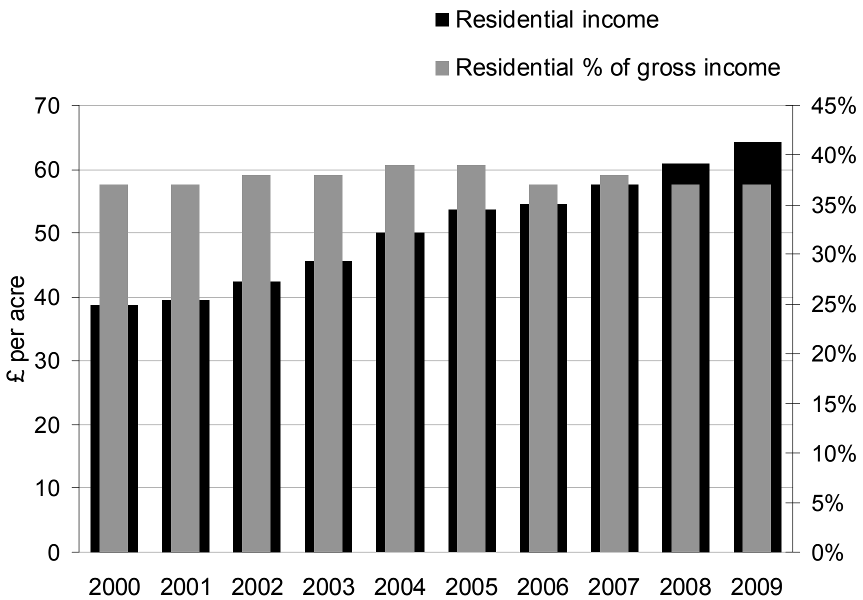
ASTs represented 73.6% of all housing stock in 2009, up from 72.5% in 2008, maintaining the steady upward trend. There was evidence to suggest some pressure on AST rents, with voids increasing from 4.7% in 2008 to 5.2% in 2009. We expect this pressure to continue into 2010 as the current economic climate impacts on voids and rent arrears.

Our survey recorded average AST rents of over £9,500 per dwelling in the South East of England in 2009 although these had come back slightly (1%) from the preceding survey year. AST rents fell a significant 10% in the East Midlands and North of England to around £4,800 per dwelling. In contrast, AST rents increased in the East (10%) and the South West (8%) of England to £6,660 and £7,790 respectively.

Income from the estate's residential assets has steadily increased to just under £65 per acre but, as total gross income has increased, the proportion this represents has remained steady at around 38% - see Graph 9. Residential assets are an important part of the estate portfolio with the average estate having around 50 houses. However, it is an area which must not be ignored. In 2009 only two-thirds of houses produced any direct rental income and a quarter of these were let at sub market rents. Almost 30% of all houses are tied up in farm tenancies or are used for estate employees and the remaining 8% produce no income at all.

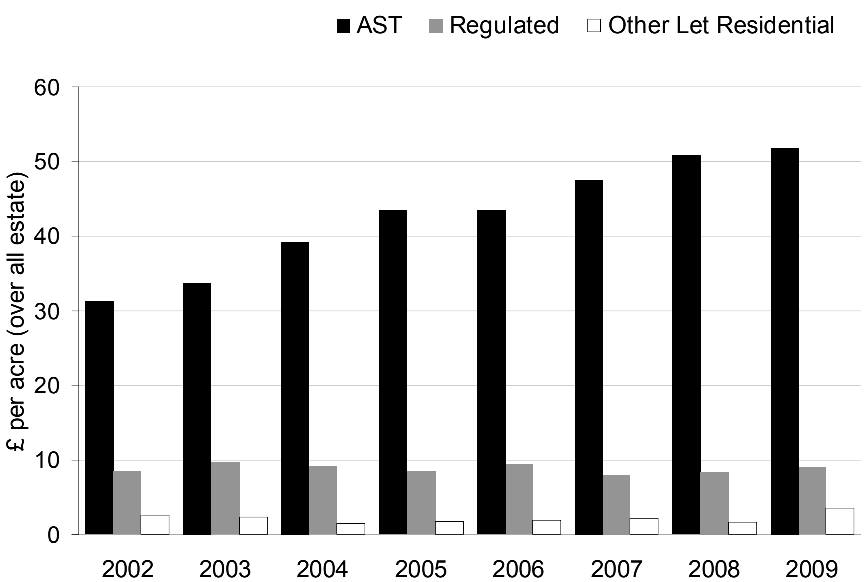
Estates have been proactive in increasing AST rental income as illustrated in Graph 10. Income sourced from AST rents now represents over 80% of all residentially sourced income; an improvement from the 74% recorded in 2002. Regulated and other residential rental income has been relatively steady for the past decade.

Graph 9. Residential contribution



Source: Savills Research

Graph 10. Contribution by tenancy type

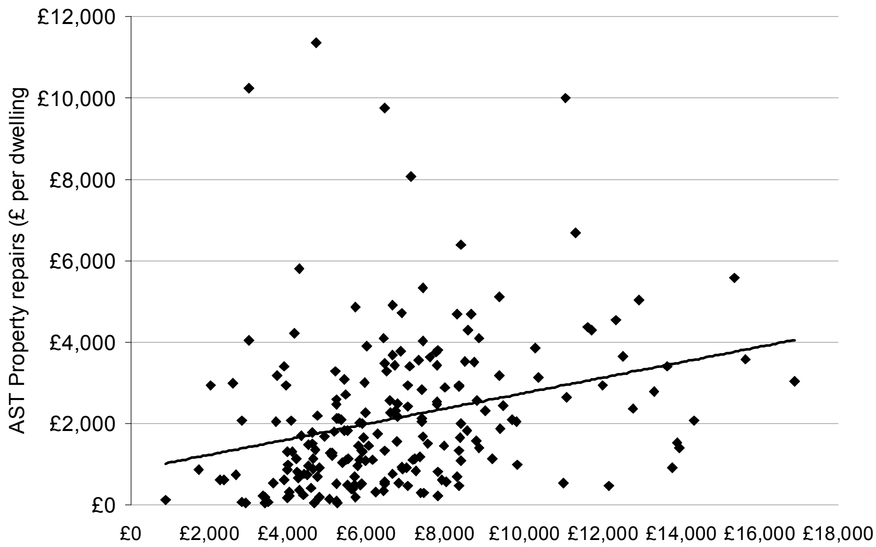


Source: Savills Research

6.2.1 Repairs

Our research (see Graph 11) shows that there is only a weak positive correlation between the amount spent on AST property repairs and AST rental income. This suggests that careful planning and targeting of repairs is necessary to maximise returns and that indiscriminate expenditure on repairs does not necessarily guarantee increased income. However, there is a cost to maintaining good order to ensure current rentals levels are sustained and to reduce voids. In addition, a well maintained property will hold its capital value and will be more saleable if a future need should arise.

Graph 11. AST repairs v AST income



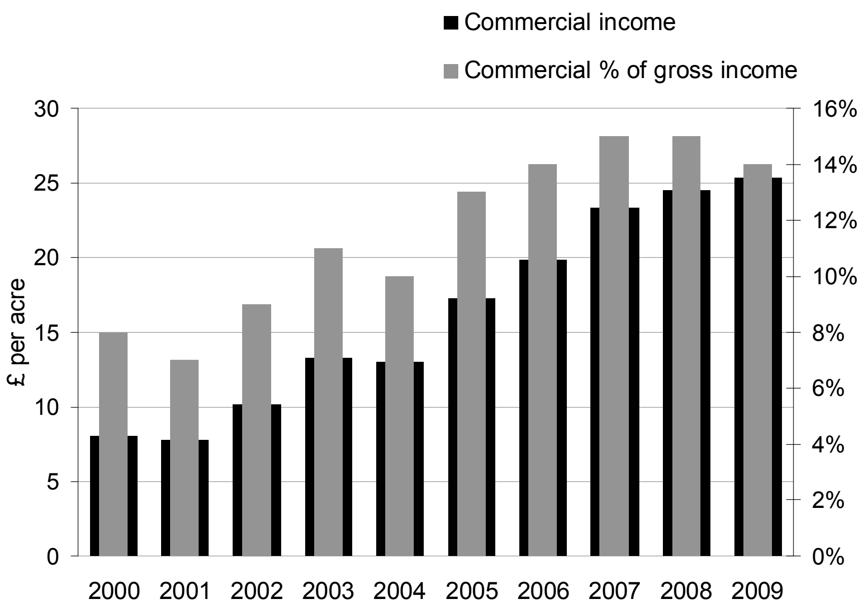
Source: Savills Research

6.3 Commercial Income

The income from commercial assets on rural estates has given their income earning capacity a real boost. In the early 2000s the income from commercial property represented less than 10% of gross income and contributed just £10 per acre to the estate as shown in Graph 12. Now, less than 10 years on, these assets represent around 15% of gross income (although the 2009 results showed that the recession had put some pressure on this sector) and contributed over £25 per acre – an increase of 150%.

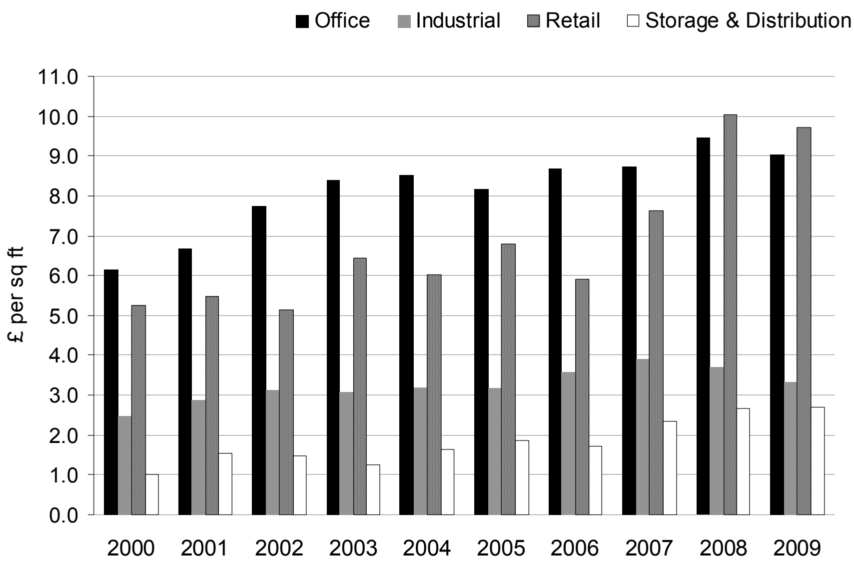
Although income from commercial assets increased in 2009, the rate of growth significantly slowed, recording 4% growth in 2009 compared with an annualised growth of 12% in the three preceding years. Our research shows that this pattern is similar in the leisure sector. This suggests the recession has

Graph 12. Commercial contribution



Source: Savills Research

Graph 13. Commercial workspace income



Source: Savills Research

had a deeper impact on these sectors in the past year.

Average office rents fell 4.5% in 2009 to £9.03 per sq ft. Softening of rental incomes was also evident for let industrial and retail units which recorded falls of -10.2% to £3.23 per sq ft and -3.2% to £9.72 per sq ft respectively. In contrast, rental income for units let for storage and distribution remained stable (up 1%) at just over £2.70 per sq ft.

Commercial workspace rental levels follow a similar pattern to residential rents with the highest levels being in the South East of England. The only exception was retail units where average rents were highest in the South West of England. Location and quality will be key in the future to ensuring low levels of void periods.

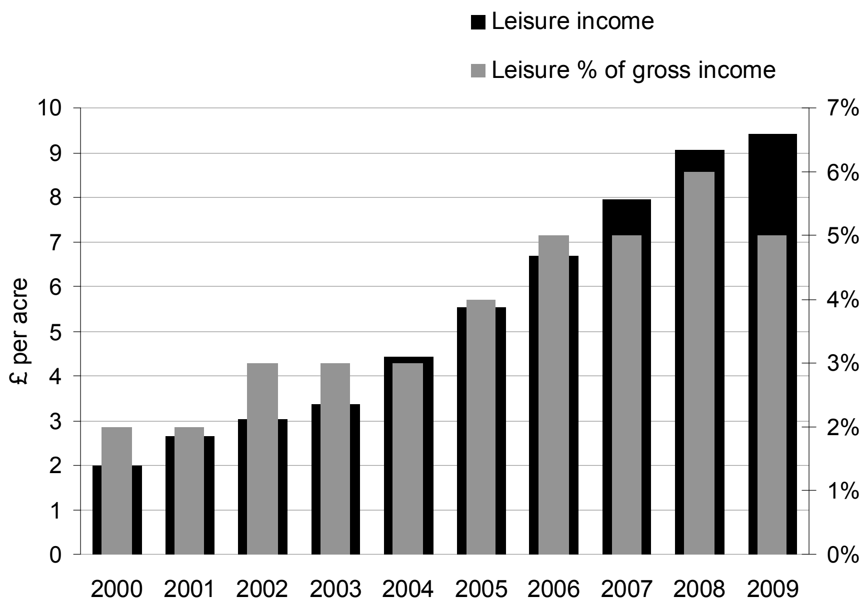
The income from telecom masts increased 8.4% in 2009 to £7,335 per mast. However, the recent trend of service providers amalgamating and consolidating aerials is likely to see pressure on this income source in the next 12 months.

6.4 Leisure Income

The opportunities offered by leisure related activities have been grasped by estate owners as illustrated in Graph 14. These would include everything from open farms, equestrian and golf enterprises to water sports and moorings.

In the early 2000s the income from leisure activities represented 2% of gross income and contributed just £2 per acre to the estate as shown in Graph 14 . Now, less than 10 years on, these assets represent around 5% of gross income (although the 2009 results showed that the recession had put some pressure on this sector) and contributed just under £10 per acre – a fourfold increase.

Graph 14. Leisure contribution



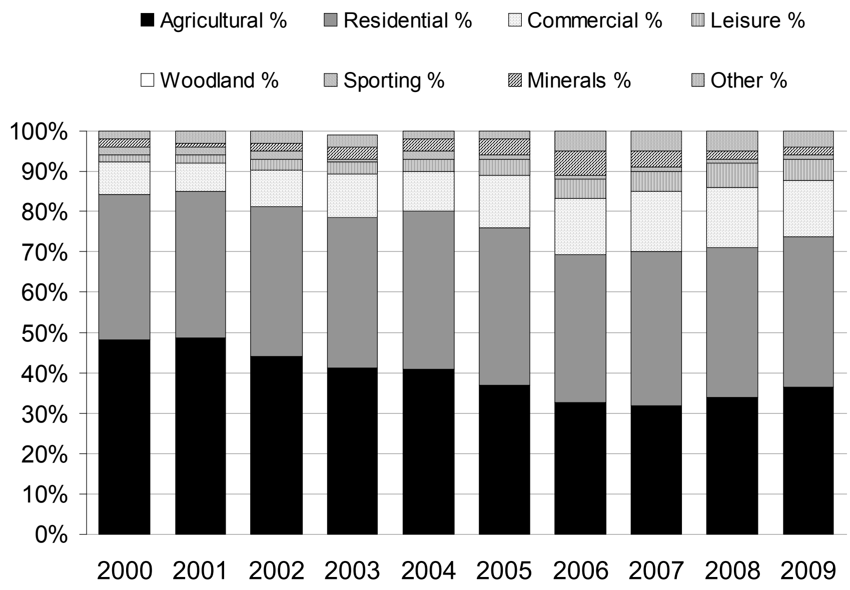
Source: Savills Research

6.5 All other sources of income

In addition to the income sources described above rural estates also generate income from:

1. Woodlands – surprisingly the average income generated by woodlands is negligible and often negative as more is spent than received. With the interest in carbon sequestration and sustainable building materials it would be expected that estate woods and forests would become a valuable income generating source in the future.
2. Sporting – the average income derived from sporting activities has been steady at around £2 per acre. It is unlikely that this position will change especially with increasing pressure on animal welfare which may impact on country sports.
3. Minerals – these opportunities are obviously not available to all and are dependant on the location of mineral deposits but where these can be exploited they are often very lucrative with the additional benefits of post extraction opportunities such as waste fill or leisure activities. As would be expected the contribution minerals makes to the average estate is relatively volatile and has varied between £3 and £8 per acre over the past 10 years.
4. Other income sources also include wayleaves, easements and miscellaneous items which are not easily allocated to the categories listed above. These have also been relatively volatile but with a general upwards trend and have represented up to 5% of gross income.

Graph 15. Income sources as % of gross income



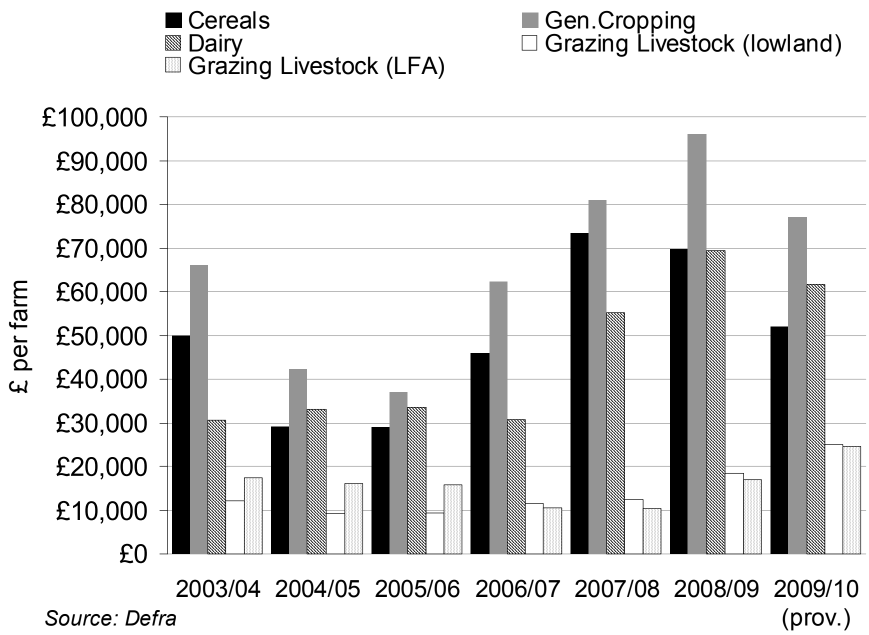
Source: Savills Research

In total these represent a relatively small and static proportion of gross income (see Graph 15) in context to the total gross income. Although it is likely that this pattern will continue these opportunities should be monitored and and exploited where possible.

7. Agricultural Comparisons

The diverse income streams on rural estates, as discussed above, have given these businesses a steadily increasing turnover. In contrast, land based businesses, which rely solely on the agricultural asset to produce an income have been more exposed to output and input price volatility. Graph 16 shows the variability in average incomes from year-to-year by farm type and clearly illustrates a significantly less stable and reliable income stream, which is more vulnerable than a business with several income streams.

Graph 16 – Average Farm Business Incomes (England)



8. Forecasts

Our forecasts for each income stream, as discussed above are summarised below and illustrated in Graph 17. It is recognised that not all these income streams will be available to all estates but the summary of the key factors that may influence the general direction of these income streams will be applicable to many estates. There will be variation in income growth depending on the opportunities offered by such factors as location, resources (physical, people and capital) and local planning.

Our analysis suggests that the gross income of the average English estate will continue steadily upwards and at a pace ahead of inflation. A positive trend in income will feed into an improving performance from an investment perspective as capital values across all property sectors respond to healthier economic conditions.

8.1 Agriculture

Agricultural income will be principally driven by the outlook for commodity prices and farm profitability. In addition we envisage that the ongoing shift to reversion of AHA tenancies will continue adding value to the total income from this source over and above AHA rental increases. We expect that another increase, although not of the size recorded in 2009, in AHA rents is likely to be recorded in the 2010 survey as the results of 2009 rent reviews are included. Thereafter our forecasts include moderate growth in AHA and FBT rental levels of 2% and 5% respectively.

We expect in-hand farming incomes in the coming year to be under some pressure as output prices fall, but this fall will be tempered by lower input prices. As Graph 16 shows farm incomes in recent years have been higher than in the early 2000s and we expect, as food security becomes an increasingly important issue globally, that the general trend will be for strengthening commodity prices. This will underpin the growth in estate incomes from agriculture which will also be enhanced by sterling's weakness. On the downside there will be some uncertainty to the final outcome of the CAP 2012 reforms.

8.2 Residential

We forecast that rents for rural residential property will continue to increase in the short term, but only at or just above inflation, in line with the forecasts for mainstream residential rental growth from the Savills Residential Research. The key to driving up real growth from the residential property assets on rural estates will be the conversion of properties currently producing low or zero rental income into market rents. This will include restructuring let farms to release houses with a high rental value whilst maintaining viable farm tenancies. In addition to modest AST rental growth (3% in 2010 moving towards 5% by 2012) our forecasts include a continuation of the historic trend for an increasing proportion of the total housing stock becoming AST tenancies reaching around 55% in 2014 from the current level of 47%.

8.3 Commercial

The income from commercial property on estates is an area which is likely to be under pressure in the current economic climate. Location and quality of the working environment will be key for those seeking to maintain rental levels and reduce void periods.

Using the rental growth forecasts for mainstream commercial property from Savills Commercial Research team and comparing the historic rental growth of this sector with rural commercial assets we have estimated our forecasts. The forecasts for main stream commercial property are for two more years (2010 and 2011) of significant pressure (-9.3% and -5% respectively) on rental growth before positive annual growth is recorded. Rental income in this sector on rural estates has not fallen to the extent that has been recorded in the mainstream market and we believe that this will continue. However, this sector will remain under pressure and we forecast slightly negative growth (-3%) in the 2010 survey results, stabilising in 2011 and around 5% to 7% annual growth in the short term to 2014.

There will be pressure on telecom rents as service providers amalgamate but conversely income opportunities from renewable energy sources, including Feed in Tariffs (FITs) will help balance this.

8.4 Leisure

Similarly but not to the same extent as the commercial sector, we expect some pressure on incomes during the next 12 months. The latest forecasts from Visit Britain suggest that domestic tourism is set for a strong year in 2010 with weak sterling being a key factor. Their latest research quotes that 70% of people surveyed are likely to book a UK holiday this year. The Olympic Games in 2012 will also help the domestic tourism market in the next few years. We estimate, as a baseline for the average estate, no growth in this sector in the 2010 survey year and positive annual growth rising to around 8% by 2014.

8.5 Woodland

This is a sector where opportunities, especially in conjunction with carbon sequestration in respect of climate change, are likely to be available but it is not easy to quantify these or the exact timing of when these might be realised. Taking the average historic performance of rural estates in this area we have forecast no income from this sector in the short term as a base line.

8.6 Sporting

As mentioned above the opportunities for this sector to contribute to the estate's income stream are likely to be under pressure in the coming years. We have used the average income of the five years to 2009, a nominal £2 per acre, as our annual estimate for the next five years. It is clear that this is an area where resources, including management time, should not be exhausted unless there is a specific opportunity for an estate in this sector and a rigorous business plan is in place.

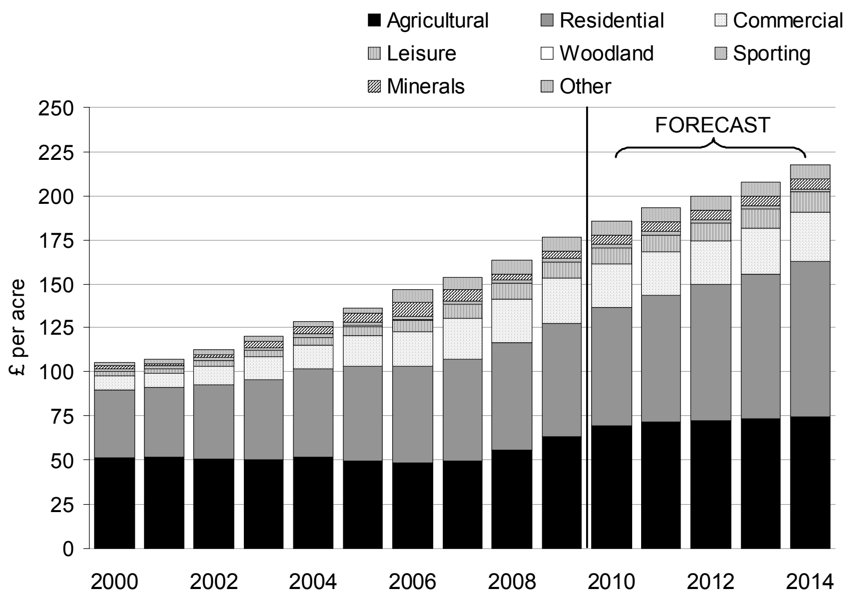
8.7 Minerals

The income derived from minerals, as recorded on the 'average' estate will no doubt remain volatile. Minerals are likely to remain a useful income stream for some estates and we have used the average income of the five years to 2009 as our annual estimate for the next five years.

8.8 Other

The survey has recorded a reasonable variation in the amount derived from those 'other' factors which can not be categorised under the main headings. However, the general trend has been upwards, and as these are impossible to estimate our forecast forward is at 2009 levels of around £8 per acre per year.

Graph 17. Gross income forecasts



Source: Savills Research

9. Conclsions

This paper concludes that the diversity of rural estates will ensure the future financial success of these businesses, at least in the short term. The forecast analysis estimates that rural estate businesses are likely to emerge from the recession in good shape, although incomes may continue to be under some pressure in 2010 and 2011. As noted in Section 9 of this paper rural estates have fared well in comparison to mainstream farm businesses and the diverse mix of property assets is likely to ensure this continues.

Effective cost management and the targeting of inputs to maximise output, such as property repairs and rental income, across the estate business will ensure that net incomes follow the same trend. Proactive management of all property assets including tenant management to reduce voids will involve a full understanding of tenant's needs and/or businesses. Outsourcing of some estate operations has been shown to deliver a saving to the bottom line.

Ultimately, the success of the business will involve the effective management of all the resources under the control of the estate manager with a focus on those income opportunities that are likely to deliver real performance working to a rigorous business plan.

Knowledge is essential, both of the past and current performance, and this is where the Savills Estate Benchmarking tool will help. In addition, the survey results can be used to monitor existing plans to ensure they stay on track or can be modified and adjusted to new circumstances.

The best practice described above with attention to detail could enhance the income growth describe in our forecasts.

About the Author

Ian Bailey (ibailey@savills.com) is head of Rural Research at Savills. His primary responsibilities include the analysing, modelling, interpretation and reporting on all Savills rural surveys. These include those on farmland markets (UK and international), rural estate benchmarking and farm incomes. In addition his work includes consultancy projects for both public and private sector clients. Ian is a member of the Institute of Agricultural Management.

Savills are just releasing their 2010 English Estate Benchmarking Survey results a summary report of which is available from the author.

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CONFERENCE PAPER

THE MODERN FARMER'S DAUGHTER: IS FARMING AN OPTION?

Louise C Elliott

This paper compares and contrasts the traditional role of the farmer's wife with her modern role, and then goes on to explore the aspirations and likely destination of the modern farmer's daughter. An online survey was completed by 447 female respondents from farming backgrounds in the UK. Although there were a number of options open to farmers' daughters including higher education, full time employment and inheritance of the family farm, they tended to aspire to be farmers' wives, not farming in their own right but marrying a farmer or farmers' son.

Key words
Women, daughter, wives, farming, aspirations, career.

Introduction

Farming is a lifestyle involving hard work and long hours (Policy Studies Institute, 2005). It is a traditional industry and the way of life is very much family orientated (Gasson and Winter, 1992). Family farms are passed down through generations (Gasson and Winter, 1993), and the business is expected to support and employ a number of family members, with outside help used in the absence of family labour (Whatmore, 1999).

A number of studies during the last century, discussed by Gasson and Winter (1993) found that farmers are likely to be farmers' sons, and similarly are likely to marry farmers' daughters. Succession and retirement planning are key to sustaining family farms (Davenport, 2007). From 1999 to 2004, the entry rate into agriculture was 2% of the farming population and the exit rate was 18% (DEFRA, 2007). Although no firm barriers to entry were identified by DEFRA (ADAS Consulting Ltd, 2004), their 2004 study did not consider gender when collating responses.

Research and experience suggests that in most farming households, the married couple, jointly running a family farm, rarely share equal power (Shortall, 1999). The male figure is responsible for making decisions and running the business, often entailing manual labour (Blanc and MacKinnon, 1990; Gasson and Winter, 1992; Goodall, 2008) whereas the woman or wife is traditionally responsible for domestic work and raising the children (Verdon, 2003; Gasson, 1980a, 1980b; Little, 1987; Gasson *et al* 1988).

This paper looks at the traditional and modern role of the farmers' wife and identifies changes. Further to this, primary research is undertaken to establish what the aspirations of farmers' daughters are, the findings will be used to determine whether the role of the farmer's wife is a role that farmers' daughters wish to fulfil.

This paper was originally presented at the ROOTS Conference 2010 – The Annual RICS Rural Research Conference – 13-14th April 2010, at Plumpton College, Sussex. It is reprinted by kind permission of the Royal Institution of Chartered Surveyors and the author.

Historical Context

The agricultural industry has seen substantial changes over the past 50 years (Grigg, 1989). Martin (2000) believes these changes have been strongly influenced by government intervention and trading patterns; however there have also been drastic changes due to disease outbreaks and market conditions (NFU, 2007). One notable change is the move from the productivist phase which was encouraged by the government following the food shortage and rationing during the Second World War (WW2), to a more conservationist and incentive-led approach following the CAP reform (DEFRA, 2006).

An increasing population over the past 2000 years has led to the majority of the UK population being estranged to agricultural practices (Ilbery and Watts, 2004). Short *et al* (2008) supported the theory that the urban-rural divide is increasing. However, DEFRA (2004) confirm that country living is becoming increasingly desirable and as a result there has been net migration from urban to rural areas since the seventies.

Agriculture, as an industry, has been struggling with low prices and increased competition from the world market worsened by heightening production costs. Diseases, including Foot and Mouth, BSE, Blue Tongue and Bird Flu have not helped the sector (NFU, 2007). Research shows a decline in large and medium sized holdings since 1950, mainly those in the labour intensive dairy and livestock sectors thus having the most significant impact on employment. There is also evidence of an increasing number of small holdings since 1990, found to be lifestyle and hobby farm sector (ADAS Consulting Ltd, 2004; Spedding, 2008).

Since the end of WW2, there has been stable growth of 20 million in the UK population (Jefferies, 2005). Three identifiable variations are; fewer births occurred during the first half of WW2, the post war baby boom in the late forties and early fifties, and the next generation of these baby boomers (ONS, 2008a; Jefferies, 2005).

As a developed country the UK strives for employment equality. With a "fairly equal" gender ratio for those of working age (ONS, 2008a), it is unclear why between 1998-2008 there were nearly 10% more men in work than women (ONS 2008c). The Labour Force Survey (LFS) 2007 Gender Pay Gap report shows an 11.5% difference in earnings between male and female workers (in favour of males). This increased when respondents were married or cohabiting; women with children were on lower pay than those without, and the pay gap increased with the number of children (Leaker, 2008).

Although the marriage rate is declining, it is important to note that it is still the most common form of partnership (ONS, 2008b). The 2001 Census shows that of those aged 30-74 years, approximately 64.7% were married compared with the 1951 Census where 77% were married. In 2001, 11% of that age group were divorced compared to 1951, where only 7% were (figures adapted from ONS, 2003; HMSO, 1956).

The Women in Employment Survey (WES) (1980) found that 46% of women agreed that it was the husband's responsibility to get an income, and the wife's responsibility to look after the home and family. While in 2002 this figure had reduced to 15%, 46% of married women with children under school age still felt they ought to stay at home (Martin, 2005). Although women tend to marry at a younger age than men, the overall age of marriage is increasing. It seems there is a direct correlation between the age of marriage and the average age of a married female at the birth of her first child; they are both increasing, suggesting a standardised period between marriage and children (ONS, not dated a; not dated b).

Research suggests that women tend to return to part time work after having children or choose not to work (Roberts, 2005). As a result, unmarried women earn more than married women (Leaker, 2008). The trend identified above, stating that women marry at a later age should improve their earning capacity, yet the choice to have children earlier in the marriage may have a detrimental affect on this.

The total number of workers employed in the agricultural, fishing and forestry sectors has been declining over the past thirty years. This could be due to a number of factors, Gasson *et al* (1988) suggest the increased cost of labour relative to other costs; moreover the manual nature of male agricultural labour suggests it is most likely due to increased mechanisation (DEFRA, 2008b). The decline of female workers appears to be less than male workers; however there is still a net loss of 28.3%. Female roles as farm administrators, secretaries and other similar roles are not likely to have been replaced by mechanisation despite technological improvements. Short *et al* (2008) argue that the decline of jobs in the agricultural sector is to some extent counteracted by an increase in jobs in other areas of agriculture, including the service sector such as conservation, tourism and recreation.

Women and employment

Historically, the work of the farmer's wife has not been recorded due to a lack of records such as employment contracts or wages (Verdon, 2003, Gasson, 1980b); however it is widely considered that the farmers' wife's contribution to the family business is economically significant (Gasson, 1992). Warren-Smith and Monk (2000) identify that the farmers' wife adds value when it is needed and is adaptable to changing economic conditions.

"A man without a wife has no business with a dairy"
(Verdon, 2003 cites BPP, 1867-8)

Verdon (2003) recognised that during the eighteenth century the domestic role of women necessitated the need for self sufficiency in providing for the family, this role extended to managing and working in the dairy (Verdon, 2003 cites Henry, not dated). As farm sizes increased and shifted towards larger scale production the "farmers' wife lost her productive function" (p.24, Verdon, 2003). It is unclear as to whether the farmer's wife chose to leave her traditional role (Pinchbeck, 1930; 1981) or was forced out as a result of mechanisation and commercialisation of the dairy sector (Valenze, 1991 in Verdon, 2003).

Shortall (1999) identified a divide in feelings as to whether men should have taken away the dairy enterprise and with it, the women's role and economic contribution to farm income. Pinchbeck (1981) (in Shortall, 1999) believed that the shift in the industry was "wholly favourable to the farm wife" (p.75) and meant that farm women had an elevated status which, allowed them to become educated, partake in social activities and leave their manual hardship and isolations behind, Verdon (2003) agreed that farm women achieved an elevated status.

Traditionally, the woman's place has been in the home with the primary role as housewife-mother (Haralambos *et al*, 2000). In urban areas an egalitarian society is developing where men and women have more equal roles, particularly in the work place; however there is little evidence to suggest that the traditional role of women has changed in the primary sector (Haralambos *et al,* 2000). Farm women have habitually been in charge of household duties, and any involvement in other agricultural activities is merely a part of their domestic role, including the raising of offspring (Whatmore, 1999; Haralambos *et al,* 2000; Gasson, 1990; Gasson *et al*, 1988). Whatmore's (1999) research established that all women surveyed carried out the majority of domestic work, including childcare. Goodall (2008) supported that women were more responsible for undertaking domestic duties.

Women in agriculture, evidently have a far more diverse role than mere household duties (Verdon, 2003; Gasson, 1992; 1980a). Goodall (2008) shows the diverse range of on-farm work that women carry out including milking, tractor driving, running errands, feeding livestock, dealing with visitors and answering business calls. Gasson and Winter (1992) suggest that the woman's role on the farm, has historically, been in the farm office and caring for livestock. In Whatmore's (1999) own research, she disagreed with Gasson (1981) finding that women were merely the 'dogsbodies', running errands and answering the phone.

Whatmore (1999) states that the treatment of family labour and the division of roles stems from a Marxist approach. She takes a feminist view of relations arguing that the so-called 'natural divide' of family labour is not natural and extremely sexist. The balance of power is a topic that has been studied in some depth by a number of sociologists (Shortall, 1999; Little, 1987; Alston, 2000), and although it is an area that deserves considerable coverage, for the purpose of this study it is only to be covered by the extent to which it forms part of, and has changed the woman's role.

Former studies show the male figure is largely responsible for making decisions relevant to the farm business (Blanc and MacKinnon, 1990; Gasson and Winter, 1992). Goodall (2008) found that 96% of men were responsible for making large decisions for the farm business, and that over 80% of women were responsible for household decisions. This supports evidence that the women's role has a domestic focus and that the male role is more associated with the farm business. Alston (2000) finds that power in the agricultural sector is linked to land ownership and is passed through inheritance and marriage to, most likely, a male.

Planning

This area is one that has been of great interest to a number of researchers and the focus of many studies globally. It is a vast topic, and although it is recognised by the researcher as significantly influential on the aspirations of farmers' daughters and arguably affects the role women adopt and accept within the rural community, it is one that is only touched on here.

"Social norms dictate that the heir is male" (Shortall, 1999, p.32)

Research suggests that the barriers and discrimination faced by women are historical. Patrilineal inheritance, whereby property and titles are passed down through male lines seems ever strong in UK agriculture (Shortall, 1999). This is, immediately a barrier for farmers' daughters as farm ownership often bypasses them in favour of a male. Shortall (1999) cites Hedley (1982) calling the term family farm a misnomer, in that the ownership is most usually found in the name of the most senior male. Inheritance and the destination of farmers' daughters has been an issue and part of government policy in Western and Central Europe (Shortall, 2006). Gasson and Winter (1993) state that in the 1940's, 80% of farmers in England and Wales, were farmers' sons; in the late sixties this had increased to 83%; and in their own research they found the figure to be nearer 75% but that over half of farmers' sons had married farmers' daughters.

MAFF (1981) state that the solution to succession is to know the aspirations of those likely to succeed. In agriculture, the preservation of the farm is often a priority; however Saffery Champness (2005) found that there is increasing pressure for an estate to be shared equally amongst children. Unlike other European countries and Scotland; England and Wales do not have a 'forced heirship' policy (Scandia, 2008). MAFF (1981) observes that division of a family farm is often unfeasible and thus offspring may be forced to find employment elsewhere. Social norms, discussed above dictate that the farmer's heir is most likely to be male, implying that any female dependants will be forced to seek employment elsewhere.

Chevalier (2001) found that male graduates of agricultural studies were highly likely to follow the occupation of their father. Laband and Lentz (1983) work supported this, finding there was a strong tendency for farmers' sons to become farmers, Gasson and Winter (1993) found this tendency was heightened as the size of the farm increased. Neither research discusses the destination of farmers' daughters. Laband and Lentz (1983) identify two issues with agriculture being an inherited occupation; one associated with the transfer of capital assets, and the second with the son's decision to farm the land. The researchers also comment that farming is the strongest example of intergenerational transfer of knowledge between father and son.

Education

"There is no tool for development more effective than the education of girls" (International Plan, 2008).

Girls are achieving higher grades than boys (ONS, 2007a), and a higher percentage of girls are studying and obtaining degrees at university (International Plan, 2008; Munn, 2006), yet fewer women are in full time employment or getting the highest paid jobs compared with men (ONS, 2008c). The number of students attaining HE qualifications is increasing; with a higher proportion of female students attaining HE qualifications than males.

> *"That part of a holding of a farmer or landowner that pays best for cultivation is the small estate within the ring fence of his skull"* (Charles Dickens (1868) in Norman, 1998)

Education in agriculture is delivered at different levels and institutions. There have been several changes in the method of delivery by agricultural institutions; including an increase in the diversity of courses offered, paired with an increase in degree level courses.

Historically agricultural colleges have seen a larger proportion of males to females, however since the mid nineties it appears the gender divide has been narrowing with little difference in post 2000 intakes.

Entry Barriers and Opportunities

This paper touches on the barriers to and opportunities for female entrants, predominantly focussing on those already involved in the industry [i.e. farmers' daughters]. The key barriers and opportunities include inheritance, marriage, and family commitments.

The CAP Health Check urged new entrants to be encouraged into agriculture. As a result DEFRA commissioned the 'Entry to and Exit from Farming' report (ADAS Consulting Ltd, 2004). Its findings are commendable, however it can be criticised in that it did not differentiate between genders. The report focused on the futures of agricultural students. Students were asked to give reasons for their choice of career, identifying any barriers they faced. Substantial evidence referred to throughout this paper shows that there is a variation in the treatment of males and females in agriculture and this discrimination appears ever strong when looking at the barriers to female entrants. Britton's (1990) research found there was little information available identifying the factors affecting women's entry into agriculture.

The report identified factors preventing entry to the industry as; increasing farm size, shortage of farms to rent, high costs of setting up a farming enterprise and the reluctance of older farmers to retire (ADAS Consulting Ltd, 2004). Emphasis in DEFRAs research is placed on the barriers to '*new entrants'*, yet there is widespread evidence suggesting that barriers are also faced by current industry members, specifically women.

Paine conducted a survey of Young Farmers Club (YFC) members in the South East of England that looked at their commitments to YFC as well as their background. Analysis of his raw data found that considerably more males than females had considered a career in agriculture; with only 15% of females considering it, even though 45% of females were from a farming background. Of those that said yes, only 33% were from farming backgrounds, suggesting that the remaining 67% of farmers' daughters were looking to move away from agriculture.

Paine (2008) finds that the majority (36%) of respondents had 'just never thought about a career in agriculture'. Excluding this, the main deterrent was *Bad Pay.* The Annual Survey of Hours and Earnings showed that those employed in the agriculture, hunting and forestry sector were the second lowest paid (Anon, 2008). Given the gender pay gap discussed above, it is conceivable that this barrier would be greater to female entrants than males, however there is no research to support this. Further deterrents, were a lack of prospects (8%), few jobs (12%), or impossible to get started.

The rise in students studying HE, and more specifically the increase in female students studying at agricultural institutions suggests the opportunities to females are widening. Britton (1990) supports this in her research, stating that females now have a wide range of courses and careers open to them. Despite these broadening opportunities, Alston (2000) states that women's main method of entry to farming is that of marriage, Gasson and Winter (1993) also found that half of male farmers in their research were married to farmers' daughters.

Survey of farmers daughters

To explore these issues further an online survey was designed and made available for 21 days targeting farmers' daughters and advertised through agricultural colleges, universities, clubs and online media. 447 people completed all the questions. Respondents from a purely 'working farm' background and aged 16-35 were selected generating 372 valid responses. This selection excluded those from hobby farms and mere houses with land to ensure the usable sample included only bona-fide farmers' daughters (Gasson and Winter, 1993).

What is the traditional role of women in UK agriculture?

In order to assess the modern role and changing role, it is first important to establish the traditional role. This has largely been done through the review of literature. A deductive approach was then used to test the theories found.

- 93% of respondents agreed/strongly agreed that agriculture is a traditional industry.
- 88% of respondents agreed/strongly agreed that agriculture is a male dominated industry.
- 85% of respondents agreed/strongly agreed that women carry out the majority of domestic work.
- 79% of respondents disagreed/strongly disagreed that manual work on the farm was not a job for a woman.
- 82% of respondents agreed/strongly agreed that the traditional role of the farmer's wife is changing.

These results closely relate to the trends found in published literature showing that the industry is traditional and male dominated. Respondents also agreed that women carried out the majority of domestic work, however they largely disagreed that women could not help with manual work which conflicts with a number of mainstream studies including Gasson (1980a; 1980b) that found women were largely uninvolved in manual work except at peak times or if unmarried and farming in their own right.

The feminist view taken by some researchers (Whatmore, 1999) described the role of farmers' wife, as one that ties the woman to the farm, takes away her independence, gives all power to the male, and leaves her to undertake domestic duties, raise the children, etc – all of which is said to be unrecognised. Stress, isolation, loneliness and social exclusion have been identified as negative factors in research. Other researchers including Little and Austin (1996) held a positive view of country living, and identified the attraction of the rural idyll.

Respondents recognised the advantages and disadvantages associated with being a woman in agriculture, yet did not appear to hold a negative view of this traditional role, and as a result were unlikely to be put off by the negativities so regularly documented in research.

What is the modern role of women in UK agriculture?

Having found that respondents largely supported researchers' views of the traditional role of women; it is interesting to find that 81% agreed their parents took traditional roles. Given the age group of respondents, and their parents; the traditional role of women is also likely to be the modern role.

Social and demographic profile

Eighty-seven percent of respondents' parents were married; this was found to be considerably higher than the 2001 national average (64.7%) for those aged 30-74 years. The proportion of divorced couples was found to be 7%; this is lower than the national average (11%). The most likely age category for marriage was 22-24 years, with 90% of respondents' mothers aged between 16 -27 when married; this was similar to the national average up to 1971.

It could be assumed that national trends found in the literature review, showing women marrying at a later age and the narrowing gap between age of marriage and time of first child are likely to be true for farm women. However, a higher than average proportion are likely to be married and are less likely to get divorced.

Background

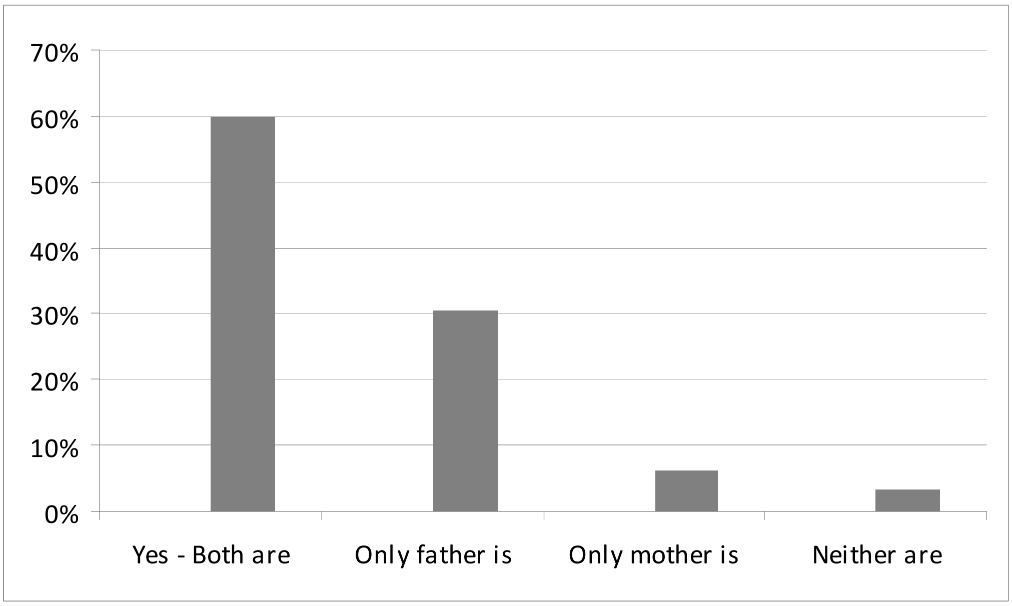
Results showed that 63% of respondents' parents were both from farming backgrounds (see Figure 1), which, in the case of males, supported the findings of Gasson and Winter (1993). However, this figure showed that, in over half of all cases, farmers' sons had married farmers' daughters, which was considerably higher than that found by Gasson and Winter (1993

Thirty-one per cent of male farmers married females from non farming backgrounds, and in only 5% of marriages was it evident that only the female was from a farming background. This suggests that either women from farming backgrounds marry men from farming backgrounds and are thus featured in the 'Yes-both are' result, or that they are not staying in the industry and do not feature in the results. Given the large proportion of parents in 'both having a farming background', it suggests farmers' daughters do tend to marry farmers' sons. It was also found that 1% had no farming background at all, supporting evidence that those entering the industry required a farming upbringing (Gasson and Winter, 1993; ADAS Consulting Ltd, 2004).

Finding a spouse

Respondents were asked to specify where their parents met (see Figure 2), finding that over half met through the National Federation of Young Farmers Clubs (YFC) and a quarter met through a farming friend or community. This shows that either farmers' daughters and farmers' sons are very suited, or that farming offspring only associate with members of the farming community. Cross tabulation was used along with Chi-square analysis to test this relationship. It was found that there was a significant relationship between the background of respondents' parents and how they met at a 1% level of significance. It found that where both parents were from a farming background, more than expected met through YFC. Where neither or only one parent was from a farming background, less than expected met at YFC. Where only the mother, or neither parent was from a farming background, it was higher than expected that they met their partner through university or school. There are now a number of new and established rural social networking channels, stating that people from rural backgrounds struggle to find partners; given the higher than average marriage rate, and the high likliehood of meeting someone through YFC, it is questionable as to why these businesses are setting up.

Figure 1: Farming backgrounds of respondents' parents

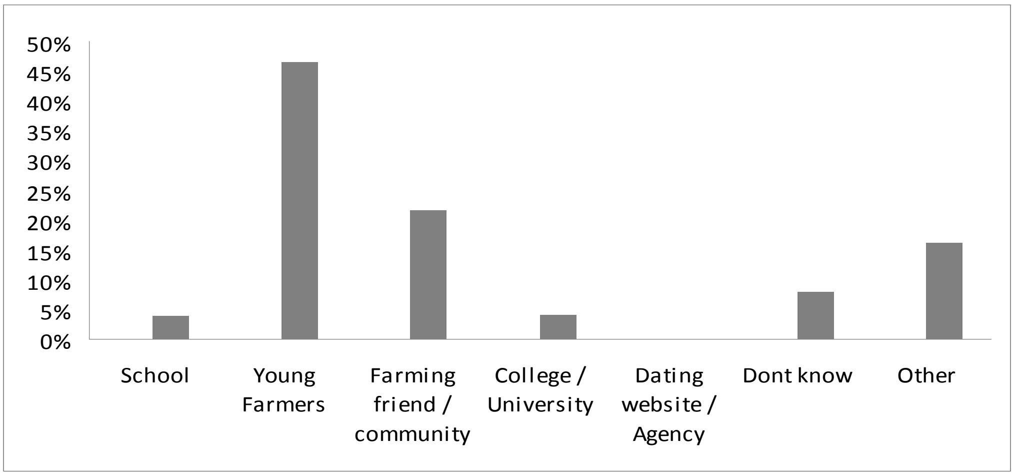


Advantages and disadvantages of a farmers' wife's role

Respondents were asked to state the advantages and disadvantages of being a farmer's wife. These were open questions and generated a number of similar responses which were grouped. Foreseen advantages included the rural idyll, bringing up children in the countryside, keeping animals including horses and a good social life. Drawbacks mentioned included stress, loneliness, having to undertake all domestic chores and raise a family, lack of holidays and long hours.

A number of advantages stated by some, were seen as disadvantages by others, for example some identified the benefit of having "*freedom from the 9-5 lifestyle*", whereas others complained that you were tied to the farm, had little independence and no holidays. Some boasted about the *"security of income*", contradicted by a number of respondents who identified poor pay, falling farming incomes and as a result, an insecure industry as a disadvantage. Some respondents felt that they would get to spend time with their husband, seeing him whenever they wanted, yet others complained they would "*never see or spend quality time with husband".*

Figure 2: Where respondents' parents met



The fact that there were similar responses suggests that there is a definite role or image of farmers' wives which is witnessed and understood by farmers' daughters. A number of factors appeared as both advantages and disadvantages, which questions the clarity of this perceived role, and suggests that it varies from farm to farm, or that respondents do not fully understand this role or have misconceptions. Although a number of these factors have been addressed in previous research (Monk, Little, Austin, Whatmore, Shortall, Gasson) few strategies or policies have been implemented in the UK to attract women specifically to rural areas, or to lessen the negativities for future generations.

What are the aspirations of farmers' daughters in the UK?

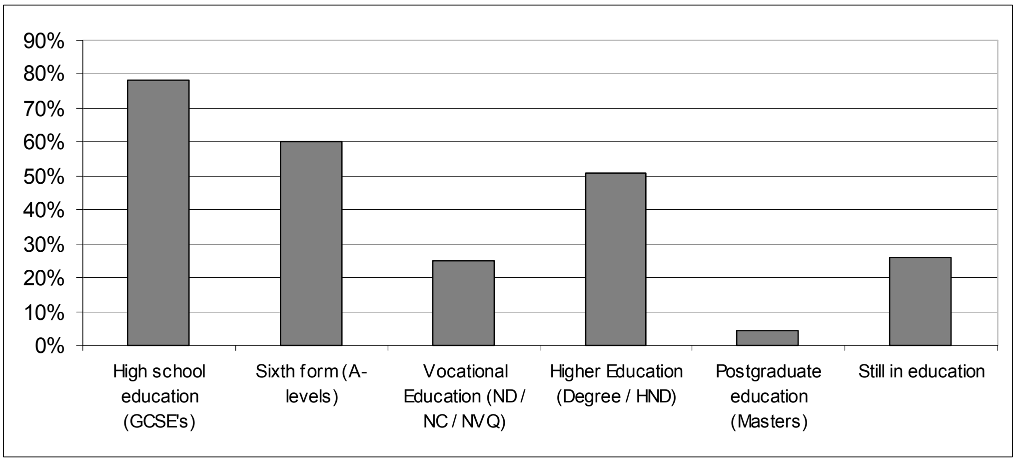
Although the traditional role of women in farming has been established it is still unclear as to whether young females are being drawn into the industry or deserting it. This section will compare and contrast the aspirations of modern day farmers' daughters in order to ascertain the extent to which they will be able to, or wish to, fulfil this traditional role.

Profile of respondents

A high proportion of respondents were still in education with a large percentage studying at agricultural institutions, this is likely to be skewed and could be unrepresentative of the population due to the sample frame.

The results (shown in Figure 3) found that 53% of respondents had studied or were studying at HE level, this is higher than the national figure which showed that 49% of females (aged 17-30) participated in education of this level. The majority of respondents specified that they left education as they had achieved all they wanted or needed, or to take up employment and earn a living.

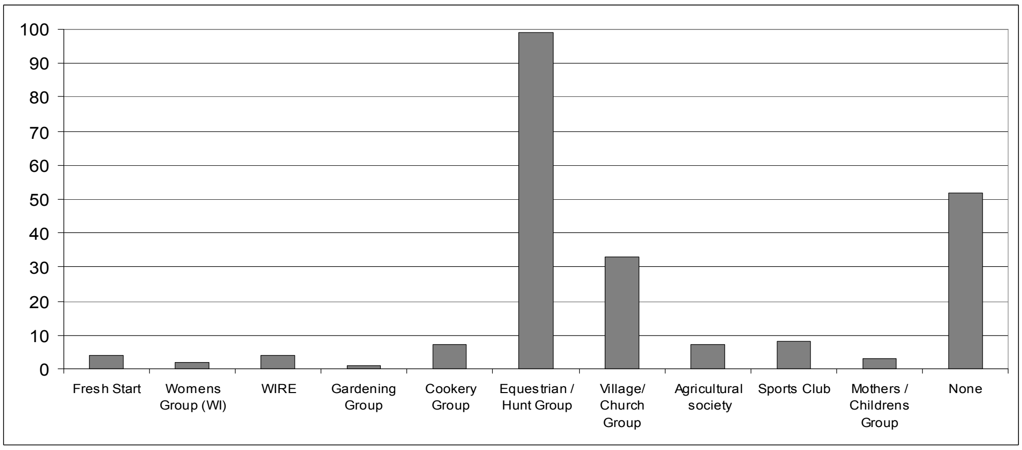
Figure 3: Level of education attained by respondents



A number of those in education reported helping on the farm and a later question probed whether this was out of choice or necessity. It found that nearly half were involved in the business as much as they would like to be, and very few were involved more than they would like, suggesting that they were happy combining studying with helping on the farm. The literature review found that women were not involved in decision making or running the farm, however these results show that women are happy with the level of inolvement they have. Gasson (1992) found that the level of involvement on farm was linked to the size of the holding. However, when tested no relationship was found in the Chi-Squared test.

It was found that a large proportion of respondents were members of local societies, this supported Gasson (1980b) findings of traditional women. A break down of groups showed that mixed gender social groups were mostly agricultural in their focus, 83% of respondents were members of YFC, with other popular clubs shown in Figure 4 as hunt or equestrian clubs, Fresh Start, sports clubs and agricultural societies, these groups had the largest proportion of members. More female focused groups included mother/children groups, cookery groups, gardening groups and women's groups. Members recognised the benefits their contribution to these groups had, showing that farmers' daughters have an important role in the local rural community.

Figure 4: Respondents involvement in local and community groups.

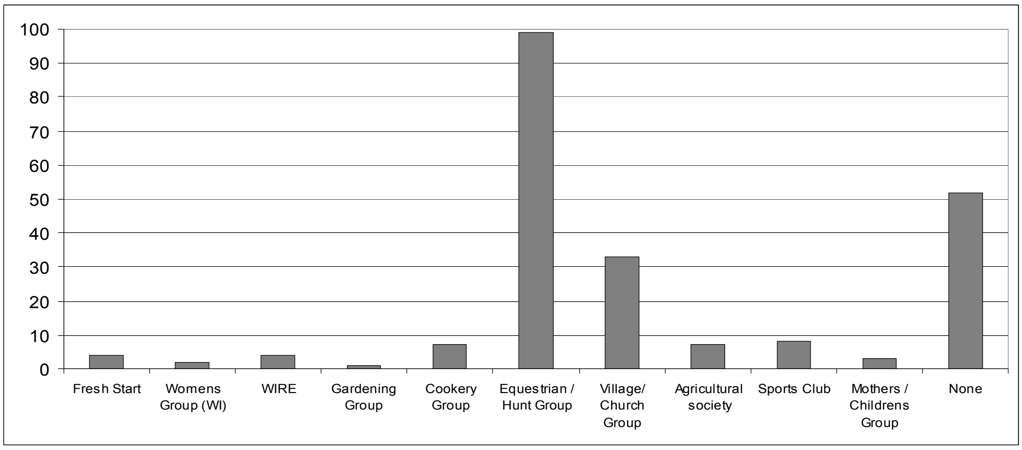


Marriage and employment

When asked their aspirations with regards to being involved in farming or not, married or working; nearly 50% of respondents specified that they aspired to be a housewife (*farmer's*) and working compared to less than 5% that would like to be housewife (*non farmer's*) and working. This was surprising given the somewhat negative and disdainful role that the literature review found of farmers' wives and suggests that there must be greater advantages than previously found or another reason.

Figure 5 shows that nearly 40% of respondents specified they would like to be employed/working with no comment on their marital status, yet when asked directly, a cross tabulation showed that 51% of these also hoped to marry a farmer. Of this group, it is suggested that their priority is to find employment, but that subsequently they wish to marry a farmer. The literature review has demonstrated that the role of farmers' wives is highly demanding and requires the woman to always be on call to support the farmer, and thus these women will, upon marrying a farmer surely be forced to commit to the farm, as a result their employment may suffer or be brought to an end. Giving another reason as to why women are not finding the highest paid jobs (ONS, 2008c).

Figure 5: Respondents' aspirations with respect to farming



Are farmers' daughters' aspirations realistic and achievable?

Marriage

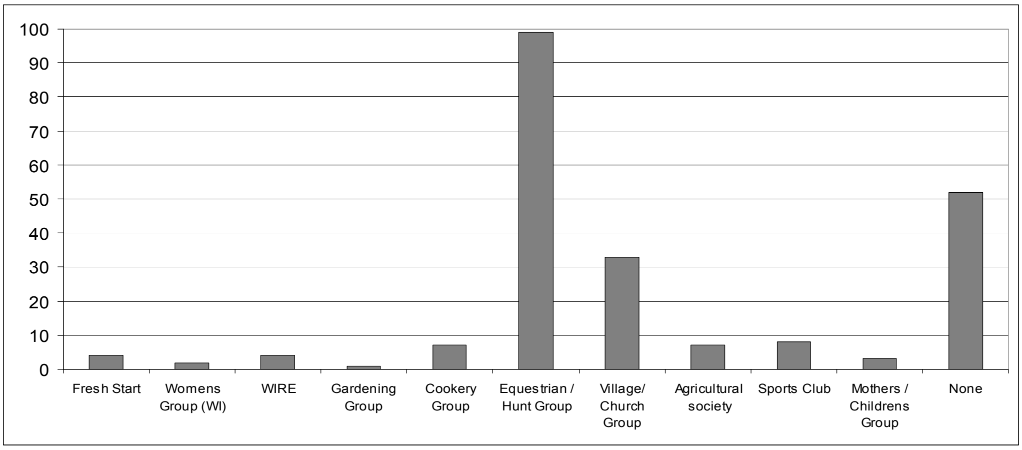
This study has found that women from a farming background have in the past tended to marry males in the same situation. However, it has been found that females do not wish to become a farmer in their own right even when given the opportunity, but wished to work themselves and take on the supportive role of the farmers' wife. This is to an extent occupational inheritance even though it could be argued that the role of farmer's wife appears to be more of a lifestyle choice than an occupation. There are a number of networking groups and dating agencies that state farmers are struggling to find wives due to the ties of their occupation, in light of this, the aspiration of farmers' daughters to marry a farmer seems realistic and achievable.

Inheritance

Patrilineal inheritance, the traditional means of inheritance in the UK, seems to be a barrier to farmers' daughters. Figure 6 shows 70% of respondents said that their brother (older or younger) was likely to take on the family farm; this supports Shortall (1999) who considered that this form of inheritance was prevalent in UK agriculture. However, when asked 50% of respondents felt that they could take on the family farm if they wished, suggesting that they did not want to.

The literature review found that occupational inheritance was especially strong in males (Chevalier, 2001 Laband and Lentz, 1983), which strengthened as the size of their farm increased (Gasson and Winter, 1993). The size of holding and background of respondents' parents showed a statistically significant relationship (chi-squared, $p>0.01$) It was found that where the holding was less than 50 acres, it was more likely that neither parent had a farming background or that only the mother had a farming background. This supports evidence that those couples without a farming background are

Figure 6: Likelihood of other family members inheriting the farm



more likely to occupy smaller holdings.

Barriers

The main issues identified were financial. Specifically, there was poor profitability in farming, the family farm was unable to support another family member, and there were no funds to purchase a farm. Similar barriers were identified by Paine (2008) and ADAS Consulting Ltd (2004). Of those that specified '*other'*, eight felt that nothing would prevent them, 20 said they were not interested in staying in agriculture, and 11 said not marrying a farmer would prevent them.

The modern farmer's daughter: is farming an option

The traditional role of the farmer's wife is a supportive role. She undertakes errands necessary to help the day to day running of the farm and household, as well as carrying out domestic duties and raising the children. She is unlikely to be involved in manual labour except at peak times including lambing and in the absence of employed help. She rarely has a say in decision making. Her work is unrecorded and requires no qualifications. She is often isolated from her husband and friends, finding that her efforts are largely unrecognised.

The modern farmer's wife will have married later than her traditional counterpart, but at a similar age to that of the national average. She is likely to be from a farming background and to have married a farmer, they are most likely to have met through YFC. She again, will undertake all the domestic duties and will help on the farm during peak times. In times of hardship, she is likely to take off farm employment or diversify part of the business. Should both husband and wife be contributing economically, then it is more likely they will share equal roles and divide the childcare duties, however the wife will still be expected to undertake the domestic duties. She will enjoy the rural idyll, living in the countryside and keeping animals, as well as appreciating the suitability of the location for raising her family and getting to spend time with her husband. She finds it difficult being tied to the farm and constantly being on call, but she enjoys the variety that the role entails. She finds the stress and isolation of rural life difficult especially during peak times when she is unlikely to see her husband or take holidays.

A number of barriers were identified by farmers' daughters, however it was found that they were not interested in pursuing farming as a career or taking on the family farm within the capacity of a farmer. 68% stated that they could take on the family farm if they wanted; it was found males siblings were more likely to take on the family farm than female siblings.

The research concluded that female entry into farming is likely to be through marriage or inheritance, although respondents did not wholly agree with this statement when asked.

When asked directly seventy-six per cent of farmers' daughters hoped to become farmers' wives. In order to achieve this, respondents identified the need to marry a farmer's son. Eighty-five per cent were members of YFC, and it would be likely that they would meet a future partner here. Over half of farmers' daughters had studied HE level education. This education is likely to have been undertaken at an agricultural institution and the participant is likely to have achieved a professional qualification including accountancy or surveying. Upon qualification, they are likely to specialise in the rural sector. This shows that tomorrow's farmers' wives are likely to be educated above the average level, and have the ability to work off the farm and earn an income higher than that expected from farming.

The respondents to this study had experienced the reality of family farming first hand despite all the disadvantages associated with being a farmer's wife identified within this study and former research, it appears that farmers' daughters still aspire to be farmers' wives. Or, to express it another way, farming is an option but not one that farmers' daughters wish to pursue without a husband.

About the author

Louise Elliott (LElliott@savills.com) graduated from Harper Adams University College with an Honours degree in Rural Enterprise and Land Management. Having spent twelve months specialising in the disposal and acquisition of farms and estates in Oxfordshire, Louise is now part of the Savills Estate Management team advising a number of private and institutional landowners across the East Midlands. Louise is currently working towards her APC and CAAV qualifications; she sits on the Junior Council of her CAAV Local Association and is part of the Nottinghamshire Matrics Committee. Having been brought up on a dairy farm in South Warwickshire, Louise finds the future sustainability of rural communities and overall economy a dynamic and interesting topic; she has recently been elected onto the Tenancy Reform Industry Group as a representative for Young Farmers members across England and hopes to undertake more research on the importance of the family farm and women in agriculture in the future.

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VIEWPOINT

HOW WILL THE GLOBAL SUPPLY CHAIN LOOK IN THE FUTURE? [1]

John Giles

Drawing on his experience as a Divisional Director with Promar International, the author assesses current movements in the food supply chain, and the consequent future risks and opportunities.

Key words Food supply chain, drivers, price, values, policy, change.

Background

The international agricultural and food supply chain has been subject to a severe shock over the last two years, as the effects of the downturn in the global economy have rippled across the world. Demand for many agricultural products has been suppressed and production across key categories such as meat and dairy has fallen in 2008/9.

While demand and production have both started to recover, there is still a fragile nature to the overall economic recovery, and it is still very uneven. Countries in Asia have come out of the slump quickest. They are at the hub of the global recovery, while in the US and the EU, there are still concerns about the speed and strength at which this can be achieved. At the current time, many questions are still to be answered as to the longer term impact of the crisis, not least in Southern Europe.

What seems clear is that the fundamentals of the supply chain that had come to be accepted as "this is the way things are" have been challenged in a way not seen before. In the future, there are also a range of factors coming together that means that the way it operates will probably never be quite the same again. What has happened in the last few years has gone well beyond being just 'a blip' as some industry commentators predicted.

Key Macro Drivers for Change

There are now a number of huge macro forces at work that food producers, processors, retailers, foodservice operators, as well as in some cases, governments will need to contend with over both the long and short term. These will all help shape the global supply chain in the future. These include:

Global population growth

It is now widely accepted that the world's population is heading for 9 billion as a minimum. Most of this growth will take place in the emerging regions of the world such as Asia and Latin America. Within countries such as Brazil, India and China, there is huge change taking place, with hundreds of

1. This article first appeared *Genus World Winter Publication, 2010/11* (http://www.genusplc.com/about/genus_world.aspx) and is reprinted here by kind permission of the publishers.

millions of consumers moving from low to middle income status and in some cases, upper income status. The implication for food producers (and the companies who in turn supply them) is clear. There will be many more consumers in the world to feed, many of these will be considerably wealthier and as a result will be able to afford and demand higher quality and added value food.

Climate change and the environment

The evidence for long term climate change is strong, and in some areas of the world it is already there. Australia, parts of North America, parts of Africa, Asia and even in Southern Europe and the Former Soviet Union are already feeling the impact of changing weather patterns and the overall impact this can have on the availability of natural resources. Water in particular is set to be a huge issue over the next few years. Some parts of the world will however remain, in relative terms, unaffected. Northern Europe, as an example, seems set to still be fundamentally a good place to farm and process food. The next implication here again seems clear. Farming and food processing businesses will have to look very carefully at how their distribution chains operate, reduce carbon emissions and make much better use of scarce natural resources.

Energy

We might have already reached, or are about to reach in the next five to ten years, the period of so called 'peak oil availability' where oil can be extracted with relative ease and traded internationally at price levels within an accepted norm. There is still plenty of oil and gas in the world to be accessed. Getting it out of the ground however will be more challenging; it will take longer and will be more expensive to do this. Even when we finally have access to it, the nature of increased global demand will have accounted for most of it already. Agriculture and food industries are heavy users of energy. Those that are less energy intensive in terms of how they produce and process food will be at an advantage over those that are not.

International agricultural policy

The direction of change is clear – it actually has been for some time, but still many around the world seem unprepared to accept it. WTO and CAP reforms all point to less protection, less management of markets and industries, more open and less distorted international markets. The global downturn has put added pressure on all forms of government funding and support for agriculture *per se*. The aspiration is set, but achieving it will still be difficult. The EU and Japan still remain largely protectionist in their outlook, while the Cairns Group are pre disposed to more open trade. The US can move between the two it seems. In the future though, the so-called BRIC countries (Brazil, Russia, India and China) and others with fast growing agrifood sectors, such as Thailand, will not easily allow the talks to be stalled and/or diverted from the final end game. There will be compromise of course but in the future, markets will be more open and less protected. Primary production will shift to where it makes sense to do it and not because it is supported by a distorting policy regime.

Volatility

In the last two years, the world economy has been riddled with volatility. This has been in terms of commodity prices, energy prices, currency and exchange rates and the nature of consumer behaviour when shopping for food. While organisations such as FAPRI[2], OECD[3] and FAO[4] are all predicting a return to more stable price patterns, many involved in the actual sharp end of production, processing and distribution of food are predicting that this sort of volatility will become part of the new norm. For those that have been operating in less protected markets and industries around the world, they are inherently more accustomed to dealing with this facet of international trade. For those that have enjoyed various forms of market protection, it has been something of a rude awakening.

The Response of the Supply Chain

The supply chain has been driven in turn by various distinct groups over the last 40 years. In the 1960s and in to the 1970s, farmers still wielded huge influence on what food was available to consumers. Markets where protected and government influence on what was produced and even traded around the world was strong. Marketing boards and centralised procurement was a key feature of the supply chain. They were very much part and parcel of the accepted way of doing things. In the late 1970s and in to the 1980s, food processors came to the fore. Production of food moved away from a commodity focus to a more added value proposition. Large scale food processors began to dictate terms and conditions to farmers around the world.

Into the 1980s and onto the 1990s, supermarket chains began to dominate and force consolidation on the supply chain and make increased technical and commercial demands on their suppliers. The power that the major international supermarket chains now have over their supply base as they look for ever higher standards of efficiency, food safety and innovation is huge.

In mature markets the major supermarkets account for around 80% of all retail food sales. In emerging markets, the percentage of the market held by the leading modern retailers is much smaller, often just 5%, but is poised for growth. Most of the leading EU and US retailers have ambitious plans for the emerging markets where they see huge opportunities. They have mastered the art of selling to mass markets in their domestic arenas over the last forty years. They will take all this skill and expertise with them in to new markets. Their best suppliers will follow them in.

Leading supermarkets have helped make some food processors around the

2. Food and Agricultural Policy Research Institute, Iowa State University
3. Organisation for Economic Co-operation and Development.
4. Food and Agriculture Organisation of the United Nations

world large and successful. Those that have learnt to deal with the demands of the major supermarkets and foodservice/catering companies have prospered. Those that have chosen for whatever reason, or not been able to change have been either forced out of business or been required to often play in niche market areas.

The idea that major supermarkets will somehow go away in the future seems naive. In the future, there will be fewer of them, they will be more global in their outlook and they will need fewer suppliers. The whole process of 'the big getting bigger' will be ongoing. This will drive further consolidation at all levels of the supply chain. Only the best will survive and they will need scale and innovation of both products and services to do this. Supermarkets in terms of sheer revenues still dwarf the largest food processors, let alone primary farming businesses and in turn their input suppliers. Who will continue to call the shots in the supply chain in the future?.The answer seems clear at this stage.

In reality, both major international supermarkets and foodservice companies are looking for the same attributes of their suppliers:

- *Scale of operation* The development of global retail and foodservice operations will mean they are looking to work with global suppliers. Strong retailers need strong suppliers with high levels of market and technical understanding, who in turn will want to partner with strong raw material and input suppliers. The ability to work in challenging new markets will be critical, as well as securing existing business in more mature regions of the world. This will require new business skills and bold, but well balanced and long term decision making processes.

- *Security of supply* At a purely commercial level, there is concern amongst the leading food retailers and processors about how they secure the best suppliers for the future. The best farming and food processing companies are in demand. Businesses that can help them identify who these best of class operations are and can help bring them to the table, especially in emerging markets, are in a strong position and at a government level, there are also worries that the impacts of climate change, global volatility and energy demands allied to the booming world population will put an increased strain on global food supplies. Companies that can help provide solutions to these problem areas through the provision of innovative technologies will be favoured and sought after, by both commercial and government partners.

- *Efficient supply* chains Major end users in the global food market will always be looking to increase efficiency as part of a culture of ongoing improvement. Country competition e.g. the EU vs US vs the Southern Hemisphere is being replaced by chain competition, the chains being those of the leading retail businesses and foodservice companies. In the future, producers and processors will often be in the chain of a leading retailer. Being outside any of these chains will leave you in a potentially vulnerable position. These chains will be more streamlined and of a more dedicated, even exclusive nature than in the past. Only those companies that can demonstrate genuinely high levels of market and technical expertise will be able to straddle these chains and work with multiple partners. To do this will require a high international reputation and a critical business mass and to have made themselves all but indispensable to their supply chain partners. Genetics companies have a strong role to play here. With increased spend in R & D (research and development) and the transfer of technology, they can help farmers produce more efficiently whether the issue is supplying a leading retailer with a specific product with enhanced attributes (see the comments on product differentiation below) or meeting the challenge of feeding an extra 3 billion consumers in the world

- *Value for money* There are numerous technical and commercial demands being made on the supply chain and these have been discussed earlier. The implications are that the more complex problems will not be solved readily without investment in R & D and technology transfer. This might prove expensive yet consumers and retailers/foodservice companies are reluctant to pay more for their food supplies. Value for money can be subjective what is good value for money in London, Beijing and Moscow is very different, as might be the experience of shopping in a high quality niche retail outlet, as opposed to a discount store. But the basic message is the same whether we like it or not, price will always be a factor and providing good value for money at whatever level is essential. If solving the challenges of the supply chain is going to have cost implications, as they will, the companies who have already invested or begun to invest in the work required will have a head start. There is no point in re-inventing the wheel, as this will only compound the problems that are likely to arise. In many cases, solutions to the challenges may already or in some cases fully exist. The task is one of effective technology transfer to supply chain partners, rather than just more R & D for the sake of it. Not least, neither governments around the world and the global supply chain cannot afford it.

- *Values for money* The move to being able to demonstrate high levels of corporate social responsibility (CSR), ethical trade and business practise will also be of paramount importance in the future. This can mean different things to different companies and can cover a wide range of activities. It might include for example the sensitive and efficient use of natural resources, investment in social projects, ensuring that labour and staff are not being exploited and well trained for the tasks they have to perform and not engaging in activities that can adversely impact on the environment and communities. The organisation, knowledge base, strength and focus of many Non Governmental Organisations around the world means that any companies not ensuring it has a defendable track record of CSR is potentially vulnerable to unwelcome scrutiny.

- *Differentiation of products* As part of the concept of chain competition, retailers and foodservice companies will be looking for differentiated and new products as a matter of course. This will give them competitive advantage over their rivals. This might take one of several forms products such milk and dairy items that can be produced with lower fat, produced in a more environmentally sensitive manner, with higher functionality, enhanced taste characteristics, better traceability, more provenance, of higher intrinsic quality, better visual appearance, and in some cases, cheaper. Again this starts with the process of input supply. Proactive crop and animal breeding companies will play a key role in all of this.

- *Food safety* This is an issue that simply will not go away. While much of the world's food is produced in a perfectly responsible and safe manner and to high levels of safety, the ongoing outbreak of animal diseases around the world shows what a challenging issue this can be. This might be the incidence of ISA (Infectious salmon anaemia) in Latin American fish farms or the outbreak of Foot and Mouth Disease (FMD) in places such as Japan and South Korea. The UK has had more than its share of similar problems in the past of course with both FMD and BSE (Bovine Spongiform Encephalopathy). This is a global issue not a local one and getting it wrong can be highly damaging to governments and food companies alike. Global food safety protocols as well as the ones developed by leading retailers and food safety will become the norm in the future. Companies in the supply chain who can openly demonstrate high levels of bio-security and a high level understanding of the issues involved will be at a strong advantage

The leading players in the supply chain who are most likely to succeed will need to have both scale and high levels of expertise. They will be of the 'chosen few'. The challenges facing food processors and retailers/foodservice companies are huge. As well as the areas that have largely been mastered to date, such as the ability to move food all round the world safely, they will require answers to a whole range of other new areas that now confront their businesses.

These include the need to feed more consumers on the planet of which many will want higher added and differentiated food products. Meeting the challenges of factors such as climate change, global volatility, more open and less protected markets and demands made on natural resources such as energy and water usage are all complicated tasks. Individual companies (even the biggest) will find it difficult to meet all of these requirements and challenges on their own. They need to access resource and expertise with other partnering companies in the supply chain. Just having excellent products will not be enough in the future. The ability to leverage and share information and genuine knowledge with key supply chain partners will be a key success differentiator.

Conclusions – what will the supply chain look like in the future?

We will see a more collaborative approach to how the supply chain works in the future. In many cases, finding the potential answers required begins with the input suppliers, providers of seeds, feeds, crop protection products and animal breeding services. Around the world, agri-food supply chains are looking to develop joint partnerships and strategic alliances, etc., and this can start at the stage of input supply. Look at what companies such as Syngenta, Bayer, Monsanto are doing in terms of understanding the supply chain. They are forming partnerships and relationships with food processors and retailers to provide workable solutions to ever more complex questions. Developing these relationships takes time and requires a new way of thinking from all involved but the potential reward is high. Genus plc has been doing the same sort of thing with the development of projects with key customers such as the likes of Tesco, Waitrose, Cargill and Mengui, the leading dairy processor in China.

It is clear that the global supply chain is under pressure from commercial, regulatory and environmental forces for change. The situation found around the world over the last 2 years has accentuated the need to find solutions to the problems faced. What we can be sure of in the future will be that the supply chain of the future will be characterised by a combination of the following:

- supermarkets, processors and large foodservice companies will still dominate the end user markets the big will carry on getting bigger;
- the supply chain will carry on consolidating at all stages from the farm base upwards;
- volatility will be a key feature of international markets in the future but closer supply chain relationships are a way of combating this and the need to partner and work in close collaboration with others in the supply chain has never been higher;
- growth will come from emerging markets but mature markets will still be very important to international agribusinesses around the world - getting the right balance will be important;
- the supply chain will be greener and more environmentally aware than in the past and consumers will be more numerous, wealthier and demanding ;
- CSR as an agenda item will come to the fore in a way not seen in the past;
- food will need to be produced in a safer and more efficient manner than in the past and with less chance of being faced with the problem of disease and contamination.

The future business environment will continue to be very tough but also full of opportunities to those with the correct skills set, technical and commercial abilities. The best positioned will be those who have achieved the status of being one of the 'chosen few'. They will have made themselves indispensable to their supply chain partners.

Looking at all the factors mentioned above it is hard to see that the future operating environment can be anything other than more challenging, potentially volatile and unpredictable. Learning to manage this will be at the heart of the skills set required for successful businesses at all stages of the supply chain. The worlds agricultural and food producing systems and their supply chains all the way from the area of input supply through to the consumer are about to put to the test in a way not seen before.

About the author

John Giles (jgiles@promar-international.com) is a Divisional Director with Promar International, the agrifood marketing and business development consulting arm of Genus plc. Promar has carried out work in assessing the development of the international supply chain for agricultural and food products and analysis of key international markets in the UK and other EU countries, Eastern Europe, Russia, the Middle East, North and Latin America, Africa and Asia. In the past John has been a Visiting Fellow at the School of Agriculture, Food and the Environment at Cranfield University, and is currently Chairman of the UK Chartered Institute of Marketing's Food, Drink and Agriculture Group. He is a Member of the Institute of Agricultural Management and is the current Vice Chair and also Chair of the Thames Valley branch.

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CONFERENCE PAPER

HIGHER LEVEL SKILLS FOR FOOD SECURITY: DO WE HAVE THE RIGHT INGREDIENTS?

David Llewellyn

This paper reviews what we mean by 'higher level skills' and who is best placed to provide them. It investigates contemporary issues that need to be addressed so that the best possible people can be provided to tackle the agri-food challenges we face in the light of the debate on food security. Finally, the ingredients for success are considered, in the context of collaborative frameworks for agricultural higher education, closer links with industry and international examples of investment in higher level skills.

Key words:
Education, training, skills, agriculture, food security

Introduction: The Role of Higher Level Skills

In the last two years there has been a significant change in the way that agriculture, and closely related land-based sectors, are viewed in terms of their role in food and energy production and the management of natural resources. The Cabinet Office 'Food Matters' report (Cabinet Office, 2008) highlighted the further challenges of the impact of food production techniques on human nutrition and, at an international scale, their contribution to the global challenges of climate change and the alleviation of food poverty. The recognition of these complex interrelationships came at a time when some parts of the world were faced with food shortages and the 'food price spike' seen during 2008, causing agriculture and the issue of food security to be considered as policy priorities.

DEFRA's subsequent strategic review of UK food security (DEFRA, 2009) was, however, surprisingly silent on the human resources required by the agri-food sector to address the challenges identified by the Cabinet Office. The House of Commons Environment, Food and Rural Affairs Committee took up this point in its review of food supply issues in the period to 2050 when it noted that, 'Several submissions expressed concern about the erosion - or even disappearance - of particular skills connected with food. These concerns centred on farming and applied research' (House of Commons, 2009, p50). The report highlighted DEFRA's initial submission on agricultural research which said that:

> 'We have some concerns that expertise in agricultural sciences, and in specific technical areas (for example, soil science, weed science, 'whole organism' biology, agricultural engineering), are not being replaced; universities are no longer teaching relevant courses, and long term career prospects are limited'

The report went on to note that DEFRA had not provided a plan of action to tackle these concerns and recommended that there was a need for urgency in addressing, 'potential gaps in food and farming skills' (*ibid*, p51), to the extent of reintroducing a postgraduate studentship scheme to, 'encourage more young people to acquire the skills that will help the UK and the world to produce more food, more sustainably'.

Whilst this recommendation remains to be implemented, substantial progress has been made on highlighting the issue of food security, and, within it, the need for expertise to address the complex environment of food production. A major shift occurred in early 2010 with the publication of the Food 2030 cross-Government strategy for food, (HM Government, 2010) and the associated strategy for food research and innovation (Government Office for Science, 2010a), both of which highlighted the need for skills and expertise to be developed, on the one hand to improve the competitiveness and the resilience of our food chain and, on the other, to ensure that we have the necessary research skills to continue to make advances in food production techniques. These documents established an objective to sustainably increase food production by 50% by 2030 to meet the needs of a growing world population. A subsequent Foresight Panel report on Land Use Futures identified the important role that agriculture and forestry will play in mitigating the effects of climate change, whilst also recognising that more intensive land use will require the adoption of, 'Advanced information, engineering and biological sciences, including technologies such as 'precision farming' and anaerobic digestion,' to, 'help farming reduce its environmental burden' (Government Office for Science, 2010b, p13).

A number of key organisations (see, for example, The Royal Society, 2009; NFU, 2009; BBSRC, 2009) have called for a greater appreciation of the role of science and technology in food production, some with a particular focus on applied research and the translation of research into practice as critical components in this approach (see, for example, Leaver, 2010). Yet others have identified a need for advances in technological capabilities to be balanced by attention on the strategic business skills necessary to create profitable farm operations in a volatile global economic and commodity pricing environment (Rickard, 2010). It is likely that the forthcoming Foresight Panel report on global agriculture, expected in early 2011, will highlight the potential for currently available science, coupled with better educational provision, to improve food productivity. At its interim stage, research commissioned by the Panel (Godfray, *et al*, 2010, p2770) suggested that there were:

'Major opportunities for yield growth through the application of traditional and novel science ….(with)…. significant yield gains that can be obtained by working closely with farmers ….. to deploy existing knowledge and resources through better education and greater social and economic equality—closing the gap between realized and current possible levels of productivity and improving efforts to reduce waste.'

So, a theme has emerged – the components of which are an acceptance that food security is a major policy concern, that skills levels need to be improved to address global challenges in food production and environmental management and that a significant element of skills development should be directed towards a broader understanding of science and technology, in terms of managing farm businesses and in replenishing our scientific capacity. The continuing ability of leading people in the UK agri-food sector to innovate and develop scientific advances, to research, identify and apply novel methods in the management of farm businesses but also to shorten the period between the identification of new techniques and their application in the field, will be fundamental to the success of modern farm businesses. These abilities, coupled with an understanding of the wider social and international impacts of the agri-food sector and the ability to think creatively, could be taken to encapsulate some of the higher level skills provided by a university education.

Given the pressures on meeting the food production objectives set out in Food 2030 there is a need for urgent action to enhance these skills. As Piesse and Thirtle (2010) report:

‘The diffusion of both biological and mechanical innovations takes many years, so there is a lag between the R&D expenditures and the productivity gains at the farm level that can be 25 to 40 years. R&D produces yield gains at the trial plot level, which then require expenditures on extension to take them to the farmer. Then, since more educated farmers are generally better at screening and adapting new technologies, farmer education plays a role.’

The acquisition of higher level skills is therefore growing in importance, not only in respect of more quickly encouraging the adoption of innovative techniques, but also as those engaging in learning seek portable accredited qualifications that will serve their needs in the global agricultural employment market. What then for the role of higher education in this rapidly changing environment, where higher level skills could be the key to solving many of the challenges in the food security debate?

The Provision of Higher Level Skills

Those working in the UK farming sector will be well aware of the recent history of publicly funded higher education in agriculture and related subjects, in which there has been considerable rationalisation over the last 20 years. A number of notable mergers (including Seale Hayne College with the University of Plymouth in 1992 and Wye College with Imperial College London in 2000) were a consequence of the perceived vulnerability of smaller scale specialist land-based higher education providers combined with the problems of student recruitment encountered in the 1990s and early 2000s because of the mixed fortunes of the agricultural sector over that period. The outcome of these mergers has generally been the closure of land-based provision, or its integration with related subject areas, leading to a loss of a clear identity for agriculture in the resulting subject base.

Other mergers and university faculty closures have since taken place, leading to a position where the UK now has only 4 specialist higher education colleges providing land-based subjects (Harper Adams University College, the

Royal Agricultural College, the Scottish Agricultural College and Writtle College) and around 10 university faculties with varying degrees of involvement in production agriculture and closely related subjects. In recent months, further rationalisation in applied research expertise has taken place with the transfer of parts of Warwick HRI to a new school of life sciences within the university, and the proposed restructuring of dedicated plant sciences provision at Imperial College London (Morgan, 2010). Proponents of restructuring claim that participation in agriculture and related subjects within higher education remains at a relatively low level, with a total (undergraduate and postgraduate) of only 0.76% of overall higher education provision in the UK (HESA, 2010), or that applied research will not be able to compete in the highly competitive funding environment for research income which continues to be geared towards more basic scientific research.

Whilst both arguments are, in the short term, true, they fail to appreciate that industry demand for graduates in agriculture and related subjects is extremely high (Harper Adams University College and the Royal Agricultural College fall within the top 10 of UK universities on this indicator of performance) and that the weight of evidence suggests that we need to encourage new entrants to agriculture and to agricultural science to meet emerging policy objectives on food security and environmental management. In other words, we are in a position where industry demand for highly qualified people is beginning to outstrip supply.

Recent reports underline this conclusion. A skills assessment by the sector skills council for the environmental and land based sector (LANTRA, 2009) suggested that intergenerational losses and predicted demand meant that the sector would need to attract 60,000 new entrants over the next 10 years. Whilst, overall, jobs with intermediate and low level skills were thought likely to reduce in this period, there were no forecasted losses in high-skilled occupations. Already, 31% of vacancies across agriculture were considered to be ‘hard to fill’ because of skills shortages, compared to 21% across all sectors, with significant problems for farm managers (70%) and farmers (59%). The Institute of Agricultural Management has recently reported (Crane and Cooksley, 2010) that only 23% of farm managers are under the age of 40, compared to 63% in its first survey in 1969. It noted also that the average salaries of farm managers increased by 14.6% from the last survey in 2007, to £44,655 per annum in 2009, reflecting recruitment difficulties and the need to retain high quality employees in a complex operating environment.

The UK is not alone in facing these issues. In the USA there has been considerable concern about its capacity for agricultural research coupled with warnings over the last decade of, ‘a growing skills gap resulting from a long-term decline in student interest together with a wave of impending retirements’, with the USDA alone estimating that 17,000 of its 100,000 staff will retire in the next five years (Gewin, 2010).

Gewin went on to note recent initiatives, such as the creation in 2009 of the USA National Institute of Food and Agriculture (NIFA) which will tackle US priorities of climate change, nutrition and food safety and has already instigated a significant increase in agricultural research funding with larger grants over longer time periods to attract new scientific talent. Furthermore, the NIFA Director is reported to have said that, 'at least one third of future Agricultural Food Research Initiative grants will require an extension or education component to help translate research findings to farmers and consumers' and a NIFA Fellows programme will offer at least 50 newly funded pre and post-doctoral fellowships (*ibid*, p.129). Other schemes to help develop agricultural research capabilities in developing countries have been supported by the Gates Foundation, the USDA and the International Rice Research Institute, whilst the UK strategy for Food Research and Innovation (*op cit*, p 51) simply noted the UK's potential for training overseas scientists which would have multiple benefits to agricultural development at home and overseas.

In mid-2009 the BBSRC, responding to the growing emphasis on food security and working with the Government Office for Science Food Research Partnership, which has brought together industry and Government representatives to consider the issue of food security, commissioned two working groups to look at the translation of research into practice and agri-skills development and capacity in the UK. In the latter case the working group found it difficult to identify conclusive data on skills shortages at graduate level but was faced with much anecdotal evidence of the need for investment in skills gaps amongst current employees in the agri-food sector. It concluded that there was a requirement for higher level skills development to be encouraged within industry so that full advantage of scientific and technological advances could be brought to bear on agricultural practice. The BBSRC has since launched a plan to fund a limited number of Advanced Training Partnerships (ATPs) that, importantly, will be focussed on industry requirements and will provide flexible learning opportunities at postgraduate level. Another key feature of the ATP scheme is that of collaboration expected in its delivery, both between universities and between universities and industry. This builds upon the concept of continuing professional development (CPD) that has been a feature of the higher education landscape for many years, but formally extends provision to advanced level skills development, including to doctoral level. It is expected that the successful ATPs will be announced in early 2011, but it is already clear that universities, and industry, have been prepared to engage in the programme, often in novel partnerships spanning the entire food chain, and that it will see advanced level skills provided in a more collaborative environment between higher education providers than may hitherto have been the case.

That is not to say that industry and the university sector have been ploughing their own furrows until now. In 2008 the Labour Government introduced the concept of 'employer engagement' to encourage greater collaboration in higher level skills development, in response to the Leitch Report (HM Treasury, 2006) which recommended that, to remain competitive in the global economy, the proportion of adults qualified to degree level would need to rise from 29% (in 2005) to over 40% by 2020. The report backed the idea that continuing professional development and 'workplace learning' should be used to enable this target to be achieved. In one such example, Harper Adams University College and the Royal Agricultural College launched the Rural Employer Engagement Development Network (REEDNet) to offer CPD programmes aligned to industry needs. One driver for provision in the early stages was the agreement to accredit, at higher education level, programmes to meet legislative requirements such as the BASIS and FACTS courses in crop production and AMTRA programmes in the dispensing of animal medicines. Since then, using fast-track methods for approval, and with the current benefit of co-funding to help industry meet the cost of providing accredited learning, novel approaches have been adopted, such as the accreditation of in-house industry CPD schemes. Recognition by universities that private sector CPD provision has a place within the broader higher education ecology has helped push back former barriers, enabling industry to achieve its learning objectives, whilst affording participants the opportunity to take advantage of 'bite sized' pieces of higher education that might encourage them to engage in further learning later in their career.

The agri-food sector has demonstrated that it is ready to take advantage of this model. Nationally, in 2009/10, the number of employers providing co-funded contributions to employer engagement learning, in cash or in kind, was 2,706, of which 562 (21%) participated in the REEDNet programme. In the same year, nationally, 1,237 employers were new to co-funded educational work with universities, of which 401 (32%) were with REEDNet. REEDNet accounted for virtually 100% of recruitment in the agriculture and related subjects category, and 25% (by full-time equivalent student) and 43% (by headcount) of recruitment in the wholesale and retail trade subject group.

Furthermore, the industry has been active in providing technical and managerial level skills development in its own company-based or externally managed programmes. One example is the Kite Consulting Dairy Managers Training Scheme, a two-year programme for college leavers intended to develop practical and business skills to produce high quality herdsmen (Harris, 2010). Whilst not always accredited for further or higher education qualifications these activities are no less beneficial in improving skills to enhance business efficiency, profitability and staff engagement. These outcomes feature in the cross-sector AgriSkills Strategy launched with Government support in February 2010 (AgriSkills Forum, 2010). The Strategy acknowledges the, 'central role that investment in personal and continual professional development plays in the improvement of business performance, competitiveness and sustainability' (p1). It also notes that there is an opportunity to use, 'proof of competence as a mechanism for risk-based implementation of regulation' by Government (p7) and that CPD has a significant role to play:

'Too often a career in agriculture is deemed to be more suitable for those who are amongst the lower academic achievers. To tackle such false perceptions industry must seize the initiative and demonstrate the professional, highly technical, innovative and fulfilling nature of what it does, to those who influence career choices.' (p9)

By matching the need for higher level skills set out in recent policy statements with flexible provision across different types of educational provider and delivery models and developing a cross-sector statement of intent in the form of the AgriSkills Strategy, the agri-food industries have sought to improve their ability to attract and retain high-performing staff, and create an attractive prospect for younger generations to forge a professional career. However, whilst these initiatives have been helpful a number of challenges remain.

Higher Level Skills: Future Challenges

The Political Environment

The notion that the existence of the AgriSkills Strategy and the continuing efforts of educational providers and industry to develop appropriate learning opportunities would be enough to encourage other bodies to see it as a suitable career choice was short lived. In March 2010, the UK Commission for Employment and Skills (UKCES) published an influential national strategic skills audit, aimed at identifying priority areas for investment in future skills development (UKCES, 2010). Whilst acknowledging that agriculture was amongst the industries with the greatest skills shortages, because of its relatively small size to other sectors, now and even more so in the future, the report ranked agriculture 25th out of 27 industry groups in terms of future overall economic significance. Perhaps more surprisingly, food and drink manufacturing was ranked 20th on the same basis. Commentators suggested that the report failed to see the integrated nature of the agri-food sector, its strategic economic and social role and the fact that, overall, it constitutes the largest manufacturing sector in the UK, contributing some 6.7% of GVA. Yet the core message from the UKCES report is that the disaggregation of the food chain is likely to cause serious problems in future skills policy development and that a concerted effort needs to be maintained to convince Government, and its advisory bodies, of the larger scale economic and social impact of the agri-food sector, as well as the increasingly technical environment in which it operates.

That work needs to cover all of the bases. Whilst DEFRA has been supportive of the AgriSkills Strategy, the results of the UKCES study could divert the attention of the Department for Business, Innovation and Skills (BIS) towards other subject areas where it is perceived that greater economic returns are possible from public sector investment. The importance of developing the higher level skills base of the agri-food sector to public sector policy outcomes in health, energy production, primary and secondary education, science and business development in the wider economy need to be stressed. Recent medical research has developed an understanding of the links between climate change and human health (Costello, *et al*, 2009), placing water and future food supplies right in the middle of this debate. Industry groups, alongside the initiatives already taken by the sector's representative bodies, such as the NFU's 'Why Farming Matters' campaign (*op cit*, 2010) must continue to make clear the wider implications of securing the capacity and capability of the next generation of leaders in the sector, not simply to tackle the issue of food production, but to emphasise the wider benefits to society of farming in what will be a markedly changed environment.

Motivating Younger People

There are a number of recent examples of the way in which the agri-food sector has recognised, and taken steps to meet, the challenge of raising awareness of the industry and the career options within it. The Farming and Countryside Education (FACE) programme, has sought to address this issue with younger children, the land-based educational sector, with FACE and others, is working with teachers to improve their understanding of modern farming practices, the sector skills councils are promoting career choices at a variety of levels and the RASE has reviewed the methods for improving the attractiveness of farming as a career option (Spedding, 2009). More general awareness raising, from the Open Farm Sunday movement to television programmes on farming and food production, together with direct branding by food producers and retailers and the debate on local sourcing of food are beginning to impact on the long held belief that food consumers are disconnected from the source of their food.

Spedding (*ibid*, p6) recognised that this was a multidimensional issue, noting that educationalists, careers advisors, industry leaders and other representative organisations should act coherently to promote careers options to the future generations of young people, and that there must be a means to, 'ensure that the message is taken to urban and rural schools, dispelling the myth that the only entry into farming and related sectors is through inherited wealth'. Other myths are equally difficult to shed, but must be taken on if the sector is to recruit successfully. These include the issues of long working hours, low pay, working conditions and the opinions of careers advisors and teachers about the prospects for a career in the agri-food sector, which may be informed only by out-of-date or underdeveloped knowledge of sophisticated farming techniques and food production methods.

Whilst acknowledging that the agri-food sector is not without its problems, including, in some cases, those identified above, it will be necessary for the sector to continue to make the case to attract young entrants by highlighting the global challenges to which those seeking a career in the sector could contribute. Furthermore, despite recent reports of graduate unemployment being at a 17-year high in the UK (Garner, 2010), there remains intense competition within the agri-food sector for good graduates, as evidenced by graduate employability rates in two of the specialist land-based higher education colleges. To secure new talent, companies and organisations must seek to replicate the approach they have taken to the primary and secondary educational system, to raise awareness of the full range of farming and food career options amongst those currently undergoing their undergraduate education, and to support undergraduate students through their university career.

Engaging Future Employees

There are many examples of approaches where industry representatives are encouraged to engage in curriculum design, conduct advisory work, external examining and the teaching or provide placement opportunities for students, all of which make invaluable contributions to the 'real world' dimension of higher education. But, recognising the current imbalance between supply and demand for highly educated people in the agri-food sector, the industry is thinking in new ways. Some sectors understand the growing cost of higher education and have been prepared to help defray those costs with scholarship support, combined with industrial placements which can provide an ideal opportunity for a long-term relationship with a prospective employee. In some cases the development of 'packages' of support has moved beyond individual companies into a sector-based approach.

One such example is the poultry sector, which has recently launched a cross-industry initiative that includes scholarships and industrial placements. This is a pre-competitive model, where, currently, 9 companies are working under the umbrella of the British Poultry Council, even though they are offering support arrangements for their own organisation. The benefits of this method are threefold. In the first instance it generates a critical mass of interest amongst students so that more are encouraged to attend scholarship events where all of the companies are represented, to see more of what the industry has to offer in a short amount of time for both prospective employer and employee. The second benefit is that each company knows the terms being offered for scholarships so that there is a level playing field when companies gather to meet students. The third benefit is that it accepts that to recruit the best possible people the company has to work hard to ensure that its placement and employment terms are competitive. Backed up with specific company presentations and other methods to raise awareness of career prospects within the sector, this approach, whilst at an early stage, has raised interest amongst a significant number of students.

This is only one example of new approaches to seeking out fresh talent, and it may not be appropriate for all parts of the industry. Yet it does point the way to a need to think critically about how young people make career choices, what they really understand about life in the sector in which an employer is seeking new entrants, and about the need to invest early in influencing career choices for recruitment to be successful.

Common Understanding

To enable these connections to take place, we must have a common understanding, and hence a common language, of what we mean by 'higher level skills' and of the granularity of levels within the framework for such skills. The university sector can be called to task for not getting its message across clearly about the products of its educational process, but industry must also ensure that it has greater clarity about its requirements and the time to understand the modern educational environment. Given that the industry view of graduate level skills is currently a subject of debate within Government, and employer organisations such as the CBI, it is incumbent on the agri-food sector to address this issue soon, to enable it to be in a better position to reinforce its case for public sector investment in skills development when the economy recovers from its current difficulties.

Although the AgriSkills strategy attempted a holistic approach to this issue it suffered from the mixing of terminology in what is, admittedly, a complex environment. One such example relates to Continuing Professional Development (CPD) which can range from a training course at technical level, to an advanced level programme accredited towards a higher education qualification. The complexity of the educational framework is compounded by the complexity of provision. The post-16 land-based educational sector is probably unique in the UK in that 40% of higher education provision is offered by further education colleges (HEFCE, 2007), with the consequence that skills levels and progression routes can be blurred and the higher-level skills base produced by different providers may have a range of exposure to, for example, cutting edge research. On the other hand, the LANTRA work on future skills needs talks of a requirement for ‘higher-level’ skills but focuses on a distinction between generic business abilities (such as communication, problem solving, management and teamwork) whilst separating them from technical abilities (such as operating machinery, animal husbandry and mechanical engineering) (*op cit*, pp36-37).

This approach runs the risk, at least in vocational educational setting, of the categorisation of business skills requirements as ‘higher level’ whilst technical abilities may be seen as the product of more ‘hands-on’ further education or apprenticeship. In making this distinction there is the possibility of disservice to the agri-food sector which needs elements of both, as well as, through training in research techniques, an understanding of the latest scientific and technological advances in its higher education provision.

We must ensure that future managers and leaders in the sector are able to run effective businesses such that they are not divorced from the technical abilities, and research environment, required to understand the wider sector in which they operate. To achieve this objective the higher education sector must encourage industry to share its views on skills needs but be clear that it must also share the task of continuing to develop its staff by investing in them through later stages in their career.

Re-engaging Current Employees

It is widely accepted that higher education is a process in which independence of thought and learning must be developed, yet this objective clashes with the proper desire of subject specialists to cover as much as they can in a crowded curriculum full of the latest scientific innovations as well as more fundamental knowledge necessary to make sense of new discoveries. In other words, the graduates of today face an enormous challenge in being all things to all people when they emerge from university and enter employment. This may be a contributing factor to some of the less positive feedback from employers on the abilities of some graduates in, for example, basic management skills, but it is also a condition that is likely to be exacerbated by the current economic climate and its consequences on the structure of higher education provision. The focus may move towards faster provision, such as two-year degrees, with fewer breaks that provide students with periods of reflection, learning and even employment to generate practical skills in the workplace and the financial resources to pursue their education. It will also be obvious to those working in the crop sciences, for example, that it will be difficult to meet industry needs when graduates may not have been able to conduct basic research projects in a full crop cycle, so this model of provision has particular issues when applied to land-based subjects.

At the other extreme, there is a need to ensure that models are provided that enable graduates to gain further, industry specific, expertise before, or shortly after, they enter the world of work. In such cases, short courses and CPD have provided the means to deliver the necessary knowledge and practical skills, either through graduate entry programmes run by the company or externally organised activities such as those provided by, or in conjunction with, the higher education sector. In yet other cases, graduates may have sought to differentiate themselves by pursuing a postgraduate qualification, although the time and financial commitment associated with this route may prove more difficult in the current financial environment.

There may be room, however, for different approaches to be explored. One such method would be to shorten and re-phase the timing of first stage graduate-level CPD so that it is delivered, in conjunction with workplace learning, in a short and intensive ‘learning package’ immediately following graduation rather than several months, or even years, beyond this point. In this way, companies would benefit from tailored graduate level CPD programmes either provided or accredited by a university partner, whilst the employee would be better placed to meet the full requirements of the employer earlier on in their career. Universities would need to be open to delivering such programmes in a flexible and relevant way, along the lines of the REEDNet programme described earlier, and at times when research activities might normally be expected to take precedence.

Furthermore, ‘learning packages’ of this nature could provide the building blocks for further engagement in learning and, if appropriately accredited, towards advanced level (postgraduate) qualifications. As collaborative means of provision are developed with the BBSRC’s Advanced Training Partnerships it is likely that progression routes of this nature will be developed, requiring industry involvement to ensure that coherent programmes of accredited learning are provided.

The need for such investment in staff development, from private and public sources, will be critical in the medium to longer term, as international scientific innovations introduce new agricultural practices and techniques and the UK is required to make similar advances to remain at the forefront of economically viable production methods. Examples of large-scale investments in Brazil have recently been reported in a US$2bn programme to improve 15 million hectares of degraded pasture over the next decade, and in the use of climate zoning techniques to increase crop productivity by 20% (Tollefsun, 2010). At the same time, Gilbert (2010) reports that Monsanto’s annual research budget is US$1.2bn, ‘just topping the US federal government’s total spend on agricultural science of $1.1bn in 2007’.

The BBSRC, and Government, are concerned to ensure that the UK science base in agriculture is not lost (see, for example, Taylor, 2010) and that a means is found to encourage young and mature entrants into research and development careers. It is thought in some quarters of the UK that these scientists may not require a background in agricultural production, yet the lessons from the US suggest (Gewin, 2010, p130) that:

'Simply luring non-agricultural scientists into agricultural research, without a concomitant increase in traditional plant breeders, agronomists, crop physiologists, plant pathologists and entomologists, could hamper progress towards agricultural productivity and sustainability'

Gewin went on to quote Achim Dobermann, of the International Rice Research Institute who said that, 'We need more people who can think and act in a systems framework, putting all the good science together into practical solutions for farmers'. Notwithstanding this ambition, the current economic climate could limit the ability of Government to invest heavily in developing the science base in agriculture and is serving to impose a new and challenging environment on education providers that may reduce participation in higher education and, hence, make the recruitment environment for industry, and science, even more competitive.

Funding for Higher Education: Some New Challenges

In October 2010, a major review of the higher education sector was published that set out a radical new funding approach (Browne, 2010). It was proposed that the financial cost of higher education should be transferred largely from direct payments by Government to higher education institutions, to students, who would, as a consequence, pay significantly higher tuition fees. The basis of the proposal has been accepted by Government, though the terms of its implementation have been altered from the initial recommendations, to impose a fee cap of £9,000 per annum on the charges that can be levied by universities and higher education colleges. A much reduced amount of Government funding for teaching will remain, directed towards a range, as yet undefined, of science and engineering-based subjects. It is widely suggested that other subjects (mainly the arts, humanities and social sciences) will receive no public funding at all.

Four other points are important. The first is that, at the time of writing, the Coalition Government faces a difficult political position in introducing the concept of higher tuition fees. The second point, assuming that first can be addressed, is that student loans and, for lower income households, an element of grant support, will be maintained so that higher education remains free at the point of entry. Loans will be repaid after graduation, as in the current system. This approach will be extended to part-time undergraduates (over a certain threshold of part-time study) but not to postgraduate students, thereby making shorter postgraduate 'learning packages' possibly more acceptable in the face of increased graduate debt. The third point is that the higher fees are unlikely to add to institutional income. The Government's recent Spending

Review signalled significant funding cuts in teaching of at least 40% to be introduced over three years from 2011/12, and starting even before the higher rates of fee become payable by first year students in 2012. The fourth point is that this major shift in funding policy will open up greater competition for the provision of higher education in low cost subject areas and significant challenges for subject areas that are unable to compete for students.

It seems likely that a number of factors, in addition to course pricing, will become increasingly important. The quality of educational provision, specialisation in provision (to be distinctive in the new marketplace for students), student retention, graduate success and employability are all critical factors. In this respect, specialist land-based higher education providers may be thought to have little to fear from these developments if they continue to meet the above criteria. A distinctive feature of these institutions, however, is their connection with industry and the emphasis that this brings to a relevant vocational education that leads to strong performance in graduate employment and, at present, solid demand for graduates from land-based disciplines.

Yet this is a period of considerable uncertainty for higher education providers, future students and their parents, just at the point when the agri-food sector needs an increase in staff with higher-level skills. We will need to act together to ensure that future students are not put off a leadership career in our sector because of increased graduate debt; that industry is able to navigate its way more easily through educational systems to secure future talent; that we have the means to continue to develop scientific and technological expertise amongst staff already in the sector; and that we can provide the next generation of scientists able to compete at an international level in agricultural and related sciences. As a first step it will be important for remaining public sector investment in higher education teaching to be directed towards industries where a combination of economic and social benefit can be demonstrated, rather than simply a reliance on a simple economic return on investment. Food and land-based energy production, together with the sustainable management of our natural resources, are key sectors where this argument must be won.

Conclusion

This paper has sought to make the case, in terms of policy imperatives and meeting current and future industry demand, for ensuring that there is an appreciation of the need for higher level skills in the agri-food sector to address the challenges we face over the next few decades in maintaining food security. Recent studies have identified an impending shortfall, over the same period, in people equipped with the necessary skills to effectively manage increasingly complex and volatile business environments, whilst also being able to successfully implement agri-food scientific and technological advances. Other countries are investing in these developments, and so must we. Yet all of this also comes at a time of uncertainty over a rapidly changing funding climate for higher education, from which the majority of the higher level skills base serving the needs of the agri-food sector in the UK is provided.

The need for educational providers and industry to act in concert has been established as part of the argument for securing new talent for the agri-food sector, and a number of new initiatives that demonstrate this approach have been explored. Greater and more innovative collaboration will be needed, to break down barriers to learning, invest in CPD for current employees and ensure that industry can encourage current students to pursue a career within the sector and not to leave it on graduation.

Finally, as in any recipe, all of the ingredients must be of the highest possible quality if the resulting product is to stand up to critical judgement. In this respect, the need to understand our respective operating environments, and support each other, will be even greater as higher education moves towards a more market-based model of operation over the next few years.

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REFEREED ARTICLE

DETERMINANTS OF THE FARM GATE PRICE OF MILK: QUANTIFYING THE IMPACT OF MILK CONTRACT AND SELLING ARRANGEMENTS

Paul Wilson

Recent variability in farm gate milk prices has led to increased interest in milk selling arrangements. Analysing data for 220 conventional English dairy producers reveals significant differences in the milk contract and selling arrangements of producers receiving the top 25% of milk prices, when compared to producers receiving the bottom 25% of milk prices. Hedonic regression analysis estimates the value of the individual attributes of milk selling arrangements. Milk price variation is likely to hasten further structural change in dairying.

Key Words Milk Contracts, Pricing, Hedonics, Profit, Dairy

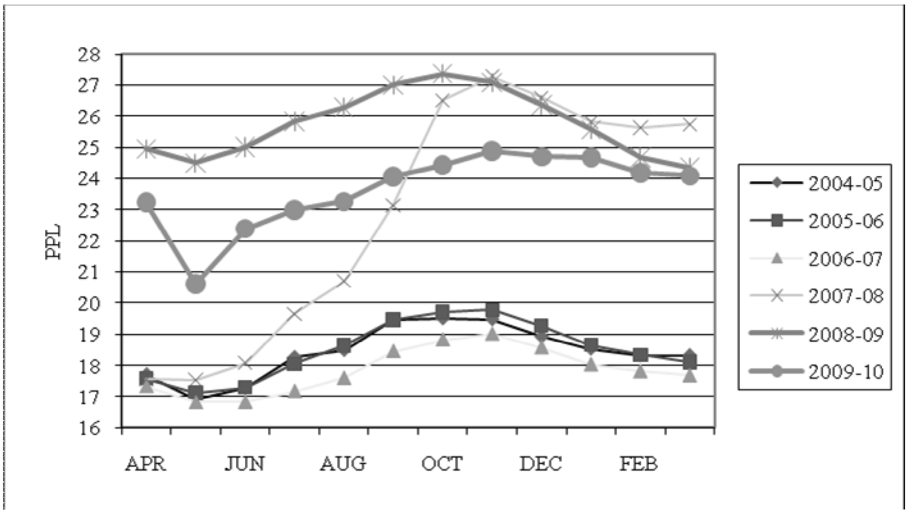
Introduction

UK dairy farming accounts for £3.1bn (16%) of agricultural output, producing 13.2bn litres of milk per annum (Defra 2010a). For milk producers, the price received is one of the key determining factors in dairy profitability (Wilson, 2011). The UK dairy industry has undergone substantial structural change in recent years, as the number of producers has decreased, countered in part by an increase in average herd size (Robertson and Wilson, 2009). Milk contracts on offer to producers can be grouped into four main categories: i) retailer contracts with producers aligned to dedicated retailers supplying liquid milk; ii) non-aligned liquid milk contracts (e.g. Arla, Wiseman, Dairy Crest); iii) contracts to supply manufacturers of higher value cheeses (e.g. mature cheddar, stilton), with the co-ops broadly falling within this sector; iv) milk sold to commodity product markets (Promar, 2009). A further milk selling arrangement is whereby milk producers sell or transfer their milk to their own milk processing unit.

DairyCo (2010) note that following the collapse of Dairy Farmers of Britain (DFoB) in 2009, the two largest UK milk co-operatives are First Milk and Milk Link, with both offering contracts in terms of the milk price, plus returns on investment in the co-operative. Other major milk purchasers are Arla Foods UK, Dairy Crest, Meadow Foods, Müller and Robert Wiseman Dairies, with these buyers offering different contract options in terms of regional coverage, bonus payments linked to milk quality, links to market conditions and length of contract exit period. DairyUK (2009) details the variation in milk processing activities amongst some of the major players, noting the scale of the sector with 524 processing plants, of which 453 process 5 million litres or less, accounting for 1.4% of milk by volume; by contrast 23 plants of over 100 million litres throughput account for 89.5% of milk by volume (DairyUK 2009).

The milk market has recently witnessed specific drivers of change linked to structural aspects; the UK's continual fall in milk production represents the visible output of structural change with recent data indicating that UK milk deliveries were “under quota” by 1300 million litres, equating to 9.1% of quota (MDC Datum 2010). This fall in production has led to some relatively variable milk prices over recent years. Figure 1 shows UK average producer ex-farmgate milk price (including seasonality; net of delivery charges) from 2004-05 to 2009-10. The summer of 2007 saw a substantial increase in milk price, with buyers seeking to secure supplies, leading to prices peaking at 27.3 pence per litre (ppl) in November 2007. Throughout 2008 prices fell back but largely remained above 25 ppl, albeit by the end of the 2008/09 milk year prices dipped below this 25ppl mark. The average price during 2008/09 (2007/08) was 25.75 (22.9) ppl. The milk year 2009/10 witnessed the collapse of (DFoB), and this collapse had a large effect on the average milk price received by producers in May and June of 2009.

Figure 1: Farmgate Milk Prices (UK)



Source: Defra (2010b)

Issues of dairy production, profitability and milk pricing have received considerable attention in both academic and industry arenas, particularly since deregulation in the sector in 1994. Bates’ (1996) assessment of the impact of deregulation provides an overview of milk prices across different milk buyers and notes the importance to farmers in understanding the market fundamentals in addition to milk quality attributes. Bates and Pattisson (1997) analyse farmers’ decisions to join the then large co-operative Milk Marque, citing ‘strength in numbers’ as the highest ranking influencing on farmers’ decision to join Milk Marque, whilst, ‘price’ was found to be the most important factor for producers supply other buyers and processors. Franks (2001) finds evidence that prior to 1993/94 smaller herds tended to receive higher milk prices, but after this date, this trend reversed with larger herds increasingly attracting higher prices, citing an 8.2% advantage of the larger herds over smaller ones, and noting that this shift in the market followed deregulation, "freeing" farmers to choose their milk buyer. Franks (2002) provides a further analysis of the determinants of milk price including significant factors of milk content and hygiene attributes, volume of milk sold, seasonality, breed and location of the farm; this large sample size and depth of data enabled a regression analysis that explained 77.5% of the variation in milk price to be presented. Franks (2002) also finds that Milk Marque suppliers achieved 1.5ppl less than non Milk Marque suppliers. In a further analysis of the milk market Franks (2003) argues that farmers need to adopt marketing strategies to counteract supermarket negotiating power, and also finds evidence that the market support mechanisms in the dairy sector have frequently not delivered a sustainable milk price to farmers; Franks thus calls for combined action by farmers to redress imbalances in the market.

Given recent price variability in the milk market, interest in milk selling arrangements has received growing attention. A National Farmers Union (NFU) survey found that 29% of milk producers were not satisfied with their milk contracts, with substantial variation being observed with respect to levels of satisfaction, with the co-operative group First Milk receiving the lowest satisfaction levels, and Wiseman's recording the greatest level of satisfaction (Campbell-Gibbons, 2010). The results also demonstrated that 73% of producers supplying to a PLC were very or fairly satisfied, whilst only 55% of those supplying a co-op were very or fairly satisfied. Campbell-Gibbons also found a link between contract satisfaction levels and volume of milk supplies; specifically that 76% of producers supplying less than 2m litres are very or fairly satisfied with their contract, whilst only 55% of those supplying over 2m litres note this level of satisfaction.

Milk represents a broadly homogeneous product; however quality parameters with respect to product content (protein and butterfat) and hygiene attributes (bactoscan and somatic cell count), and the influence of these parameters on milk price, are well understood across the industry, with milk buyers and levy boards providing pricing details based upon content, hygiene and volume of milk variables, e.g. interactive milk price calculator tools (DairyCo, 2011), also freely available data on milk price variability over time exists (e.g. Defra, 2010b). However, whilst certain attributes are more transparent in the industry it is less transparent how milk buyers value the individual attributes of a particular farm supplying milk (e.g. location, daily or every other day collection, number of buyers from which the farmer can choose to supply to) and moreover, how the characteristics of the contract (e.g. sales to a co-operative versus a processor; retailer linked contracts) influence milk price independently of product content and hygiene attributes.

For England, Wilson and Darling (2010) provide evidence that for conventional and organic producers combined, producers supplying co-operatives or buying groups received the greatest milk price; however when examining data for conventional producers alone, it was producers supplying non co-operative processors that received the greatest milk price. Wilson and Darling note that a higher proportion of lowland producers are satisfied with their milk contract than their LFA counterparts, and that for conventional producers, those operating under long term contracts received higher milk prices than those operating under shorter contract arrangements; LFA producers were typically more constrained in their choice of milk buyers than producers in the lowlands. Additionally, Wilson and Darling find that a higher proportion of LFA and organic producers had their milk compulsorily collected on an every other day basis (EoD) (Wilson and Darling, 2010).

The above literature indicates that factors beyond content and hygiene attributes can significantly impact on the farm gate price of milk and the level of satisfaction milk producers have with their milk contracts and buyers. However, it is generally not possible to directly observe the market value or impact of non-content / hygiene attributes on the price of milk; the impact of these factors can only be observed when they are either combined with other attributes (i.e. single analysis which compares co-operative to processor supplied milk) or quantified through an estimation procedure which seeks to decompose the overall price or value of the product into its constituent attribute parts. The literature on understanding and quantifying the value of individual attributes of products has grown from the work of Lancaster (1971). Previous empirical research on valuing product attributes covers many different product types and market environments. Within this there is a considerable literature in relation to agricultural and food products including: dairy products in the USA (Chavas and Kim, 2005); wine in British Columbia (Carew and Florkowski, 2010); bread wheat in Turkey (Karaman *et al.*, 2009); milk in the UK (Franks, 2002) and the USA (Lenz *et al.*, 1994); labelling attributes of French wines in the British market (Steiner, 2004); thoroughbred broodmares (Neibergs, 2001); chickpeas in India (Agbola *et al.*, 2002); regional analysis of fresh tomato prices (Huang and Lin, 2007); apples in British Columbia (Carew, 2000); Swedish wine (Nerlove, 1995); cottonseed prices in the USA (Misra, 2000); and sheep and goats in Southern Nigeria (Jabbar, 1998). The literature shares a common overall concept in eliciting unobservable values of attributes from observable product price data; these papers generally consider different model specifications and functional forms in order to obtain the optimal model outputs in terms of explanatory power and significance of the parameter estimates, taking into account model efficiency and complexity.

Whilst the UK milk market is well defined with respect to the price of milk linked to particular product and hygiene factors, the factors behind milk price determination, that flow as a result of different milk selling arrangements, are less well-defined or visible. Findings from Cambell-Gibbons (2010) and Wilson and Darling (2010) provide contemporary insights into the contract selling arrangements of producers, but these studies do not offer an analysis of the milk contract arrangements associated with particular milk price bands, nor do they seek to determine the value of individual attributes of milk selling arrangements as in previous studies of the UK milk market (Franks, 2002). The aim of this paper is therefore to analyse the milk contract arrangements associated with different groups of producers, as defined by the milk price they received, together with a further analysis that explicitly quantifies the individual attributes of milk selling arrangements on milk prices.

Data and Methods

The data were derived from the Farm Business Survey (FBS) for England (2008/09), combined with a subset of 220 conventional dairy producers, who took part in a telephone survey of their milk selling arrangements in February and March 2010 undertaken by Rural Business Research. The physical and financial data from the FBS returns comprised of: milk production per farm; milk value produced per farm; yield per cow; price of milk (milk value divided by milk produced)[1] and herd size. In addition data from the FBS detailed lowland or Less Favoured Area (LFA) status of the farm, together with the EU Super Region in which the farm is located. Data derived from the telephone survey included the following broad data categories: type of organisation to which milk is sold (e.g. co-operative, processor); whether or not the producer changed milk buyer during 2008/09; reasons for changing milk buyer; length of milk contract with buyer; flexibility to switch milk buyer; prevalence and extent of retailer-driven premium; prevalence and nature of price guarantee contracts; intention to change milk buyer in 2011; number of milk buyers the producer had to choose from; frequency of milk collection and reasons associated with this. These combined data provide a unique set of 220 observations on physical, financial, attitudinal and contract information, and is a subset of the data used in Wilson and Darling's (2010) analysis; the data used in this paper relate to conventional producers only.

The data were analysed in terms of number of producers associated with each of the broad categories from the telephone survey. In addition, in order to explore the link between the price producers received and the milk contract arrangements under which they were operating, the sample of 220 producers was divided into milk price quartiles, with quartile A representing the producers receiving the highest 25% of prices, followed by quartiles B, C and D, with the latter representing the producers receiving the lowest 25% of prices. Within each data category, a Chi-Squared test was performed to test the hypothesis that there was no significant difference in the milk contract arrangements or attitudes across the four milk price quartiles. For continuous variables on herd size (cows), production (litres), value of sales (£), yield (litres/cow) and milk price (ppl) ANOVA tests were undertaken to test the hypothesis of no difference in the mean values across the four milk price quartile groups. These series of Chi-Squared and ANOVA tests provide an initial indication of the factors that should be included in an analysis to quantify the value of individual milk selling arrangement attributes.

Following the above statistical tests, hedonic regression equations were constructed drawing upon the evidence derived from these tests. Initial regression equations were constructed including those non-continuous variables where a significant difference of 99.9% was detected from the Chi-squared tests. Moreover, ANOVA tests of the continuous data were used to inform model construction by inclusion of the continuous variables of herd size and yield. In order to assess and test for the most robust model a two-

1. Milk price does not include dividends paid on capital invested in a milk buying organisation, and thus returns to investment in milk buying organisations lie outside of this analysis. The value of milk (and hence milk price) accounts for on-farm milk consumption to reflect the true volume and value of milk produced irrespective of destination

stage estimation procedure was undertaken. Firstly, four model specifications were detailed to examine the impact of the following function forms: i) linear; ii) linear-log; iii) log-linear and iv) log-log as detailed below in equation 1:

$$D = \alpha_o + d_1 B + d_2 R + d_3 CL + \beta_4 CB + \beta_5 FC + \beta_6 H + \beta_7 Y + e \qquad (1)$$

Where:
a_0, d_k (k=1,…7) are coefficients to be estimated

D Dependent variable: Price of milk in pence per litre (P) or natural logarithm of the price of milk in pence per litre (LnP)

B Buyer variable: 1 if sold to a processor; 0 if sold to co-operative / group

R Retail contract variable; 1 if sold under retail contract; 0 otherwise

CL Cost-linked variable: 1 if sold under cost-linked contract; 0 otherwise

CB Choice of buyers variable: 1 if have choice of 3 or more buyers; 0 otherwise

FC Frequency of milk collection variable: 1 if milk collection is every other day; 0 otherwise

H Herd size of the farm (H) or natural logarithm of herd size (LnH)

Y Average milk yield for the farm (Y) or natural logarithm of yield (LnY)

e Disturbance term with the usual properties.

The choice of appropriate model form was made on the basis of goodness of fit and the number of significant parameter estimates. Note that in previous regressions (not presented), herd size and yield per cow were replaced with volume of milk produced, however, this offered no advantage in the explanatory power of the regressions and the significance of parameter estimates. The second stage of analysis used the preferred model form and undertook likelihood ratio tests (Judge *et al.* 1985) to examine the statistical difference between reduced models and the preferred full model form from stage 1.

Results

Production, location and price characteristics are shown in Table 1. Average herd size from the sample was approximately 128 cows, averaging 6,884 litres per cow (l/cow), producing an average of 924,000 litres of milk per farm; an average sale price of 25.93 pence per litre (ppl) generated an average £244,000 of milk value with significant difference for these continuous variables noted across the four milk price quartiles. Herds in the lowlands dominate the sample (163 herds), with 57 in the LFAs. The EU North, East and West regions respectively accounted for 79, 48 and 93 of the producers in the sample. Within Table 1 it can be seen that the highest milk price quartile group (A) is represented by an average herd size of 170 cows, yielding 7,346 l/cow and achieving an average milk price of 28.28ppl. Milk price quartile groups B and C do not differ greatly in their average herd size (130 and 122 respectively), however, with respective average yields and milk prices of 7,315 l/cow at 26.54ppl and 6,814 l/cow at 25.36ppl, the average value of milk between these two groups differs by nearly £45,000 per farm. Milk price quartile group D is characterised by a relatively smaller herd size (90 cows) producing 6,058 l/cow averaging 23.54ppl to generate a milk value of £138,200. Comparing the value of milk from quartile groups A and D, a difference of £219,000 is observed, with the average output in quartile D representing 38.7% of the value from quartile group A, from a herd size equal to 52.9 % of that in quartile A. The typology and regional characteristics of the quartile groups are also provided in Table 1. There is a significant difference (see Table 6 which presents the overview of all the Chi-squared tests undertaken on the observed data in this section) with respect to the number of producers in the lowlands across the quartile groups, with the number

Table 1: Production, Location and Price Characteristics of the Sample and Milk Price Quartile Groups

	A	**B**	**C**	**D**	**All**
Herd Size***	169.82	129.68	121.64	90.27	127.85
	80.94	*84.26*	*68.75*	*57.57*	*78.46*
Production (litres)***	1,269,814	987,751	856,646	580,101	923,578
	677,508	*712,337*	*573,302*	*478,750*	*661,630*
Value of sales (£)***	357,471	262,314	217,592	138,204	243,895
	190,202	*189,512*	*146,714*	*118,045*	*181,172*
Yield (litres) ***	7,346	7,315	6,814	6,058	6,884
	1,305	*1,393*	*1,372*	*1,446*	*1,467*
Price (pence / litre)***	28.28	26.54	25.36	23.54	25.93
	1.81	*0.32*	*0.31*	*1.02*	*2.03*
Lowland	48	42	39	34	163
LFA	7	13	16	21	57
EU North	10	23	22	24	79
EU East	14	12	10	12	48
EU West	31	20	23	19	93
n	*55*	*55*	*55*	*55*	*220*

Standard Deviation in italics for continuous data; n = number of observations; statistical significance of continuous variables at 99% (***); statistical tests for discrete variables are provided in Table 6

Figure 2: Number of Conventional Producers by Price Received ppl Bands

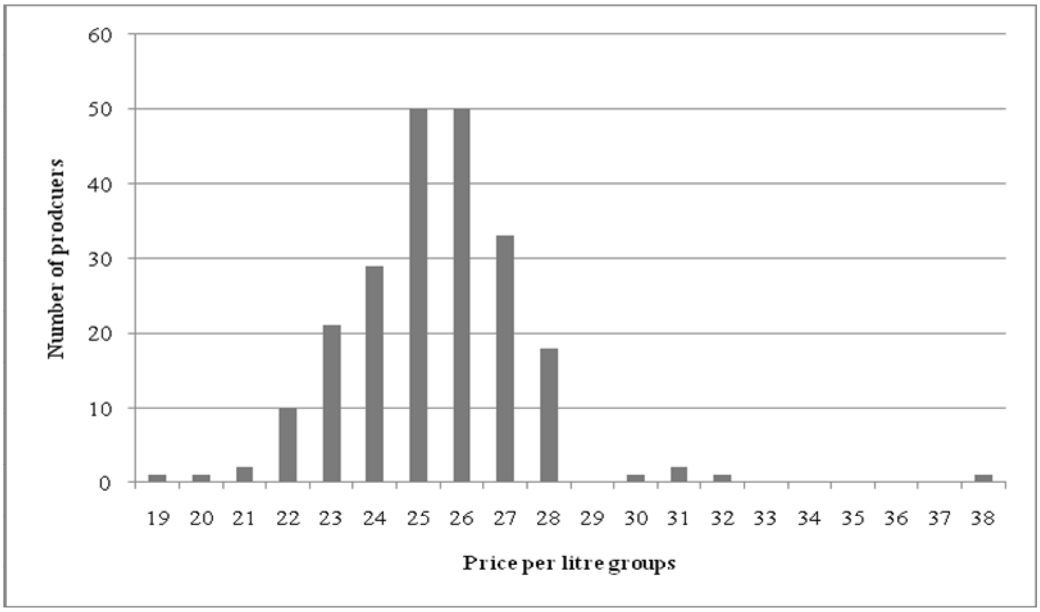


Table 2: Number of Producers by Milk Selling Arrangements, Changes in Milk Buyer and Reasons for Change

		Milk price quartile group				
		A	**B**	**C**	**D**	**All**
Organisation to which milk is sold	Co-op / group with no processing capacity	2	4	5	6	17
	Co-op / group with some processing capacity	10	13	31	43	97
	Other Processor	43	38	19	6	106
Change in milk buyer*	No change in milk buyer in year	53	50	51	50	204
	Changed buyer once	2	5	4	5	16
Reasons for change in milk buyer*	Not applicable (not change)	53	50	51	50	204
	Concerns over viability of DfoB	1	0	1	2	4
	Previous buyer ceased trading	0	0	0	1	1
	Previous buyer not willing to collect milk	0	0	0	0	0
	Better terms offered by new buyer	0	4	2	2	8
	Other	1	1	1	0	3
n		*55*	*55*	*55*	*55*	*220*

n = number of observations; * Unable to undertake Chi-Squared test due to observed values <5 per cell of producers located in the Less Favoured Areas (LFAs) increasing as the average milk price decreases. Moreover, there is a significant difference in the regional location of producers against milk price quartiles with more producers in quartile A being located in the EU West region, and fewer Northern producers located in this quartile; the converse holds true with respect to the numbers of producers in quartile group D.[2]

Figure 2 shows the number of producers classified by pence per litre price band. Within Figure 2, each price band represents a one-pence band, for example the 19ppl band includes producers receiving prices of 19ppl to less than 20ppl. Figure 2 represents a broadly normal distribution of milk prices across the sample.

Table 2 shows the number of producers by type of organisation to which their milk was sold, together with the number of producers who changed milk buyer in 2008/09 and the associated reasons for this change. It is instructive to note that whilst the majority (43) of producers in quartile A sold their milk to a non co-operative / buying group processor, only 12 producers from this quartile sold milk to a co-operative (with or without processing capacity). Conversely 49 producers from quartile D sold their milk to a co-operative or buying group, with significant differences (Table 6) being observed across the quartile groups in respect to the organisation to which milk was sold. The majority of producers in each quartile group did not change milk buyer in 2008/09; the main reasons cited for changing milk buyer was the better terms offered by the new buyer. The relatively small number of observations on changing milk buyer meant that cell size was not sufficient to undertake statistical tests on these data.

The length of contract and flexibility to switch contract can be considered as measures of contract stability and freedom which may influence milk price received. From Table 3 it can be seen that the most popular contract type was a one year contract (either rolling or fixed term) followed by long term contracts of 10 years or more (including evergreen contracts). However, note from Table 3 that over 50% of producers in quartile D operated on the basis of a one year contract, and only 20% of this group held long term contracts of 10 years or more. However, no significant differences were observed across the quartile groups with respect to length of contract held. Most producers were required to give at least 12 months notice to avoid penalties on exiting their milk contracts, however quartile groups C and D were more likely to have to give 12 months notice than producers in quartiles A and B. Whilst no clear patterns emerge with respect to contract flexibility across the performance groups, statistically significant differences with respect to contract flexibility were found across the groups.

The presence of retailer-linked contracts, the nature of guaranteed prices on milk contracts and the intention to change buyer are presented in Table 4.

2. For the purpose of presenting the milk price quartile groups, no data outliers were excluded. However, for the upper quartile price group (A), excluding one outlier at the high price end produced an average price of 28.08ppl (*cf.* 28.28ppl), whilst excluding the five highest milk price observations reduced the average price for quartile A to 27.82ppl. Excluding the two lowest milk price observations in quartile D increases the average milk price to 23.66ppl from 23.54ppl.

Table 3: Number of Producers by Milk Contract Length and Flexibility to Switch Buyer

		Milk price quartile group				
		A	**B**	**C**	**D**	**All**
Length of Milk Contract	Under 0.5 years #	6	1	2	0	9
	0.5 to < 1 year #	3	4	3	10	20
	1 year (fixed and rolling)	15	24	21	27	87
	1.5 to < 3 years λ	6	4	2	1	13
	3 to < 6 years λ	4	4	7	1	16
	6 to < 10 years λ	4	3	0	5	12
	10 years or more (inc. evergreen contracts)	17	15	20	11	63
Flexibility to switch buyer	Penalty irrespective of notice given #	4	3	5	3	15
	Penalty unless 12 months notice given #	25	30	36	32	123
	Penalty unless 6-12 months notice given	9	14	8	6	37
	Penalty unless 3-6 months notice given	11	5	2	5	23
	Penalty unless 1-3 months notice given λ	0	0	2	5	7
	No penalty payment λ	6	3	2	4	15
n		*55*	*55*	*55*	*55*	*220*

n = number of observations; # or λ = groups combined within category for the purpose of Chi-Squared test

Whilst quartile groups A and B include 15 and 21 producers who respectively supplied 100% of their milk under a retailer-linked contract, only six and one producer from quartiles C and D respectively operated under such a contract. Most producers in quartile groups C and D did not operate under these contract arrangements and this difference is statistically significant. There is a significant difference in the number of producers in each quartile that operated under a production-cost link contract or some other form of price guarantee. Whilst 136 of the 220 producers were satisfied with their buyer, 33 noted that they would not be changing buyer because they have no alternative to change to; nearly one-half of this group of producers are contained within quartile group D. Those producers most satisfied with their current buyer were found in groups A and B.

The number of buyers from which producers can choose to supply milk to is presented in Table 5 alongside data on the frequency of milk collection. It is striking to note that of the 55 producers in quartile group D, 20 had the choice of only one buyer, whilst a further 17 had the choice of only two buyers. By contrast there are 18 producers in quartile group A that were constrained to only one or two buyers. It is interesting to note that whilst there is a significant difference across the quartile groups with respect to the number of choice of

Table 4: Number of Retailer Linked Milk Contracts, Nature of Price Guarantees and Intention to Change Milk Buyer

		Milk price quartile group				
		A	**B**	**C**	**D**	**All**
Retailer linked milk contracts and proportion of milk guaranteed associated with this.	None	33	30	46	51	160
	Paid on <25% milk#	2	3	2	2	9
	Paid on 25to <50%milk#	0	0	1	0	1
	Paid on 50to <75%milk#	0	1	0	0	1
	Paid on 75to<100 milk#	5	0	0	1	6
	Paid on 100%of milk#	15	21	6	1	43
Nature of contract Price guarantee	None	34	38	40	40	161
	Linked to prodn. costs#	12	5	1	0	18
	Other#	9	12	14	6	41
Intention to change milk buyer	Definitely not; would like to but no alternative	1	8	9	15	33
	Definitely not, satisfied with current buyer	42	40	31	23	136
	Possibly#	7	7	7	6	27
	Probably#	1	0	1	2	4
	Definitely yes$^{\lambda}$	4	0	6	6	16
	Other / not applicable$^{\lambda}$	0	0	1	3	4

n = number of observations; # or λ = groups combined within category for the purpose of Chi-Squared test

buyers, 16 producers in quartile C had the choice of five or more buyers. A clear, and statistically significant, pattern with respect to the frequency of milk collection is noted (Table 6), where producers in quartile groups C and D are more likely to have their milk collected every other day, either voluntarily or compulsorily when compared with producers in quartile groups A and B, where daily collections are more common.

Table 7 provides the results of four hedonic regression equations specified in the first stage of the regression analysis. With respect to interpretation of the non-continuous variables in Table 7, a value of 0 for these variables represents milk sales to co-operatives or buying groups, without a retailer-linked contract, the choice of one or two milk buyers, a non production cost linked contract, and with milk collected daily. The continuous variables of herd and yield per cow (or their logarithmic counterparts) indicate the change in dependent variable from a one unit change in these independent variables. The

Table 5: Number of Producers by Buyer Choice and Frequency of Milk Collection

		Milk price quartile group				All
		A	**B**	**C**	**D**	**All**
Number of buyers producers had to choose from	One	7	7	9	20	43
	Two	11	15	17	17	60
	Three	22	22	10	8	62
	Four	6	6	3	5	20
	Five or more	9	5	16	5	35
Frequency of Milk Collection	Daily (voluntary)	9	8	7	7	31
	Daily (compulsory)	23	26	10	6	65
	Every other day (voluntary)	16	13	30	27	86
	Every other day (compulsory) #	7	8	8	14	37
	Other / not applicable #	0	0	0	1	1
n		*55*	*55*	*55*	*55*	*220*

n = number of observations; # = groups combined within category for the purpose of Chi-Squared test

results from models 1 and 2 (with milk price specified as the dependent variable) demonstrate that the additional milk price from sales to a processor are approximately 1ppl (1.012 to 1.067ppl). A retailer linked contract is estimated to provide an additional 0.577 to 0.611ppl. A cost-linked contract is estimated to provide an additional 0.727 to 0.781ppl, with the choice of three

Table 6: Summary of Chi-Squared Tests

Category	Chi-Squared Probability	Significance level
Typology (Lowland or LFA)	0.0210	95%
EU Region	0.0883	90%
Organisation to which milk is sold	7.59E-14	99.9%
Length of Milk Contract	0.2244	NS
Flexibility to switch buyer	0.0459	95%
Price guarantee and proportion of milk	3.54E-06	99.9%
Nature of contract price guarantee	0.0108	95%
Intention to change milk buyer	0.0009	99.9%
Number of buyers producers had to choose from	0.0007	99.9%
Frequency of Milk Collection	0.0002	99.9%

Table 7: Results from Hedonic Regression Analyses Stage 1

	Model 1	Model 2	Model 3	Model 4
Dependent Variable	Milk Price (P)	Milk Price (P)	Log Milk Price (LnP)	Log Milk Price (LnP)
Independent Variables				
Constant	25.767 (0.000)***	10.970 (0.0084) ***	3.126 (0.000)***	2.644 (0.000)***
Buyer Organisation (B)	1.067 (0.000)***	1.012 (0.000)***	0.0425 (0.000)***	0.0404 (0.000)***
Retailer Contract (R)	0.577 (0.028)**	0.611 (0.019)**	0.0218 (0.032)**	0.0232 (0.021)**
Cost-Linked Contract (CL)	0.781 (0.060)*	0.727 (0.075)*	0.0284 (0.077)*	0.0263 (0.0968)*
Choice of buyers (CB)	0.227 (0.282)	0.203 (0.330)	0.0101 (0.215)	0.0092 (0.2558)
Frequency of collection (FC)	0.141 (0.511)	0.164 (0.480)	0.00506 (0.580)	0.00598 (0.507)
Herd (H)	0.00583 (0.000)***	-	0.220E-03 (0.0001) ***	-
Yield (Y)	0.000206 (0.0098) ***	-	0.854E-05 (0.0057) ***	-
Logarithm of Herd (LnH)	-	0.958 (0.000)***	-	0.0364 (0.000)***
Logarithm of Yield (LnY)	-	1.077 (0.0317)	-	0.0453 (0.0196)**
Adjusted R^2	0.359	0.377	0.365	0.384
Log Likelihood	-390.91	-387.81	321.00	324.21
Log likelihood test value	104.46	110.66	106.84	113.28
Chi-Sq Critical	14.07	14.07	14.07	14.07

Statistical significance at 99% (***); 95 % (**); 90% (*). Observations = 219, one data outlier excluded from hedonic regression analysis

Table 8: Results from Hedonic Regression Analyses Stage 2

	Model 4a	Model 4b	Model 4c
Dependent Variable	Log Milk Price (LnP)	Log Milk Price (LnP)	Log Milk Price (LnP)
Independent Variables			
Constant	2.669 (0.000)***	2.646 (0.000)***	2.654 (0.000)***
Buyer Organisation (B)	0.0394 (0.000)***	0.0406 (0.000)***	0.0430 (0.000)***
Retailer Contract (R)	0.0220 (0.026)**	0.0223 (0.024)**	0.0276 (0.003)***
Cost-Linked Contract (CL)	0.0243 (0.118)	0.0242 (0.119)	-
Choice of buyers (CB)	0.00853 (0.287)	-	-
Frequency of collection (FC)	-	-	-
Logarithm of Herd (LnH)	0.0362 (0.000)***	0.0372 (0.000)***	0.0378 (0.000)***
Logarithm of Yield (LnY)	0.0431 (0.0239)**	0.0457 (0.0160)**	0.0443 (0.0197)**
Adjusted R^2	0.386	0.385	0.381
Log Likelihood	323.98	323.40	322.143
Log likelihood test value	0.46	1.62	4.14
Chi-Sq Critical	3.84	5.99	7.81

Statistical significance at 99% (***); 95 % (**); 90% (*). Observations = 219, one data outlier excluded from hedonic regression analysis

3. Note also that this contrasts with the broad finding in Table 6, but reinforces the value of undertaking a hedonic regression analysis to estimate the value of individual attributes taking into account other determining factors.

or more buyers providing an additional 0.203 to 0.227ppl, however these later estimates are not statistically significant. Having milk collected every other day is noted to be valued at an additional 0.141 to 0.164ppl but these estimates are insignificant.[3] For every 10 extra cows, model 1 estimates an additional milk price of 0.058ppl, whilst for every extra 1000 litres produced per cow, this model indicates an extra value of 0.206ppl. Model 2 presents the influence of herd size and yield in logarithmic terms, indicating that increasing herd size by 10 cows from the average 128 cows will lead to an increase in milk price of 0.072ppl, whilst for herds increasing yield by 1000 litres per cow from the average of 6884 litres, an additional milk price of 0.136 ppl would accrue. Models 3, 4, 4a, 4b, and 4c specify the dependent variable as the natural logarithm of milk price, and the model results cannot be interpreted directly. However, the additional impact of these estimates are calculated to be as follows: selling to a processor (0.580 to 0.987ppl); retail contract (0.321 to 0.501ppl); cost linked contract (0.355 to 0.655ppl), choice of more than two buyers (0.124 to 0.231ppl); every other day collection (0.084 to 0.115ppl); an additional 10 cows to average herd size (0.029 to 0.050ppl); an additional 1000 litres per cow to average yield (0.124 to 0.160ppl).

The adjusted R^2 results indicate that across all models in Tables 7 and 8, approximately 36 to 39% of the variation in the milk price can be explained by the factors included in the hedonic regression equations.

Whilst the R^2 results are modest, these indicate that up to two-fifths of the variation in milk price within this sample can be explained by these factors alone. Whilst most variables are statistically significant, this does not universally hold. In order to provide a judgement on the preferred model function, the R^2 values and the number of significant variables was used to determine the preferred functional form from those models presented in Table 7. On the basis of this judgement, model 4 was determined to provide the most appropriate functional form. Note that models 1 to 4 inclusive were each statistically superior to a "null" model which regressed the dependent variable against the constant in isolation of other independent variables.

Discussion and Conclusion

The results presented above show that those producers receiving the highest 25% of milk prices tend to have larger herds of higher yielding cows, reinforcing the findings of Franks' (2001) analysis of milk prices. The findings show that a greater proportion of the 'top 25% milk price' producers are located in the lowlands and the EU West region. Milk price quartile groups A and B contained a greater number of producers who sell milk to a non co-operative processor, concurring with Bates and Pattisson's (1997) findings that producers supplying to non-co-operative milk buyers ranked 'price' as their highest ranking influence. The lowest milk price quartile group (D) contained a greater number of producers on one-year contracts, and moreover, quartile groups C and D were more likely to have to give more notice (e.g. 12 months) on their contracts than groups A and B. This reinforces Campbell-Gibbons (2010) who cites equal termination rights as the fifth most important aspect of milk contracts from producers' perspective. Greater numbers of producers in quartiles A and B held retailer-linked milk contracts, corresponding with

Campbell-Gibbons findings that those producers supplying processors were more satisfied with their milk contract. Milk price quartile group A also contained significantly more producers operating under production-cost linked contracts. Producers in quartiles A and B were more likely to have the choice of three or more buyers and have their milk compulsorily collected daily, whilst most producers in quartile D had the choice of only one or two buyers and most had their milk collected every other day.

The results of the preferred hedonic regression equation have estimated the individual impact on the price of milk from selling to a non co-operative processor, holding a retailer-linked contract, and increases in herd size and yield. The results presented show that selling to non-co-operative processor adds 0.624ppl to milk price, whilst holding a retailer-linked milk contract adds a further 0.398ppl. Franks (2002) found that selling to the co-operative Milk Marque reduced milk price by 1.5ppl; hence the results from this current study potentially find that the gap between co-operative and non co-operative milk price to have narrowed, albeit that that the combination of a retail-linked contract to a non-co-operative milk buyer will provide an additional 1.02ppl over the estimated base price. Current milk price profiles (DairyCo, 2011) indicate that retailer-linked contracts offer 2-3ppl premiums over non-aligned contracts, arguably being indicative of the increasingly tight milk supply conditions that exist in the market (Robertson and Wilson, 2009). It should be noted that the co-operatives tend to offer a return on the price of milk plus a return on the investment in the co-operative. However, it can be argued that any dividends accruing from the investment in the co-operatives should be viewed as a separate return on investment and not linked to milk price.

The results of this study show that increasing herd size and yield (and hence volume of milk) both provide significant increases in the milk price. Franks (2002) notes an increased value of 0.82ppl for a supply of 1.5 million litres compared with 1 million litres; the results presented here indicate increased prices of 0.27ppl, from an increased herd size, or 0.38ppl, from an increase in yield, over the same production levels, whilst industry results currently return typical premiums of 0.2 to 0.3ppl for this increased volume (DairyCo, 2011). Hence whilst the results presented here indicate a lower marginal value for increased production than the results of Franks (2002), they are broadly in-line with contemporary industry practice. The results presented reinforce the findings of Bates (1996) that producers need to understand both market fundamentals, the value of milk quality attributes and, increasingly, contractual arrangements.

Comparing the statistical power of the hedonic regression presented here with previous studies, provides a useful indication of the value of this approach. The preferred model explains 38% (R^2=0.38) of the variation in milk price and this contrasts with: Franks' (2002) analysis of milk price (R^2=0.775); Agbola *et al.*'s (2002) analysis of chickpea prices in India produced (R^2 of 0.80 to 0.87); Jabbar's (1997) analysis of sheep and goat prices in Nigeria (R^2 of 0.68 to 0.76); Huang and Lin's (2007) regional analysis of fresh tomato prices (R^2 of 0.306 to 0.510). Hence the goodness of fit measure reported herein is at the lower end of reported values in the literature. Nevertheless, it is argued that the limited data availability and the significant parameter estimates obtained, serve to reinforce the importance of analysing the factors considered in this study which have clear impacts on the dairy sector. These findings suggest considerable variation in milk price exists across regions, between the lowlands and the LFAs, the organisation to which the milk is sold and the intended destination of the milk. Additionally milk price variation exists in respect to length of milk contract, the flexibility that producers have to switch buyer and the frequency of milk collection. This study suggests that volume of production, supplying to a non co-operative processor and holding a retailer-linked contract have individually demonstrable benefits with respect to the milk price obtained. These findings concur with previous research and industry observations.

As the number of dairy farmers continues to decline and the cost of transport fuel continues to increase, it is likely that milk buyers will continue to look for increased efficiencies in the milk supply chain by attracting producers that can supply large volumes of high quality milk. For some producers the choice of milk buyer is highly restrictive and a more restrictive choice leads to a lower milk price; producers in the LFAs are more likely to face this limited choice, though this is not exclusively an LFA issue. For those producers operating under production cost linked retail contracts, the price of milk is substantially greater than for those operating outside of these arrangements, and this is argued to be driven in part by the greater number of buyers that these producers typically have to chose from. The price of milk is one of the key determinants of profitability for producers (Wilson, 2011) and the results presented here suggest that LFA producers who are constrained in their choice of milk buyer will need to operate at lower production costs if they are to compete with typically larger, higher yielding herds located in the lowlands and selling their milk under cost-linked retail contracts.

Given the importance of economies of scale in milk production (Wilson, 2011), it is likely that the current structural change in the dairy sector will continue for some time to come. Dairy farmers who intend to remain in the sector will arguably need to adopt a strategy of investment for growth in supply and increased specialisation to achieve high quality production, or seek niche marketing opportunities through processing of their own milk. Given the range of market and environmental pressures that exists in the sector, the findings of this study serve to reinforce the relative price pressure that many smaller dairy farmers in the LFAs face; these pressures are unlikely to abate in the near future and will lead many in the sector to consider ceasing milk production, whilst a selection of larger lowland herds will expand to gain further economies of scale.

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RESEARCH REVIEW

OUTREACH DEVELOPMENTS OF THE FARM BUSINESS SURVEY: AN OVERVIEW BY RURAL BUSINESS RESEARCH

Paul Wilson and Ben Lang

Funded by Defra, the English Farm Business Survey (FBS) is undertaken by Rural Business Research (RBR). The research programme provides a fully reconciled management account on nearly 2000 farms across England each year, meeting part of the UK's submission to the Farm Accountancy Data Network (FADN) and the UK Government's needs for farm business performance data. RBR host a series of free-to-use on-line data delivery services, including: FBS Farm Business Benchmarking, incorporating benchmarking at EU level; FBS regional reports capturing physical and financial data by farm type; FBS data builder, allowing users to specify bespoke data requests; farm type, enterprise and regional intelligence reports. During the spring of 2011 and 2012, RBR aim to host a series of regional workshops showcasing the benefits of these free-to-use data services.

Key Words: Farm Business Survey, On-line, Benchmarking, Farm Type, Enterprise, Reports, Workshops.

Introduction

Rural Business Research (RBR) comprises the academic consortium of Rural Business Research Units from the Universities of Nottingham, Cambridge, Newcastle and Reading and Askham Bryan and Duchy Colleges. RBR undertakes the Defra-funded Farm Business Survey (FBS) in England, and as part of this research programme provides a series of specific outreach activities. These include individual management accounts for participating farmers, on-line Farm Business Benchmarking, Regional Reports providing in -depth analysis and data by farm type and region, plus a specialist Data Builder service allowing users to define their own bespoke data requirements. RBR has recently improved these services with enhanced user interface, strengthened signposting of the on-line site and the addition of new ways of presenting FBS data. In addition, RBR provides a series of enterprise, farm type, technical and intelligence reports, with plans to hold regional workshops in the near future. The purpose of this note is to provide readers of the Journal with an introduction to the FBS and an overview of the enhanced outreach activities provided by RBR.

Farm Business Survey

The FBS began life as the Farm Management Survey in 1936, providing government, farmers and the industry with an analysis of farm management activities and farm income level data. The objectives are broadly the same today, although the survey now covers a much wider breadth of data, looking at many aspects of the farm business. Whilst the purpose of the collection and analysis of this data is to aid government policy making, a further role of the FBS is to provide valuable management information to the farming industry. Over the years, the FBS has developed and grown in coverage and depth of data collected in order to remain contemporary and relevant to the agricultural industry of the day. In 2004/05 the FBS underwent a major development, which included a wider range of farm business activities being included in the survey (e.g. income from diversified activities) plus other data analysis (e.g. gross and net margins for main enterprises). Wilson *et al.* (2006) provide an overview of these developments, noting that these changes have the potential to open up new research possibilities. The FBS is therefore the cornerstone of the economic evidence base on farm incomes and policy developments within England and the UK.

For England, RBR annually researches approximately 2000 farm and horticultural businesses. Similar research surveys are undertaken in Wales, Scotland and Northern Ireland. Together, the four sister FBS surveys comprise the UK's submissions to the Farm Accountancy Data Network (FADN) which is a European requirement for data on the agricultural activities of EU member states, and is used for policy analysis and setting purposes within the EU. FADN data are also widely used by government and external researchers, looking at issues such as incomes, structural change and impacts of policy.

Individual Management Accounts

Farm businesses take part in the FBS on a voluntary basis. They are recruited in England by RBR from recruitment lists supplied by Defra. These recruitment lists are drawn from June Survey information. In order to ensure strong representation across regions and farm types, the FBS must meet specific quotas for the return of farm types across particular regions and farm types. In return for taking part in the FBS, farmers and growers receive a fully reconciled set of management accounts for their business together with data with which they can compare their business against similar businesses in their region, or nationally. For participating farmers and growers, these management accounts are particularly valuable, representing the full management account for their business; farmers and growers often note that these accounts are more informative than their "tax" accounts from accountants due to the management focus of the FBS accounts. In addition, participating farmers and growers who wish to undertake enterprise analysis alongside their full account also receive gross margin returns to support their farm-level data and information.

Farm Business Benchmarking

Alongside the benefits that are available to FBS participants, the FBS offers a series of on-line facilities to all with an interest in the research findings. RBR provide an on-line, free-to-use, FBS Farm Business Benchmarking service to all farmers, growers, advisors, students, researchers and other stakeholders (as are all RBR's on-line outreach activities) on a non-commitment basis. Users can benchmark performance against national data for: enterprise gross margins; farm profitability; business ratio analysis (return on capital and labour and machinery efficiency); balance sheet analysis.

In addition, this service has recently included an EU benchmarking component, where users can undertake farm profitability benchmarking for a growing range of farm types across the 27 EU countries. This EU benchmarking service specifies the £:/€ exchange rate as the Rural Payments Agency exchange rate for the appropriate year, but allows users the option to set a different exchange rate should they wish to do so. The FBS Farm Business Benchmarking service can be found at: http://www.farmbusinesssurvey.co.uk/benchmarking/

Regional Reports

Regional Reports provide a range of stakeholders with in-depth data on the performance of farm and horticultural businesses across the regions and over time. The service allows users to specify particular farm types, regions and details of their data requirements. The range of data available includes: detailed farm business incomes and costs; farm business income (FBI); net farm income (NFI); management and investment income (MII); family farm income (FFI); cash income; balance sheet; flow of funds; cropping and stocking; outputs and inputs. To facilitate use of the service, the data can be specified on the basis of either per hectare or per farm analysis, depending upon the user's preference and requirement from the service. Moreover, the site includes an in-depth commentary on the cropping and financial year for each region together with data on the characteristics of the industry in the region. The Regional Reports service can be found at: http://www.farmbusinesssurvey.co.uk/regional/

Data Builder

The extensive results provided by the FBS Farm Business Benchmarking and Regional Reports services represent a series of pre-determined tables and data that serve the vast majority of users extremely well in terms of their data requirements. Nonetheless, the wealth of data held within the FBS allows for the possibility of more bespoke data requests being met efficiently and without incurring personnel costs in the delivery of such bespoke individual requests. Within the FBS Data Builder service, the user specifies their own request and the system provides this data. The interpretation of the bespoke data is left with the user, rather than commentary accompanying data as is often the case in traditional publications (e.g. Agriculture in the UK). Some examples of the types of data that the service can provide include: farm tenure status by different farm sizes; relationship between farmers age and farm type; relationship between farm type and farm size. Because the FBS Data Builder Service is a specialist tool, new users should expect to commit time to familiarising themselves with its operation. An on-line user guide tutorial takes users through the stages to specifying bespoke data requests and provides examples to facilitate use of the service. Experienced users can go straight to the data service, and the system allows users to specify multiple requests, providing reference numbers for the recall of previous data requests to the service. The FBS Data Builder service can be found at:
http://farmbusinesssurvey.co.uk/DataBuilder/

Farm Type Enterprise Reports

Building on the new opportunities for research heralded by the FBS in 2004/05, RBR has now completed four years of farm type and enterprise reports that draw extensively on both farm level and enterprise costing data for major enterprises and business types. These annual reports provide data and commentary that extensively use FBS data, but also place this analysis in context, particularly with respect to national and international developments in the market place or policy environment. These reports are freely available to users and currently cover the following areas:

Crop Production in England
Dairy Farming in England
Hill Farming in England
Poultry Production in England
Pig Production in England
Horticulture Production in England
Lowland Grazing Livestock Production in England
The farm type and enterprise reports can be accessed at:
http://www.ruralbusinessresearch.co.uk/ under “RBR Publications”

Technical and Intelligence Reports

The FBS, and associated one-off FBS linked research projects, provide a wealth of data opportunities for individual research analyses on specific subjects, or for the analysis of data which will enhance the methodological underpinnings of the FBS research programme. RBR has undertaken a range of these Defra-funded technical research projects, with topics including:

Analysis of gross and net margins
Analysis of labour usage data
Analysis of milk selling arrangements on dairy farms in England

Whilst the data collected, analysed and reported provides the main outreach activities from the FBS, RBR is in a position to report on the contemporary issues facing the industry, from the hill farms of the Pennines to the fertile soils of the Fens. RBR’s coverage of the farm types and regions across England allow for contemporary intelligence evidence to be collated and reported. These reports are provided twice yearly, in the spring and again post harvest, to provide an overview of the issues and activities of farmers and growers from across the country. The technical and intelligence reports can be found at:
http://www.ruralbusinessresearch.co.uk/ under “RBR Publications”

Workshops

To further enhance the use of the FBS data, RBR aim to host regional workshops in the spring of 2011 and 2012. These workshops will be aimed at farmers, advisors and regional policy makers, together with other interested stakeholders, with the objective of both raising awareness of the FBS and its data outputs, but additionally to provide an interactive event where workshop participants will be guided through the above data services. The workshops are a new initiative that will enable users to gain the most from the FBS and its internet reports. Anyone with an interest in attending a workshop is encouraged to contact Mark Bieri on 01223 337153 or via email at mcb64@cam.ac.uk.

Joining the FBS and contacts in your region

The FBS only recruits from mailing lists derived from the June Survey. In this way, the sample retains the correct balance of farm types, sizes and locations and avoids sample bias, therefore providing authoritative findings that apply to the whole industry. The maximum time that most farmers and growers can remain within the FBS is 15 years. Hence, each year the FBS recruits new farmers and growers to the survey, and over the autumn and winter months of each year RBR writes to a sample of farmers and growers inviting them to join the research programme. As part of RBR's recruitment policy, awareness is raised through providing presentations to farmer discussion groups. If you are interested in hosting a talk, or just want to find out more about the FBS, please contact the RBR Unit Manager for your region. Contact details can be found at:
http://www.ruralbusinessresearch.co.uk/ under "RBR Units"

Summary

This note has provided an overview of the FBS in England and the outreach activities undertaken by RBR. The wealth of data available from the FBS to farmers, advisors and stakeholders is large and growing. Business planning in the future will increasing require farmers and growers to be armed with information, and the FBS Farm Business Benchmarking service provides an independent non-commitment benchmarking tool to facilitate competitiveness analysis. The Regional Reports provide in-depth output on the changing nature of farm incomes and are accessible in forms suitable for farmers and policy markers. FBS Data Builder service represents a bespoke data capture service that allows users requiring further details to specify their data requests. The series of farm type and enterprise reports, coupled with technical and intelligence reports add further value to the FBS suite of outreach activities. In the near future, interactive workshops will guide users through these services and further enhance the reputation of the FBS as the central evidence base on farm business economic performance in England.

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CONFERENCE PAPER

ROBOTICS AND SMART ENGINEERING

David Gardner

Developments in robotic engineering and computer based technologies offer huge opportunities for agriculture. Robots have the potential to undertake a wide variety of operations on the farm including some of the mundane tasks such as manual harvesting. This paper explores the way in which the good robotics engineer is capable of thinking 'outside the box' and how he has to have a good grasp of the economics of the problem he is seeking to solve. The various components available to the engineer are considered including sensing systems, power units and control systems as well as the mechanical machine that does the work. Case studies include an asparagus harvester, robotic weeding, fruit harvesting and movement sensors for use with dairy cows.

Keywords Robotics, technology, sensing systems, machine learning, harvesting, milking, condition scoring.

Introduction

Developments in engineering and computer-based technologies offer huge opportunities for agriculture. Many tasks in farming are dull and routine and involve huge gangs of labour performing repetitive tasks. These mundane tasks can potentially be replaced by robots. Farmers also require information about their operations in order to manage them effectively and developments in new sensing technologies offer opportunities to produce more timely data and information that has to date been uneconomic to collect.

Robots have the potential to undertake a wide variety of operations on the farm including cultivating, seeding, spraying, nutrient application and harvesting. The drivers for introducing robots on to the farm are economics and the poor availability of manual labour. There is the potential for robots to complete tasks at lower cost and possibly to higher standards. Robots don't get tired and will complete the one thousandth task as effectively as the first. The farming industry has suffered with a lack of available labour. In recent years the UK industry has relied on willing workers from Eastern Europe but they probably won't be available for ever. However for many years the USDA had a moratorium on funding research into robotics because of the threat to employment. That moratorium was only lifted 3 years ago.

The development and use of robots in agriculture is still in its infancy. The robotic milker is becoming established with numerous installations across the UK. Lely believes that 20% of all new installations in the UK are now robots (Dunn, 2009). The robotic milker has been developed over the last 30 years and is a sophisticated machine. The accurate placement of the cups on the teat was a significant challenge but the machine also had to rise to the challenge of mastitis detection and to maintaining milk hygiene standards. All these issues were overcome and a small group of pioneer farmers then brought the machines into commercial use.

The good robotic engineer has to be capable of thinking outside the box to solve problems. The starting point in developing suitable robotic technology is

Columnar trees make harvesting easier for robots

understanding the problem. What is it that has to be done? And are there opportunities to adapt what is done to make the robotic solution easier? For example growing strawberries on table tops presents fruit to a robot in a much more acceptable way than growing strawberries on the ground. Can fruit trees be grown to present fruit to a robot in a way that will make picking much easier? Apple breeders at Cornell University are using genetics to develop 'columnar' trees that will present a 'fruiting wall' to robots for harvesting – an easier environment than searching for fruit in the canopy. 'Re-positioning' the problem is often a significant part of the solution for the robotics engineer.

The engineer also has to understand the economic environment that the machine is going to work in. Indeed this is a fundamental issue in technical development; does the engineer solve the problem and then try to reduce costs or does he work at low cost and then work his way up to solve the problem?

As in most fields of research and development (R&D), robotic engineers work at different levels. Some engineers work at a theoretical level developing novel sensors, control systems and tools for which they do not have an immediate need. They create the 'new science' that is then used by those engineers who are closer to the market place to develop marketable machines (the military are a key driver in the development of robotics and smart engineering: they do not have the same cost constraints as the commercial world and can develop concepts that are then used by commercial engineers). Once the technical problems are overcome bringing down the cost usually follows. Global Positioning Systems (GPS) provide a good example of this process; once they were developed both the physical size of the GPS units and their cost came down quickly. This model works over and over again.

Robotics

Robots consist of a number of key components –

- Sensing systems – to see, locate and feel;
- Control systems including a CPU (Central Processing Unit);
- Power units – to provide the power;
- The mechanical apparatus that actually does the work.

Sensing systems

Robots make use of a number of different sensing systems including machine vision. Machine vision is used to help robots locate where they are working and also for a wide variety of other applications including locating produce for harvesting, plants for spraying and animals for condition scoring. Machine vision is based on a number of different sensors that can include:

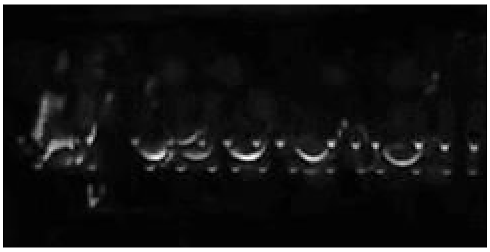
- Colour cameras
- Infra-red cameras
- Cameras tuned to specific light frequencies
- Radar
- Lasers
- Ultra sound

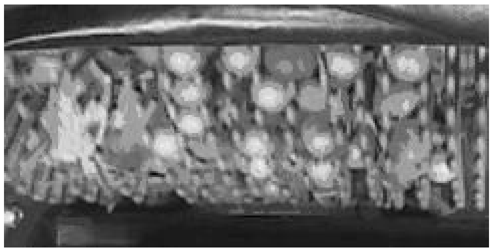
Often stereo cameras are used to help create a 3 dimensional image and sensors can also be fitted with motors so that they nod and scan a field of vision. In some cases a number of different sensors is used to create reliable images. These images are then combined using complex algorithms to create an image of the surrounding area. It is important that the sensing system can detect the floor and any vertical surfaces so it can place objects into that space. Sensors on a vehicle that is travelling on bumpy ground represent a particular problem. They have the potential to produce 'noisy' images. The CPU has to be capable of taking these images and producing clear images. It also has to be capable of synchronising images coming from different sensors.

These cameras can take thousands of pictures a second and the processing units must be capable of processing that data in real time to produce an image of the working environment. One of the challenges of vision systems is coping with shadow – areas of dark and light. This can be overcome by using double exposures that the CPU then processes in real time to produce a single image but it is costly. This helps to 'see' objects in the shade. The human eye and brain is particularly good at doing this.

Work done by the National Centre for Engineering in Agriculture at the University of South Queensland demonstrates how lighting can be used to aid computer vision. The research team wished to develop a computer aided system for assessing the yield of macadamia nuts. The pictures below show how working in an environment of structured light can make the target easier for the computer to identify in comparison to uniform light.

Robots also use sensors other than machine vision to locate where they are.





Pictures Courtesy of Cheryl McCarthy-NCEA

The disadvantage with machine vision is that it can only locate position relative to a feature and it doesn't work in an unstructured environment. Alternatives include:

GPS (Global Positioning Systems), with which most farmers will now be familiar. GPS signals are used to pin-point exactly where the machine is. Systems associated with the very high levels of accuracy required for field operations are still expensive and the signal can be lost, particularly under tree canopies.

Wheel encoders, which can be used to track vehicle position. They are electro-mechanical devices that measure the rotation of an axle and calculate how far the vehicle has moved from a known starting point.

IMU (inertial measurement units), which are electronic devices that measure and report on a vehicle's velocity, orientation, and gravitational forces, using a combination of accelerometers and gyroscopes. They are commonly used in aircraft. These measurements are likewise used to calculate how the vehicle has moved from a known starting point.

Both wheel encoders and IMU use a process known as dead reckoning to calculate vehicle position. Position is calculated from a known starting position based on speed over a period of time. A disadvantage of dead reckoning is that since new positions are calculated solely from previous positions, the errors of the process are cumulative, so the error in the calculated position grows over time. In a fixed environment such as an orchard these errors can be corrected using 'high precision way points' that the vehicle uses to adjust its calculated location.

Arial photo graphs can also be used to help a machine locate its position and some research has been done into using cameras positioned high above working areas to help locate position. (Zhang: 2009)

Sound is not widely used on robots for sensing. It has been used by the military to 'listen' for gunfire but has limited value in an agricultural setting.

Touch is a particularly challenging sense to imitate. Force feed back can be used where the electrical current required to pick something up can be measured. Tactile sensors are useful in unstructured and changing environments and play a major role in grasping objects. Imitating the human hand is particularly difficult in terms of robotic development – it is very expensive. Humans use vision and touch to handle objects – we locate the object with vision but then use touch to actually handle it.

Other sensors that are used in robots include tilt and stability sensors.

Control systems

Robots require effective control systems based around a CPU. These include:

High Level Controllers – for mission decisions, path planning, safeguarding, specialty sensors and user interfaces that handle large amounts of information;

Low level controllers – for steering, engine and implement control.

The two systems must effectively communicate in a timely and fail-safe manner. An architecture is required for this (Cameron, 2009). Cooling the CPU can be a problem.

Power units

A number of different power options are available to the robotics engineer. These include:

Many types of batteries, such as:

Lithium Ion batteries that offer good power density and can be shaped to fit into any space. They require recharging and if mishandled they can explode;

Wet Lead Acid Batteries that are heavy, lack power density and also require recharging.

Electricity through a power lead which is low cost and light weight but lacks freedom of movement;

Petrol and diesel engines that work for a long time on a tank of fuel but produce vibration, noise and heat.;

Hybrid power where engines are used to recharge batteries. Electricity has good power characteristics and the engine smoothes the power requirement.

Cooling the power units can be a potential problem

The mechanical apparatus

The machine uses a variety of solutions to solve 'doing' the task including:

Hub electric motors that offer great torque and are easy to design into a machine. They have no direct drives and very little loss of energy.

Hydraulics which results in a loss of power if used to drive the vehicle. However they are easy to design in. Hydraulics can also be used to move components like mechanical arms.

Pneumatics that are 'soft' in their operation. Gases can compress and take shocks which can be very useful in controlling some mechanical operations. They are also easy to design in.

The movement of the robot is usually accomplished using wheels but tracks can be used, and some robotic engineers have worked with 'walking' machines in certain applications. When wheels are used a wheel can be put on to each corner of the robot with the possibility of using four-wheel steer and four-wheel drive. Turning circles can be made tighter using braking control.

(Idia, 2009)

Machine learning

'Safeguarding' is an important feature of any robot. Invariably this involves creating images to detect dangers. Safeguarding needs to be conservative in its operation and should detect false positives, that is the robot should stop on suspicion of a problem at the risk that there eventually proves to be no obstacle actually present. Typical obstacles in a farm environment include telegraph poles, trees, people, animals, other vehicles, irrigation pipes and pumping stations. When a machine stops it can send an image that highlights the obstacle back to a supervisor who decides if he should override it. (Moorehead, 2009)

Machine learning is a key component of robot development. The robot adjusts its own software based on previous experience. The algorithm learns patterns from the data sets and then uses them in a predictive manner. The robot's perception is thus improved. For example if the robot is fitted with long distance vision sensors and short distance vision sensors it may ' see' something in the distance but may not know what it is. The short distance sensors may then recognise that object as a tree when it gets close to it. Next time the machine 'sees' a similar object in the distance it will recognise it as a tree. Or when it hits an obstacle it remembers what it saw and then next time it recognises it as an obstacle. Robots can use this process to reset their own parameters in a new environment, saving programmers huge amounts of time and cost.

Machine learning was used in the development of an oestrus detection aid that the Livestock Improvement Corporation (LIC) in New Zealand has developed. The system that is commercially available is designed for large herds. It uses a camera to 'read' Kamar heat detectors. Creating an algorithm that could read the Kamars was difficult and eventually a blue Kamar was produced to overcome the problem, but machine learning was used to refine the software during the development of this product.

LIC are also investigating using machine learning to analyse data for individual cows. For example each milk cluster could be adjusted based on the machine's previous experience.

BRAIN in Japan - The driverless machine is a reality

Most robotic engineers currently envisage a future based on groups of small robots under the control of a single operator. Such a system will require a supervisory system with a communications infrastructure. In the future the operator might be a 'mothership' controller with sophisticated systems to control the smaller machines, along with an infrastructure to refuel and replenish them. The driverless machine is a technical reality and its uptake appears to be limited by legal issues rather than technical ones: for instance who will be responsible if the machine drives through someone's living room? Smaller machines will limit the potential damage that might occur and could also be more easily retained by a series of 'tank trap' ditches around the working area.

Developments in sensor technology are creating a revolution in the information that is available to farmers (Singh, 2009). A plethora of sensors and communication systems is being developed that can be used for applications as diverse as:

- Identifying crop stress
- Identifying crop disease
- Measuring the nutrient content of plant leaves in situ
- Estimating crop yields
- Identifying internal defects in produce
- Measuring body condition score in livestock
- Measuring livestock activity

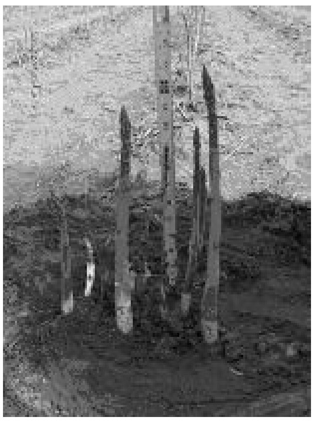
These will help farmers react more quickly and to make more informed decisions.

Case studies

Asparagus Harvesting

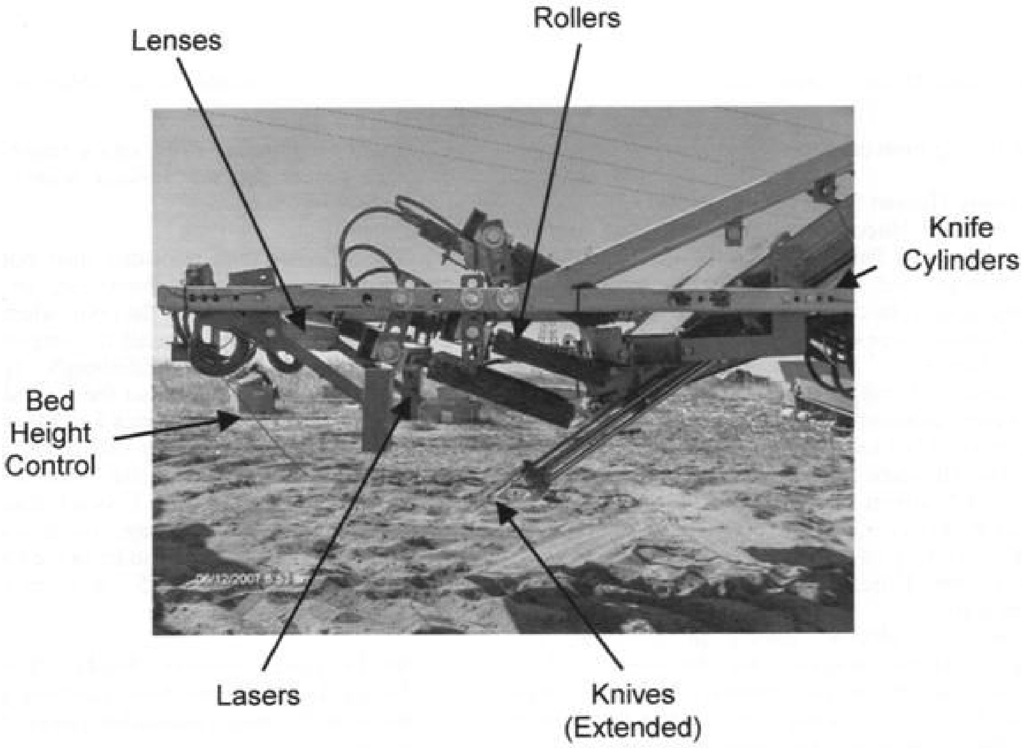
Geiger-Lund Engineering in California has successfully developed a robotic asparagus harvester that is now ready for the market (www.asparagusharvester.com).

Harvesting asparagus with a robot is not easy. The crop is selectively harvested and cut below ground. Any automatic harvester has to be capable of identifying the spears that are ready to harvest and then cleanly cut and collect them without damaging the spears that are developing. The machine has to be quick and reliable because during the peak harvesting season the crop is cut on a daily basis.



Bill Lund first started building prototype harvesters in the very early 70s and persevered throughout most of the 1980s before putting the project aside. He returned to developing the machine in 2000 as a result of renewed interest in automated harvesting and technical developments that offered the potential to overcome the obstacles that had been encountered over a decade earlier. The development of the machine has been slowed because there is only one short season each year in the Western United States to develop and test it.

The machine uses two laser beams along with a series of sensors to identify where the spears to harvest are; it then uses pneumatically fired knives to cut the spears and finally uses rollers to collect the spears and deliver them onto a conveyor. The cut spears are then manually packed into trays.



A variety of sensors was tried over the years. An early video camera was tried, as were small flappers that touched the spears. It quickly became clear that any sensor that touched the spears was unacceptable. Spears that leaned over also represented a problem in terms of detecting exactly where to cut them. The chosen sensing system uses two laser beams. The higher beam is used to determine if the spear is ready to harvest. If the spear is lower than the beam then it doesn't get cut. The lower beam is used to determine where to cut. The beams create a red spot on the spears that is 'seen' by optical sensors that sit behind a series of lenses. There are two sensors behind each lens; one focused on the top laser beam and one on the lower laser. Each sensor then has its own micro controller with its own programme running. The laser is modulated and the sensors detect a rapid change in intensity. The sun does not interfere with the system.

The header is constantly kept at just the right height above the bed using a simple rod that moves and activates a pair of proximity switches. Earlier versions had mechanical switches, ultrasonics and laser distance detection but they proved to be unreliable or unsatisfactory. Where a harvester has more than one header they will all move independently. Farmers grow asparagus on differing widths and heights of bed and machines will be custom built to suit the farmer's requirements.

Cutting the asparagus is a real challenge. The machine has to calculate just the right spot to cut. If the machine is moving at one mile per hour it moves almost two inches in a tenth of a second. The knives have to be very accurately targeted to cut the spears. The harvester has a shaft encoder on the axle that calculates the machines speed every tenth of a second. The CPU then calculates when to 'fire' the knives to cut in the right spot.

The knives are two inches wide and fitted to the end of 20 inch stroke pneumatic cylinder that can fire five times each second. The knife has 100lbs of force and reaches full velocity within an inch of starting to move. It takes just 0.07 of a second to go down. The cylinders had to be custom built to provide ports that were big enough to allow enough airflow to meet the performance requirements. Its movement is cushioned by a small pneumatic cylinder that ensures the cylinder rod does not strike the cylinder case at the top of its stroke. On the down stroke the cylinder reverses direction before it bottoms out. Early versions of the cylinders shook themselves to pieces: rods that held the cylinders together stretched and fittings shook themselves apart. Lock nuts and lock tight were tried without success. Cylinders that are welded together with tapered fittings provided a reliable solution. The current cylinders have a one inch bore with a centre-to-centre spacing of one and three quarter inches.

The width of the knives and cylinders has been reduced as the machine has been developed. The knives were originally five inches wide. They cut the asparagus well but did far too much damage to spears that were developing around the spear that was harvested. They were having a negative impact on the overall yield across the season. As targeting was refined their width was progressively reduced. Sometimes two knives are fired at once if the sensors detect that a spear sits in the margin between the two knives.

There are three sets of rollers that pick the spears up and carry them into the conveyer. The first set starts to grip the spear before it is cut. The rollers then 'pass' the spears from set to set and lift the spears well out of the way of the knives before putting them onto the conveyor. The rollers have been developed so they don't damage the spears.

The machine is finally ready for the market place and Geiger-Lund expects to sell one into Australia in 2010. The cost is expected to be in the region of £150,000 for a machine with three headers. In a commercial environment the machine should be able to work at two miles per hour.

Images courtesy of Bill Lund

To date no study has been done comparing the machine in its current form with a manual team cutting the crop but it is envisaged there will be a small yield penalty associated with its use.

Weed Control

Weed control is an area where alternatives to conventional spraying are being pursued by a number of research groups. Our existing spraying techniques result in potential risks to the environment and the possibility of product contamination. In Europe many agrochemicals are being removed from the market and in some cases alternatives are urgently required. Possible solutions are robotic weeding and targeted spot spraying.

Dr Nick Tillett of Tillett and Hague Technology has been working on alternatives to conventional spraying for over twenty years, and his success in this area demonstrates how frontier technology develops over a period of time. As long ago as the late 1990s he and his colleagues had developed a tool carrier that could steer itself through a field of row crops using machine vision. This developed into the first Robotic weeder, the Robocrop, which was launched in 2001. A number of different techniques were tried to differentiate between the crop and the weeds. Colour differences between the crop and the weed were found to change constantly and were insufficient to differentiate successfully. Leaf shape was tried but it required very high definition cameras and too much computational capacity. The solution was found by using the planting geometry to identify where the crop rows were. Colour cameras were able to quite easily distinguish between the green crop and the background soil. A band pass filter tuned to the known row spacing was then used to create an image of the rows that the hoes could follow.

Unfiltered image

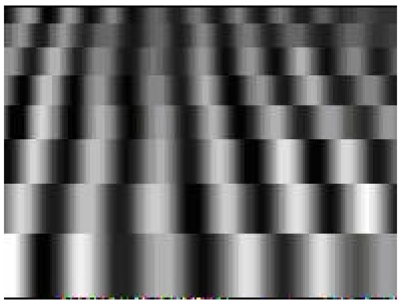


Image after filtering

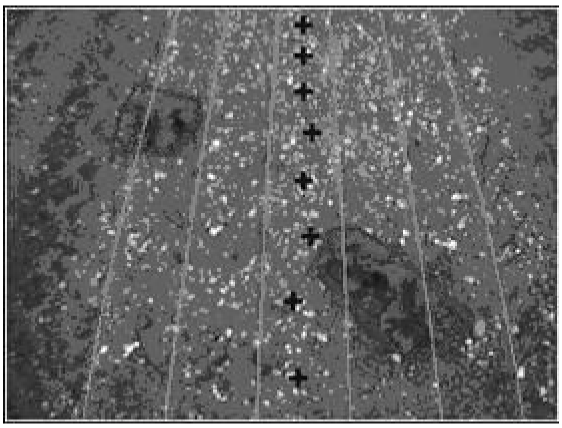
The machine tracks crop rows from image to image and uses knowledge of the tractors forward motion to ensure reliability. This solution was found to very robust in terms of identifying the rows and even worked reliably when the tractor was deliberately driven badly. The Robocrop found a market with vegetable farmers and organic cereal farmers and sales have risen to about 50 machines each year. The research team continued to refine the machine over the next few years but their attention moved on to the next challenge.

Weeding in between vegetable plants within the row as well as between the rows was the next problem to be addressed and overcome. This required both vision innovation and mechanical innovation. Once again knowledge of the geometry of the crop is the basis on which the machine works. The camera produces 30 images each second and the machine predicts when a plant will appear at the top of the image. It then refines the location of the plant as it moves across the image and rotating hoes are then run around each plant as the weeder passes over them. When an unusually large gap exists between two plants the hoe can be clearly seen to hesitate before it sweeps through the gap.

The Robocrop in row – hoes weed around each individual plant

The Robocrop InRow was successfully launched in 2007 and offers a real alternative to spraying in precision drilled or transplanted vegetable crops where large gaps exist between individual plants. Once again the research team moved on to a fresh challenge.

Using the technology to identify individual weeds and spot spray them is the current focus at Tillett and Hague Technology. The particular challenge that they are addressing in a collaborative



Potatoes identified for spraying

HortLINK project is volunteer potatoes in onions and carrots. The current agrochemicals used for this task may well be withdrawn in the near future and they have a reputation for checking the crop. On the prototype machine the camera looks forward and down across a 1.8 metre wide bed. Once again it differentiates between plant material and the background soil on the basis of greenness. The potatoes are identified based on a weighted combination of their distance from the crop row, their size and their shape; that is their aspect ratio (width divided by height) rather than the leaf shape. The algorithm then identifies spots to be sprayed.

Control plot alongside a crop that has been spot sprayed. Between 75% and 95% of potatoes have been removed in one pass in trials with very low levels of crop damage

This project has involved solving the problem of spot spraying the weeds as the machine passes. The sprayer has to turn on and off very sharply with no drift at very low flow rates. This has been achieved with Glyphosate where quite large droplets have been used to give good drift control and targeting. However these may not be suitable for all other chemicals. The machine is now an advanced prototype and is probably 2 years from becoming commercially available. One of the problems to overcome is a legislative one; there is no approval for using Glyphosate in onions and carrots.

A research team at the National Centre for Engineering in Agriculture in Australia has successfully used colour differences to identify different weeds. They managed to identify weed grasses in sugar cane using the 'blueness' of the leaf. Accuracy of detection was over 90%. Although this is not directly applicable to the UK it does demonstrate that there are potentially alternative ways of identifying weeds to the one outlined above. Indeed it may well be that individual solutions have to be found for particular weeds in particular crops.

A really futuristic approach to chemical application is being researched at Washington State University. The programme is seeking to use cold plasma to accurately apply chemicals to fruit crops. The long term aim is to apply pesticides to just the part of the crop that requires treating – so when the apples need spraying they will get coated in pesticide but not the leaves. Once again vision technology is used and cold plasma is used to apply an even film across the target. It may be many years before this technology is available to use in the orchard but it could be available much sooner for applying materials to harvested crops in the store or pack house.

Smart engineering for livestock farmers

Progressive dairy farmers have been aware for many years that locomotion scores and body condition scores for their cows are valuable data that can improve management, but obtaining this information through manual assessment is laborious and interpreting it to produce meaningful trends has not been easy. IceRobotics in Edinburgh have developed technical solutions to gathering and interpreting this information and are due to launch an animal activity recorder onto the dairy farm market that will not only produce locomotion scores but a variety of additional management information in relation to both individual cows and the whole herd. IceRobotics' expertise is in sensing technology. They have already developed an activity recorder that monitors, records and reports detailed animal activity. Called the IceTag3D it is based on an accelerometer that picks up the forces of gravity in three dimensions – up/down, forward/backwards and left/right.

It records information 16 times each second and transmits the data wirelessly. This is a progression from the pedometers that have been on the market for some time that record just stepping activity. Software interprets the raw data into the animal's activity patterns rather than just recording step count. The IceTag3D is currently used by animal scientists to support research into animal health and welfare. Typically, devices are attached to animals for the experiment period and then removed and the data downloaded wirelessly to the researchers' computers.

A new system is being launched at the Precision Dairy Management Conference in Toronto in March 2010 to enable much larger longitudinal datasets to be collected to support research. Called the CattleGrid, the device combines the IceTag3D with automated data download on the farm and internet connectivity. This will allow devices to stay on animals for several years and the researcher to access the data remotely. Oestrus detection will be available to participating farms through the system. A system is also being launched in Autumn 2010 that is being designed specifically for commercial dairy farmers. This will be based upon a localised system but will be internet enabled to allow for downloading updates and to benchmark with other herds. Initially this will provide monitoring and alerting for oestrus and lameness. IceRobotics have been holding farmer focus groups to develop an understanding of exactly what information farmers want from a commercial system.

The accuracy of the information generated is currently being validated to ensure that the system is accurate whilst minimising the detection of false positives. In addition to individual cow monitoring, the system will also produce whole herd information; how long cows are spending lying down, how long do they spend just standing. This will allow farmers to assess the impact of management changes on the behaviour of the herd. Has a ration change resulted in the cows spending more time standing at the feed face? This should lead to the development of 'time budgets' that the farmer can use to maximise the time his cows spending eating and lying rather than waiting to be milked. It should allow good management practices to be scaled up.

IceTag3D on grazing cow

The IceTag3D incorporates battery saving technology that gives its batteries a prolonged life and it sits within a tough plastic housing that can tolerate life on a cow's ankle.

The concept of gathering information from sensors on the animal can be further developed. Researchers in Japan have collected data automatically on the number of bites an animal takes when feeding. It should be possible to put a bolus into the animal that would take temperature readings. All this information could be linked back into sensors in the milking system and in the future it should be possible to gather a wide variety of data that will give us new insights into individual cows and whole herds.

IceRobotics have also been involved in the development of automatic body condition scoring. They have developed a system demonstrator that uses a thermal imaging camera to assess the shape of a cow. At present body condition scoring is manual and subjective. It is time consuming and requires trained labour. Very few farmers consistently measure body condition scores although many recognise the value of the information associated with the practice.

The system developed by IceRobotics works by determining the presence of the animal and then taking an image of the back of the cow from above. The data is then analysed to identify certain points on the animal's back. The angles associated with these are then calculated and the appropriate resulting body condition score generated.

Thermal image of cow's back from above

Studies to date with the system have demonstrated its effectiveness, although it still requires some refining before full commercialisation. Automatic body condition scoring could also be used to select animals for slaughter in beef feedlots.

At present the cost of thermal imaging cameras is prohibiting the commercialisation of this approach to automated body condition scoring, but technology is constantly coming down in cost and there is every prospect that this technology will be available on the farm in the future.

Fruit Harvesting – a significant challenge for the robotics engineer

A number of research groups around the world are working on this difficult issue. A consortium from Washington State University and Pittsburgh University is working on an orange and apple harvester, Washington State University (WSU) is working on a cherry harvester and BRAIN (Bio-oriented Technology Research Advancement Institution) in Japan is working on a strawberry harvester. The challenges associated with harvesting fruit are considerable but the most significant was probably summed up by Marvin Pitts of WSU: 'If I touch a fruit, I bruise a fruit'.

The robotic fruit harvester has to navigate and power itself around the orchard; it has to see the fruit to be harvested, differentiate between fruit that is ripe to pick and fruit that is still immature, restrain it to grab it, remove it from the tree or plant and then put it into a tray or bin. It has to do all that economically, and a large part of doing it economically means doing it quickly. Locating the fruit is made difficult because it grows on a plant that is not uniform. Fruit can be hidden behind branches and leaves. To locate red fruit a colour camera is probably the lowest-cost option, but green fruit against green leaves creates problems. In this case neo-infra-red, ultrasonic or laser scanners may be the best option. The machine will have to reach and grab the fruit. As the fruit gets further away from the robot this becomes more difficult. The machine has to be able to judge distance and to grab fruit that is moving in the wind. Of course one possible solution to this is that the trees are trained. As discussed above columnar trees may have a big role to play in this respect if they are used to create a 'fruiting wall'.

Having located the fruit the next challenge is to handle it. Robots are often built to mimic humans. When we reach out to pick an apple we use vision to guide us to the point of grabbing the apple but then touch takes over. Touch is a very difficult sense to mimic. Indeed it would appear that nobody has yet produced an effective robotic finger tip. That finger tip would require a number of sensors – 3, 20 or 100? It would then require very rapid feedback loops from the sensor to the mechanical actuators to stop the 'finger' bruising the fruit before it had stopped moving. Progress is being made here. Until recently the fastest actuator took one tenth of a second to respond; too slow to prevent damage. This has been reduced to a two-hundredth of a second – twenty times quicker.

The 'hand' that grabs the fruit has to be soft but not so soft it won't work. If it grabs too firmly it will bruise but if it isn't firm enough the fruit will slip within its grasp and scratch. The 'hand' that grasps the apple could consist of 3 fingers, or 4 fingers or may make use of suction. Will one device handle all sizes and shapes of fruit?

The fruit will then have to be moved back to the tray or box. Will that be done with the picking arm? If so can it be quick enough? Can it be done through a vacuum tube? Without bruising the fruit?

Any harvester will have to be reasonably straightforward to operate and calibrate.

Power options include electrics through a cable, batteries and engines.

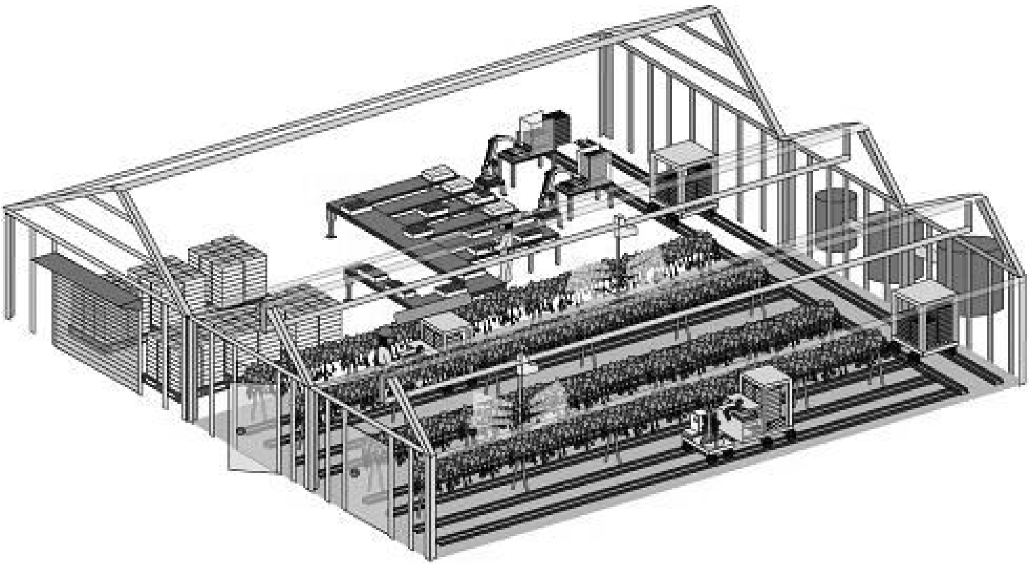
Traction systems could include rails, wheels or tracks. On a slow machine working in a confined space an umbilical system on rails may well be the preferred option.

GPS could be used to guide the machine around the orchard but trees interfere with the signal. A portion of the signal bounces back.

In developing a robotic harvester the design parameters are important. What is the specification? What is the tolerance level in terms of bruising? However technological breakthroughs could make a huge impact. If someone develops an effective 'touch sensor' next week development could be much faster than we might expect.

Strawberry Harvesting

Research engineers at BRAIN in Japan have produced two prototype robots that will harvest strawberries. The eventual goal is to develop a complete automated harvesting and packing operation based around strawberries grown on table tops in either greenhouses or poly tunnels.

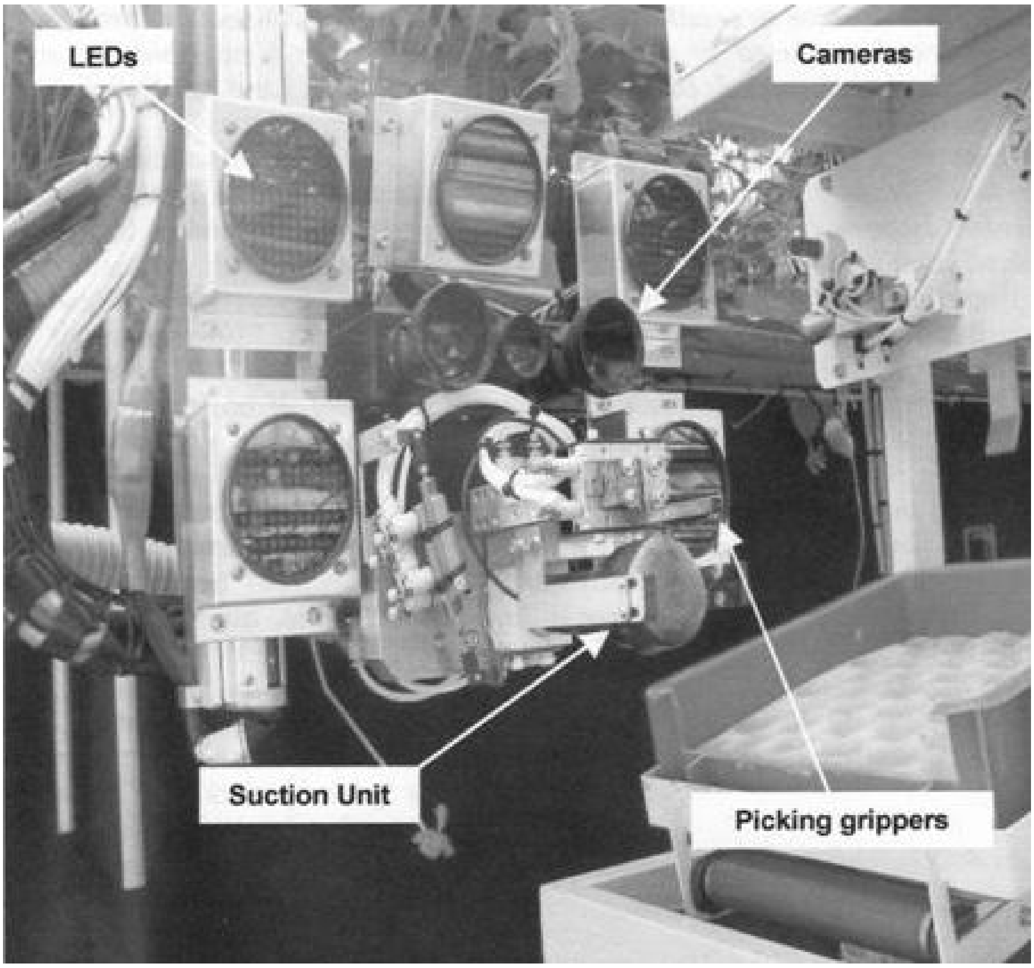


The robots are designed to work at night when shadow does not interfere with the machine vision. The robots travel on rails, are battery powered and work under LED lights. Cameras are used to identify the fruit and an algorithm calculates the proportion of the fruit that is white at the top to determine if the fruit should be picked.

The team have developed two prototypes -

A cylindrical type robot that picks just from the aisle side of the plant;

An articulated type robot that picks from both the aisle and the bed side of the plant.



The cylindrical machine uses machine vision based around five LEDs and three cameras. The centre camera is used to detect the peduncle and the two

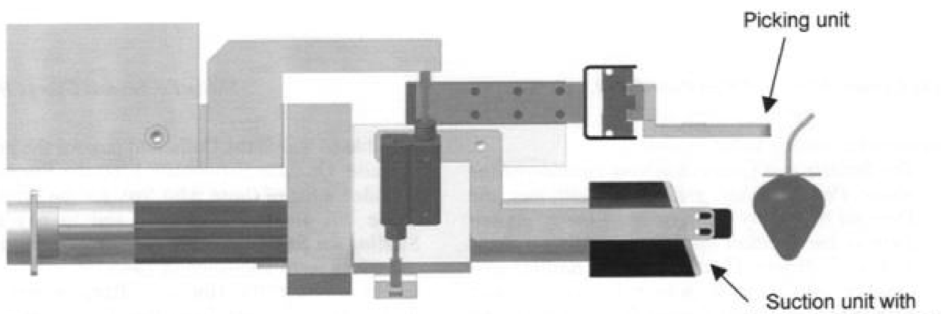


Diagram of the picking arm

side cameras are used to create a three-dimensional image.

The picking arm reaches out and picks the strawberry at the peduncle. The fruit itself is not actually touched. This has overcome the problem of damaging the fruit when it is touched. The machine has been fitted with a small suction system to hold the fruit stable as it is picked and has been tested with and without this in operation. The articulated machine uses machine vision based on two cameras and one LED. It also handles the fruit by the peduncle but can approach the fruit from both the aisle side and the bed side.

The machines have been tested. They do not pick all the fruit, and do pick some fruit that isn't ripe. Indeed it seems likely that for the foreseeable future

Working from the aisle side

Working from the bedside

a feature on robotic fruit harvesting will be that a manual picking team will have to follow the robots to pick what has been missed. Results are shown in the following table:

	Success rate (%)	Execution time (s/fruit	Mature fruit left (fruit/10a)	Immature fruit harvested (fruit/10a)	Damaged (%)	Test length (m)
Target	60>	<10 [1]	<1440-2880 [2]	<216-432 [3]	0	-
Cylindrical (Suction)	41.3 (7.7-75.8)	11.5	1491	558	0	684
Cylindrical (Non-suction)	34.9 (18.0-61.5)	11.5	1188	500	0	360
Articulated	49.1	11.6	136	1443	0	23

1) Theoretical working hours per 10a

10[s]x7200[fruit/10a] x 0.6 = 43200[s/10a] = 12[h]

10[s]x3600[fruit/10a] x 0.6 = 21600[s/10a] = 6[h]

2) Mature fruit: 3600~7200 fruit/10a

3) 10% of harvested fruits

The results show that the robot has created no damage, which is a significant improvement on manual picking where finger bruising is a problem. The machines do not quite meet the target execution time and at present pick too much immature fruit. Improvements to either the vision systems or fine tuning the algorithms will be required to solve the latter problem. The team also have not yet solved the problem of automatically moving the machine around the greenhouse from the rails in one row to the rails in the next row. They are going on to produce a third prototype and believe that a commercial strawberry harvesting robot is still about five years away from the market.

Conclusions

Developments in engineering and computer-based technologies are set to make a huge impact on agriculture. A number of complex robots are already on the market and more are set to follow. Driverless machines fitted with GPS and machine vision are a technical reality and legal issues appear to be the greatest obstacle to their commercialisation. Harvesting fruit is a particular challenge to the robotic engineer. Locating it and handling it without bruising is difficult but a research team in Japan have created a prototype strawberry harvester and teams elsewhere are working on apple and cherry harvesters. An important feature of robotic development is to rethink the problem to make the task easier for the robot. In this respect plant breeders and geneticists have a role to play in changing the structure of the crop to improve the presentation of the fruit.

Sensing and communication technologies are creating a revolution in the information that is being made available to farmers to improve their decision making processes. Information that was historically difficult to collect can be created automatically and analysed to help fine-tune management and spread best practice.

About the author

David Gardner (David.Gardner@co-operative.coop) is Head of Fruit Operations for the Co-operative Farms and is responsible for developing the fruit business to supply the ‘Grown By Us’ brand into Co-operative stores. During his career with the Co-operative Farms he has held a variety of roles in several different industry sectors. Since 2002 he has been part of the Senior Management Team. Prior to this date he held management roles on farms and spent 10 years at Stoughton Estate in Leicestershire managing combinable crops and dairies.

He has recently completed the Nuffield Frank Arden Memorial Study on New Technologies. This study took him to leading research institutes in the UK, USA, New Zealand, Australia and Japan. His study focused on gene technology, functional foods, non-food uses for agricultural produce and robotics.

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BOOK REVIEW

BENCHMARKING IN FOOD AND FARMING: CREATING SUSTAINABLE CHANGE

Edited by Lisa Jack

This is a useful and topical book edited, and partly written, by Lisa Jack, with contributed chapters by five other benchmarking specialists. After an introduction which discusses the concept of benchmarking, the book has four main sections focussing on: Comparing Farm Performance; Improving Farming Practice; Environmental Benchmarking; and Innovative Practice and Future Developments.

Much of the early part of the Farm Performance section is concerned with historical development of the concept which, unfortunately, is partly repeated in later contributed chapters. However, there are good guidelines for the establishment of benchmarking activities, well underpinned by evidence from case studies of systems established in other countries – particularly New Zealand, Australia and the United States. The New Zealand example is the most detailed, providing actual examples of data analysis sheets. The various vehicles for benchmarking activities – Business Clubs and Groups – are well reviewed, and much useful anecdotal evidence provided. The treatment of environmental benchmarking techniques and structures is less specific.

While this book certainly sets the scene and provides a wealth of examples, there is still a gap in the sense that it is not possible to 'lift' sections of this book and apply them to specific food or farming situations. However, each chapter is very well referenced with sources of this more detailed information, making it a useful starting point.

Philip Cain, Senior Lecturer and Farms Director, Newcastle University.

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JOURNAL OF FARM MANAGEMENT

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EDITORIAL

My first thought when contemplating this last Editorial for the *Journal of Farm Management* was that it should include a grand review of the long history of the Journal since its first issue in 1967, complete with analysis of topics covered, lists of editorial committee members, and valedictory messages from the great and the good. On reflection, though, this does not feel the occasion for finality and valediction. Some time ago, in a conference paper,[1] I used the expression 'not death but transubstantiation' to describe the way that farm management teaching and research was changing shape. I have since learned that my understanding of the term 'transubstantiation' was a little shaky, but nevertheless I would apply the spirit of that phrase to what is happening to our Journal now. The Institute of Agricultural Management will continue to publish a quarterly journal, but in partnership with the International Farm Management Association (IFMA), merging with the *Journal of International Farm Management*. The editorial team of the new *International Journal of Agricultural Management (IJAM)* is formed from those of *JFM* and *JIFM*, so there *will* be continuity – our work goes on.

However there would be no point in such a move if it did not promise a better offering for readers. The partnership with IFMA will give us a broader outlook and better access to many excellent authors from other countries – essential for a professionalised, dynamic farm management community. Many of the most influential articles in JFM in the past have been written by non-UK authors, bringing us new perspectives and adding to our managerial tool-kit. This will not be at the expense, though, of the well-written UK/European article, whether a research paper, technical review or polemical viewpoint.

The new journal will be published quarterly online, reflecting the increasing expectation of electronic access, together with around ten years' worth of back issues. For members and paying subscribers, a print edition will bring together each year's content for those who like to have a copy on the shelf. Best of all, we hope to be able to raise quality, not just in narrow academic terms, but also in terms of 'usability' by those who are at the sharp end of agricultural management and rural land use.

So read on and enjoy the varied articles in this issue, comfortable in the knowledge that in three months' time you will be doing the same with the first issue of *IJAM*.

I would like to thank the current Editorial Committee of *JFM* for their vital contribution in the past, and I look forward to their future involvement in *IJAM*: Ian Ashbridge, Carl Atkin, Alison Bailey, Mark Robins, Andrew Crossley and Paul Webster. But finally, a real valediction. Douglas Brown, who currently manages the whole process of typesetting and printing of *JFM*, will be stepping down when we move on to the new journal and a different production process. Douglas is the only person who has had a continuous involvement with the journal for the whole of its 44 years, and has been an absolute cornerstone for as long as I can remember. Joni Mitchell sang "you don't know what you've got till it's gone", and I have a nasty feeling that the truth of this will be all too apparent when I am preparing the first issue of *IJAM*. But all good things come to an end, and Douglas has been looking forward to this opportunity for some time. We wish him well in his future endeavours, and offer him sincere thanks for a job very, very well done.

Martyn Warren, Editor

1. Warren, M.F. (2000) Farm Management: death of a discipline? *5th European Conference on Higher Agricultural Education*, September 2000, University of Plymouth, UK

REFEREED PAPER

FARM DIVERSIFICATION: A RESOURCE BASED APPROACH

Keith Walley, Paul Custance, Faye Smith

Diversification is an important strategy for many farm businesses in the UK. However, farm diversification is not always successful and this suggests that there is a need for additional insight into the subject. This paper presents the results of a study that applies the Resource Based Theory (RBT) of the firm to farm diversification. The study is based on a case study methodology involving six farm diversifications. The results suggest that the key resources underpinning farm diversifications are the staff, information, and personal relationships. It was also apparent that the farmers who led the diversification had an intuitive understanding of the characteristics of resources which allowed them to manage them as either "basic" or "strategic" resources, and focused on the resources rather than the nature of the diversification. This then suggests that the farmers are entrepreneurs who are one of, if not the most important resource involved in the diversification.

Keywords: Farm diversification, Resource Based Theory, RBT

Introduction

According to Johnson *et al* (2008) diversification is *"...a strategy that takes an organisation away from both its existing markets and its existing products"*. In terms of farm diversification this relates to the exploitation of income generating opportunities that can support the income of the farm household and in turn the viability of the agricultural business (Bosworth and McElwee, 2009).

In recent years diversification has become a popular strategy for those farmers who want to survive and be successful in the changing economic environment (McElwee *et al*, 2006; Turner *et al,* 2003; DEFRA, 2010a). In practice, however, farm diversifications are not always successful (Turner *et al*, 2003) and it would appear that research is required to both understand the issues better and to improve the rate of success. Indeed, this paper seeks to address these matters by applying the Resource Based Theory (RBT) of the firm which according to Collis and Montgomery (2008) *"...combines the internal analysis of phenomena within companies (a preoccupation of many management gurus since the mid-1980s) with the external analysis of the industry and the competitive environment (the central focus of earlier strategy approaches)",* to farm diversification.

The paper will review the Resource-Based Theory of the firm prior to outlining the methodology used to gather the data on which this paper is based. The key findings are then explained and the paper concludes by considering the implication for the farm diversification. To begin, however, it appears propitious to acknowledge the drivers that cause farmers to diversify as well as the extent and nature of farm diversification.

Farm Diversification

In the UK and elsewhere in the European Union CAP reform and the withdrawal of production subsidies has forced farmers to adapt their strategies in order to maintain profitable businesses (Maye *et al,* 2009; Vesala and Vesala, 2010) and diversification has emerged as a popular strategy. According to DEFRA (2010b) there were 57,000 farms in England in 2008/09 and 51% of those had diversified activity which equates to approximately 29,070 diversified farm businesses. Farm diversification may take a variety of forms and a comprehensive typology has been developed by Bosworth and McElwee (2009).

Agriculture has been subject to extreme and rapid change which has led to many farmers becoming involved in entrepreneurial activities (DEFRA, 2010; Bosworth and McElwee, 2009; Clark, 2009; McElwee *et al*, 2006; Alsos *et al,* 2003; McElwee *et al,* 2006). Indeed, Alsos *et al* (2003) identify three types of farm entrepreneur. The *"pluriactive entrepreneur"* is motivated by lifestyle and diversifies in order to maintain a lifestyle when the farm business is facing difficulties. The *"resource exploiting entrepreneur"* undertakes diversification in order to utilise unique resources which are connected to the farm. The *"portfolio entrepreneur"* enters into diversification in order to exploit a business idea which is not necessarily linked to the farm's resources.

There are multiple measures by which to evaluate a diversification. Typical measures include annual sales, turnover, market share, growth in output, number of employees, added value, value of the business, earnings per share or rate of return on equity (Grant 1991; Kay, 1995). In addition typical internal measures might include the number of new products and various product quality ratings (Rantamkai-Lahtinen, 2009). It is apparent, therefore, that the success of diversification is determined by the measures applied and that this is dependent on business objectives.

In terms of farming, some measures used to determine the success of diversification are generic such as *"cash flow"* and *"profitability"* but others are more farming related and include *"reduced dependence on agricultural subsidies"*, *"more stable income"*, *"fitting in with the farm business"*, *"satisfied customers"*, and *"personal and family satisfaction"* (Clark, 2009, Turner *et al*, 2003). Indeed, Turner et al (2003) found that four out of five farm diversifications were considered successful in the context of their own particular objectives.

According to Rantamaki-Lahtinen (2009) and Forsman (2004) successful farm diversification is frequently based on resources such as buildings, finances, human resources and machinery. Such resources need not be wholly owned by the farm but may be shared, as is often the case in agricultural cooperatives, which may lead to an additional advantage in terms of farmers learning from each other (Rantamaki-Lahtinen, 2009). The apparent importance of resources suggests that the RBT might provide useful insight into their role in underpinning farm diversification.

3.0 The Resource Based Theory and Diversification

The RBT originated from the work of authors such as Richard Coase (1952) and Edith Penrose (1959) while the term Resource Based View was first used during the 1980s by Birger Wernerfelt (1984). The concept was subsequently refined and became known as the Resource Based Theory of the firm in the 1990s (Grant, 1991). Today the RBT is considered one of the most influential frameworks for understanding strategic management (Barney *et al*, 2001).

At the heart of the RBT is the concept of organisational resources. It is tempting to think of resources as simply items such as land, buildings, vehicles and machinery. However, they may in fact be anything that constitutes a strength or weakness for a company (Wernerfelt, 1984). In this context, therefore, the term resource is all-encompassing (Forsman, 2004) and may include tangible, intangible and human resources. At an operational level the strategic value of a resource may be determined by impact on unit margin (Bowman and Ambrosini, 2007) and identified via a *"resource audit"* (Grant, 2008).

Tangible resources refer to physical resources such as land, finance, buildings and machinery. These resources appear on the company balance sheet and their value deteriorates over time (Prahalad and Hamel, 1990). Intangible resources include production, marketing and manufacturing capabilities, corporate reputation and corporate culture. While classifying resources as either tangible or intangible is useful it also has its limitations. One of the most important resources of any business is its employees and especially their *"know-how"* or tacit knowledge (Phelan and Lewin, 2000). Human capital is difficult to classify as while people are obviously tangible their training, skills, experience, judgement, intelligence and relationships are not.

In practice resources are themselves rarely productive and they have to be marshaled in order to perform some task or activity. This process creates *"capabilities"* such as the ability to create a favourable reputation or offer superior customer services. The capabilities that generate a competitive advantage for the organization are often referred to as *"core competencies"* (Prahalad and Hamel, 1990, p82).

The RBT suggests that resources that underpin sustainable competitive advantage are often *"durable"* so that they are long lasting, *"non-appropriable"* so that they are difficult to acquire, *"non-substitutable"* so that alternative resources cannot be deployed in their place, *"superior"* so that competitors may only deploy inferior resources, and *"inimitable"* which means that they are difficult to copy (Collis and Montgomery, 2008; Peteraf, 1993). Resources that possess most of these characteristics are considered to be *"strategic resources"* while resources that do not generally possess these characteristics are known as *"basic resources"*. As a general guide the more that an organisation does to accentuate heterogeneity in its resource base, the stronger and more sustainable its competitive advantage is likely to be (Grant, 2008).

The RBT argues that failure in the market-place or under-utilization of resources leads to redeployment in another industry which makes diversification an efficiency decision (Montgomery and Wernerfelt, 1997; Penrose, 1959; Peteraf and Barney, 2003). As a consequence, Wernerfelt (1984) believed that RBT was the only theory of strategic management able to explain the full range of diversifications and is thus a very useful underpinning to a study of farm diversification.

Methodology

Diversification is a common strategy for farm businesses to follow but it is not without risk of failure and research was undertaken to improve knowledge and reduce the associated risk. RBT has been used to understand diversification in general but its application to farm diversification has been limited. As a consequence RBT was used to underpin this inductive study of diversification in the farm sector.

The project employed a three stage methodology advocated by Yin (2009) and comprising Define and Design; Prepare, Collect, & Analyze; and Conclude, to study diversified farm businesses in the Cheshire area. Information provided by the National Farmers Union (West Midlands region) and the Farm And Retail Markets Association (FARMA) was used to identify farm diversifications suitable for study. A sample size of six diversifications was chosen in order that patterns of replication might emerge (Yin, 2009) that would permit the building of *"case law"* (Gill, 1995).

Patton (2002) advocates the use of heterogeneous sampling to ensure maximum variation within a sample and suggests that it is good practice to identify diverse characteristics prior to selecting your sample. Different approaches to farm diversification are likely to require different underpinning resources and so in this study a purposeful sample was selected in order to highlight the implications of diversifying into very different types of business. The key characteristics of the sample cases are summarised in Table 1.

Semi-structured interviews were used in order to obtain rich contextual and qualitative data from business owners/managers. An Interview Schedule listing key themes and issues arising from the literature was developed, tested and modified following a pilot interview, and used as the basis of the interviews. All the interviews were taped and transcribed.

Irrelevant narrative was removed from the transcriptions (Hair *et al,* 2007) before the remaining text was coded using different coloured ink, key words and different font types and styles (Myers, 2009). Individual summary reports were written for each of the six cases which were reviewed for reasonableness, accuracy and validity by an agricultural expert. When deemed reasonable, accurate and valid a cross-case analysis was completed to identify common themes, patterns, exceptions and outliers.

The fact that only six cases were investigated means that it is impossible to calculate statistical significance in order to determine the reliability and generalisability of the results. However, while the study must be seen as exploratory in nature the systematic approach to data collection and the use of an independent expert to review the case data means that the results have *"face"* or *"content"* validity (Kinnear and Taylor, 1996) and constitute useful insight into recent farm diversification activity.

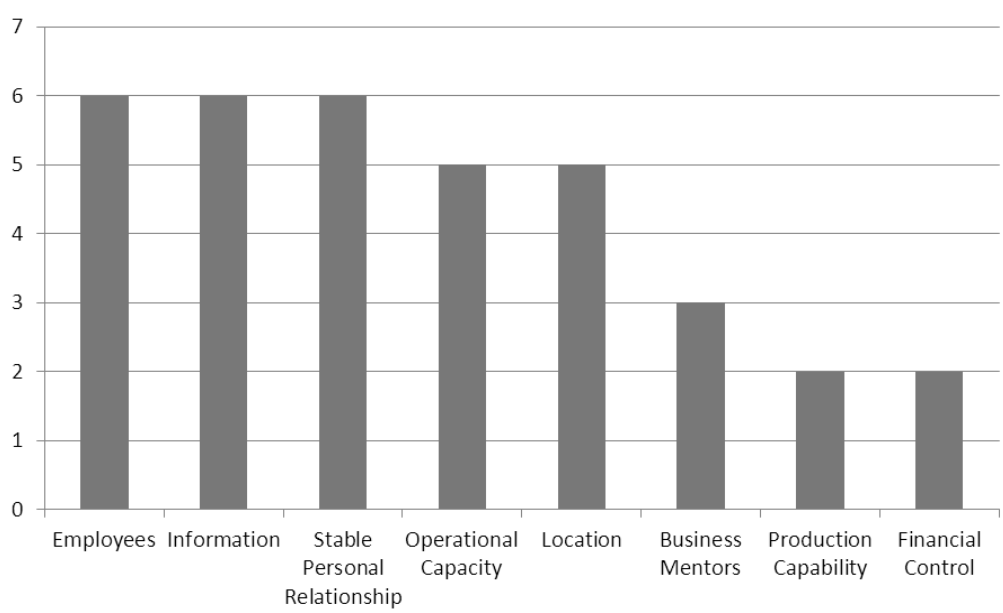
5.0 Discussion

Despite the fact that a heterogeneous sample was taken involving different

Table 1 – Profile of Sample Cases

Business	**Original Business**	**Diversification Business**	**Type of Diversification**	**Respondent**	**Previous diversification experience**	**Previous business failure**	**Number of employees**
A	Dairy farm	Marina	Diversifying into new activity	1. Business owner / manager	Yes	Yes	6-10
B	Dairy farm – no longer exists	Ice cream	Diversifying the farm business	2. Business owner / manager	No	No	15
C	Dairy farm	Document storage and archiving	Diversifying into new activity	3. Business manager of a franchise	Yes – several previous businesses	No	15
D	Dairy farm – contracted to neighbour	Ice cream and leisure	Diversifying into new activity and diversifying the farm business	4. Business owner / manager	No	No	30
E	Dairy farm – no longer exists	Goats	Diversifying the farm business	5. Business owner / manager	No	No	7
F	Arable	Dried flowers	Diversifying the farm business	6. Business owner / manager	Yes – several previous businesses	No	4-15

Figure 1 - Key (Strategic) resources behind success



types of diversification, including a franchise and business owners with varying years of experience, there are some clear and interesting patterns that have emerged across the case studies.

Key resources underpinning diversification

An unprompted question regarding the key resources underpinning the case diversifications produced the results shown in Figure 1.

It is apparent from the data shown in Figure 1 that stable personal relationship, information, and employees are resources that were considered important in all six cases.

People who work together are faced with a number of challenges but the main one for those who work with their personal partner must be that of managing their professional and personal relationships (Amarapurkar and Danes, 2005; Venter *et al*, 2009). However, the number of husbands and wives who work together is increasing and they are sometimes referred to as *"copreneurs"* (Venter et al, 2009). The nature of the wife's contribution to the business may vary as at one extreme she may be a co-owner and a member of the management team who receives payment for her efforts (Birdthistle and Fleming, 2007; Danes and Olson, 2003) while at the other end of the spectrum she may simply contribute to the business in the form of unpaid labour (Philipps, 2008). It is clear, however, that whatever the nature of the role undertaken by the wife the respondents to this survey consider *"personal relationship"* an important resource underpinning the diversification.

"You can't do without a stable marriage or a good partner."

Respondent 6

The fact that all of the respondents considered *"information"* as an important resource underpinning farm diversification is also not surprising. The old maxim of *"information is power"* would appear to be as relevant to farm diversification as to any other situation as the more information farmers have regarding customers, markets, and competitors then the more informed they are and the better their decision making. In fact, while most of the respondents made reference to the challenge of acquiring information about the retail markets into which they had diversified Respondent 3 revealed that access to knowledge about the archiving market was the primary reason that Business C diversified via the franchise route.

The importance of *"employees"* supports the view of Phelan and Lewin (2000) who consider the tacit knowledge of individuals as the most important strategic resource that many companies possess because it is unique, non-tradable, and may be enhanced over time.

The staff are *"...proud of what they do and I think that's the most important resource."*

Respondent 2

Although the question focused on resources, five respondents suggested that *"organisational capabilities"* were also important to the success of their diversified business. In this context the respondents acknowledged that resources such as staff are not sufficient in their own right to ensure that the diversification is successful and mentioned that good operational processes and procedures, IT systems, and communication networks were also needed. While the practitioners did not appear to distinguish between resources and capabilities it is encouraging to note that most appreciated the importance of both in a successful diversification.

Location of the business was another strategic resource mentioned by five respondents in terms of proximity to the customer base, access to raw materials, and proximity to natural resources. These are all heterogeneous factors which are hard to imitate and substitute without incurring high cost.

"We thought here was a good place to do something else because of our location."

Respondent 2

"We're different because we're stuck on the farm - in the middle of nowhere. Clients when they come and look for us don't quite believe we're here. They enjoy that."

Respondent 3

The study also found a strong sense that continual re-investment in the underpinning resources is of paramount importance to the success of any diversification venture. Businesses B, C and D all alluded to the importance of re-investment which has allowed them to expand slowly and within their means. Businesses A and E had gone through a more aggressive development phase but the respondents indicated that as the businesses moved into a consolidation phase then a strategy of gradual re-investment would be pursued.

Basic / strategic resources

It is interesting to note that the more frequently cited resources have many, though not necessarily all, of the characteristics of *"strategic"* resources. For instance a team of loyal and experienced staff may very well be *"durable", "non-appropriable"* , *"non-substitutable"*, *"superior",* and *"inimitable"* while at the other end of the scale *"production capability"* is a resource that is not *"durable", "non-appropriable"* , *"non-substitutable"*, *"superior",* and *"inimitable"* because a competitor with sufficient funding may buy similar or better resources relatively easily. As such, it would appear that even if it is only intuitive, the individuals involved in diversification do have some understanding of the characteristics of resources that are required in order to generate sustainable competitive advantage.

Previous research using RBT in a small business context suggests that basic resources such as buildings, finance, human resources and machinery are more strongly associated with success of the diversified enterprise than strategic resources (Rantamaki-Lahtinen, 2009; Forsman, 2004). However, in this project success appears to be based on a healthy mix of both basic and strategic resources.

The respondents as a resource

According to Conner (1991), discerning appropriate inputs that will support successful diversification may ultimately be a matter of entrepreneurial vision and intuition. While none of the respondents acknowledged it as such, and no questions were asked about the matter, the interview transcripts provided evidence that all the respondents were entrepreneurs and had an entrepreneurial mentality. Thus while Respondent F may state that *"I'm not quite sure what an entrepreneur is"* he did reveal classic characteristics of an entrepreneur when stating that he was an *"ideas person"* who *"loves starting new business ventures"*. As such, this study appears to support the view of Alvarez and Busenitz (2001) which suggests that not only does the farming culture engender entrepreneurial skills but that these individuals have been a major factor contributing to the success of the diversification and that they too constitute a strategic resource.

"The biggest benefit of starting a farming business off the back of a farm is that you are prepared to do anything and you're prepared to work harder. In farming you're cultured to work long hours. We're into [meeting] *clients sometimes at 5.00am. Do you think* (our competitors) *would do that?"*

Respondent 3

Interviewees clearly showed a flair for wanting to do something different and to take on a new challenge. Respondent A provides a typical illustration of this mentality when he states that *"If you get an idea you want to role with it, you just want to get started"*. Even though the respondents did not appear to have strong preferences about the nature of the business into which they would diversify they were clearly able to identify the relevant resources which would allow them to gain the stronger and more stable market presence that they sought.

Of the six case studies on which this investigation is based, in only one case did the respondent have any knowledge and experience of the business into which the organisation diversified and none claimed to know a lot about the industry into which they were diversifying. For instance Respondent B *"... looked upon it as another business and it just happened to end up being ice cream"*. This means that the respondents developed that knowledge after having diversified which suggests that the individuals involved were adaptable and learnt quickly. Indeed, when asked what farm resources had benefited the diversification Respondent D actually admitted it was his ability to be a *"jack-of-all-trades"*.

In this study the majority of the respondents had successfully matched external opportunities with internal resources which means that they may be deemed what Alsos *et al* (2003) refer to as *"resource exploiting* *entrepreneurs"*. The exception is Respondent 5 who appears to be a *"portfolio entrepreneur"* due to the nature of his diversification.

Sharing resources with the farm

The literature suggests that many diversifications involve the deployment of the same strategic resources in the diversification as used in the original business activity (Phelan and Lewin, 2000; Markides, 1997; Markides and Williamson, 1996; Prahalad and Hamel, 1990; Farjoun; 1994; Lemlin, 1982; Rumelt, 1984; Mahoney and Pandian, 1992; and Montgomery and Wernerfelt, 1997) and this was not different in this study. Each of the six case businesses used land, natural geographic resources, buildings, financial capital and/or raw materials from the farm business as the underpinning for the diversification.

"We could not have done what we've done without the backing of the capital base of the farm and without a profitable business alongside especially when times were tough."

Respondent 6

It is interesting to note, however, that while all the case diversifications initially made use of resources associated with the original farm business there was no overt strategy to gain benefit from sharing resources between businesses and all of the respondents stressed the importance of separating the two businesses as soon as possible.

"The farm subsidised it (the diversification) *at the beginning and in the first three or four years and then it was self financed."*

Respondent 4

Respondents made it clear that if the two businesses were not run independently then it is very difficult to appropriate costs and manage the financial side of the two businesses. Indeed, Case F had actually been split into three parts (arable, flowers and estate) primarily in order to clearly distinguish and facilitate the management of the three strategic business units but also as a means of succession planning for the three sons.

"We try as much as possible to keep the finances of the (diversified) business separate to the farm business."

Respondent 2

Conclusion

The main limitation of this study is that being based on just six case studies it is inherently qualitative in nature which means that it is not possible to generalise the findings with any known level of statistical significance. However, the methodology facilitated an in-depth investigation which means that the results appear valid and provide good insight into the subject of farm diversification. Indeed, the application of the RBT to farm diversification has revealed a number of insights that relate to the RBT and farm diversification.

In the first instance, and bearing in mind that applications of the RBT to farm diversification are very limited, this study serves to confirm that the RBT is a valid means of both understanding farm diversification and of gaining insight into successful farm diversification. While this study does not suggest that any modification is needed to the RBT to apply it in terms of farm diversification it does provide another practical example of the application of RBT in this context.

A second point is that the decision to diversify must be based on an opportunity in the external environment matched with the appropriate internal resources. Individuals considering a farm diversification are clearly encouraged to identify, develop, and strengthen the resources that in the diversified businesses will be *"strategic"* and which will form the basis of sustained competitive advantage.

Another point that became evident during the study was that resources may play a different role in the diversification than they do in the original business. Resources that the RBT would classify as *"basic"* in the original farming business when redeployed in the diversification sometimes became *"strategic"*. Whether resources are *"basic"* or *"strategic"* is very much context specific and dependent on the nature of the diversification so it is difficult to provide anyone considering diversification advice on the matter. However, it is clear that the Respondents in this study were aware of the role played by the different types of assets underpinning a diversification and would be *"diversifiers"* should be sensitive to the roles played by *"basic"* and *"strategic"* resources.

It would appear that successful farm diversification relies heavily on the presence of an entrepreneur. In this context these individuals appear to possess an inherent appreciation for the characteristics of different resources which allows them to identify *"basic"* and *"strategic"* resources and manage them in order to achieve a sustainable competitive advantage. It is then possible to speculate that the ability to appreciate the characteristics of various resources is a trait of a successful entrepreneur which in turn reinforces the notion that the individuals themselves are a particularly valuable resource of the business.

It was also apparent that respondents did not have a strong preference regarding the nature of the business into which they diversified. Of far greater importance for them was the deployment of resources so as to achieve sustainable competitive advantage and to meet the objectives of the diversification. Indeed, this may indicate that *"risk"* was a more important factor impacting the respondent's decision to diversify than the nature of the diversified business itself. It would appear possible to conclude, therefore, that an appreciation of the underpinning resources is more important in determining the success of a diversification than the nature of the business itself.

According to Kay (1995) success is more illuminating when contrasted with failure and this advice certainly provided insight in the context of this study. While the individuals involved in all six cases on which this study is based were now operating successful farm diversifications Respondents 1, 3, and 6 had made attempts to diversify in the past and failed. What was interesting in the context of this study, however, was the fact that the individuals concerned did not appear to dwell on the failure but treated it as a learning experience which they then used to underpin their subsequent, successful diversification. As such, the information generated through the failed diversification became a valuable resource in the successful diversification.

" we learnt what not to do."

Respondent 1

Knowledge was also at the heart of Respondent 3's decision to become a franchisee and this certainly appears to constitute a strategy that warrants more attention from potential farm diversifiers and policy makers. Knowledge is clearly a very important resource for any farm diversification but its acquisition can be difficult and costly. As such, franchising which makes use of someone else's business experience would appear to represent a very useful approach to farm diversification that could not only speed-up the diversification process but might require less investment while offering an improved chance of success.

Finally, while this study has provided useful insights into farm diversification it is readily apparent that there is considerable potential for conducting further research into the subject using the RBT. Further research utilizing a qualitative (exploratory) methodology could usefully investigate subjects such as resource decisions or the owner's motivations and objectives and the impact on resource deployment. On the other hand, further research could be conducted using a quantitative (confirmatory) methodology which might be employed to investigate such subject s as resource deployment within a farm diversification with respect to scale of the businesses involved or the attitude of farmers toward resource deployment and risk. However, despite the potential for further research farmers considering a farm diversification are still advised to take note of the findings from this study while policy makers may wish to use these findings to create an environment that will better support farm diversification.

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INTERNATIONAL JOURNAL OF AGRICULTURAL MANAGEMENT: CALL FOR CONTRIBUTIONS AND EDITOR

We are launching a new journal, rooted in sound scholarship but relevant to everyone with a professional interest in profitable and sustainable food production, rural business and land management. We seek contributions from professionals and academics working in those fields. We also seek nominations for a new Editor.

A new academic/professional journal will be launched in the summer 2011, published jointly by the Institute of Agricultural Management (IAgrM) and the International Farm Management Association (IFMA). The ***International Journal of Agricultural Management (IJAM)*** will combine the resources and expertise of the *Journal of Farm Management* (first published in 1967) and the *Journal of International Farm Management*, while extending their depth of content and geographical coverage. Publication, through the Charlesworth Group and Publishing Technology (Ingenta Connect) will be quarterly online, with an annual print volume for subscribers.

The purpose of the new journal is to provide an international forum and source of reference for those working in agricultural management and related activities, including social, economic and environmental aspects of food production and rural development. Its objectives are:

1. To survey and report agricultural business management in its widest sense, including the application of existing and innovative methodologies to the analysis of production, marketing and agricultural merchandising throughout the whole supply chain, and the diverse use of agricultural resources to support and supplement rural household income and the rural economy.
2. To encourage the transfer of agricultural management principles across geographical, cultural, social and national boundaries, to the benefit of rural populations in both poor and rich economies.
3. To report developing pressures on agricultural and rural resources around the world; the challenges arising from those pressures; and the consequent opportunities for managers of land-based industries.

The provisional editorial team is seeking contributions which are relevant to those objectives, including:

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

The target readership includes farmers and farm managers, growers, land managers, environmentalists, consultants, advisers, administrators, educators, researchers, students and those who formulate and/or implement government policy for rural areas. The requirements of academics are different from those of practitioners, though there is significant overlap, and so a balance will be sought between learned articles based on theory and research and more applied, practice-oriented contributions (though still of high professional standard). Articles which can cater for both requirements, being based on rigorous applied research and drawing conclusions with direct relevance to professional/business practice, will be especially welcome.

Please write in the first instance to the Editor at editor.ijam@gmail.com, ideally with a short summary of the proposed submission. Detailed Notes for Contributors will be available on application.

What we offer contributors

For **academic writers**, IJAM will:

- offer a fast turn-round from submission to publication;
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- give an excellent opportunity for publication in an English-language publication, in a field that is under-represented in many parts of the world.
- Help to meet requirements for a comprehensive dissemination process in European and other publicly-funded projects, and cope with the rising emphasis on demonstrating 'impact' in judgements of research quality assessment, with the mixed readership of the Journal providing an ideal audience.

For **professionals such as consultants and advisers**, a major incentive will be the opportunity to reach a wide audience and to highlight (indirectly) their own services or that of their employer. Those involved in research and rural development projects will find the Journal valuable in meeting their dissemination requirements. In some cases, it will be possible to reprint articles originally written for house magazines or conferences.

Editorial appointments

In the first instance *IJAM* will be run by an editorial team comprising Martyn Warren (University of Plymouth, UK; current Editor of the Journal of Farm Management) as Editor, with John Gardner (Massey University, NZ; current Editor of the Journal of International Farm Management) and Carl Atkin (Independent consultant, UK; current member of IAgrM Council and Journal Committee) as Deputy Editors.

The editorial team will be supported by an Editorial Board of around 20 persons. The Editorial Board will act as a sounding board for the Editor in operation of the journal, and will be a prime source of reviewers for journal articles. Criteria for selection of Board members will include wide geographical spread (to reflect the international nature of the journal), high professional and/or academic standing in the land-based industries and rural development, and proven ability in writing and/or reviewing articles at the level required by the editorial team. There has been an excellent response to calls for volunteers for the Board, but we would still be glad to hear from potential members in Asia, Africa, Latin America and Eastern Europe, as well as non-academics irrespective of location.

We will be searching for a new Editor to take over once the Journal is established, with a modest honorarium: please let us know if you would like to be considered – or to recommend someone else – by writing to editor.ijam@gmail.com.

TECHNICAL REVIEW

SAFE, LEGAL, AND MANAGEABLE PESTICIDE STORAGE ON BRITISH FARMS: AN EVALUATION OF TWO ARABLE SITUATIONS AND SUGGESTED LOW-CAPITAL SOLUTIONS

Ian Ashbridge

It is already widely known that many useful pesticides could face withdrawal from the market due to a change in the way active ingredients gain approval for use. The shift in the EU's approach to approving pesticides for use in agriculture from risk-based to hazard-based threatens to strip more useful chemicals from the farmer's toolbox. Particular chemicals currently on the Annex 1 list of approved active ingredient, but which may fail re-registration under new criteria, include many useful herbicides like pendimethalin. The background to this is the EU's Sustainable Use Directive (2009/128/EC), which follows on from the Thematic Strategy on the Sustainable Use of Pesticides, adopted in 2006. The Chemicals Regulation Directorate (formerly the Pesticides Safety Directorate) has estimated that 15-20% of existing pesticides will be lost. Chemical approval is also influenced by the EU Water Framework Directive. In this case, it is the responsibility of the Environment Agency to monitor chemical residues in groundwater, but useful products already identified as under threat include carbetamide and propyzamide herbicides. This broad-spectrum threat to many key tools used in crop management means responsible use and storage of pesticides becomes ever more important for farmers and farm managers.

Key words pesticides, chemical stores, EU sustainable use directive, thematic strategy on pesticides, 91414

Introduction

Adequate pesticide storage is a subject which deserves to be taken seriously to protect farm staff from exposure to harmful chemicals, prevent point-source or diffuse pollution from misuse of agrochemicals, and demonstrate to legislators that pesticides can continue to be used in food production by safe and responsible operators with no risk to environmental or public safety.

In the years since the BSE and foot-and-mouth crises, public opinion of farming and food production has improved significantly. Nevertheless, a degree of public concern remains around the safety of pesticides and their use; poor practice on farms threatens to shake public confidence further. This undermines public confidence in food and environmental safety and could lead to:

- Collapse of consumer confidence in food leading to sudden shifts in consumer behaviour, causing market prices to collapse.

- Domestic or EU legislation being introduced to restrict pesticide use or remove essential products from farms, hampering efficient production of raw foodstuffs at a time when agriculture is expected to respond to growing world populations and a changing climate.

Safe pesticide storage also prevents:

- Damage to environment, pollution of drinking water and harm to biodiversity

- Harm to human health. The maximum permitted concentration of any single pesticide in drinking water is 0.1ųg/litre (micrograms) or 0.1 parts per billion. [EU Drinking Water Directive]

Pesticides, when used in the context of crop protection, are sophisticated scientific tools to make the production of food more efficient. When not used in their proper crop protection context they become dangerous pollutants or poisons. Therefore safe, safe storage is important.

This paper seeks to explore the context for pesticide storage in the UK today, how this affects farm businesses and farm staff, and actions necessary to maintain high standards of agricultural production while remaining safe and within the law. It will identify desirable characteristics of pesticide stores for them to remain compliant and safe. Passing references are made to pesticide handling areas but this is not the main focus. Nor does this paper cover storage of pesticides by suppliers or contractors, or transporting pesticides from suppliers to their end user. Specific guidance on these aspects is available from the Department for Environment, Food & Rural Affairs (DEFRA) in its *Code of Practice for Suppliers of Pesticides to Agriculture, Horticulture and Forestry*, usually known as *The Yellow Code*. (DEFRA 1998)

Having reviewed the criteria for acceptable pesticide storage, this paper goes on to examine two differing pesticide stores in real situations on real farms; to critically evaluate their suitability, performance, legality and suggest areas where they may be improved. It will also identify practical courses of action to achieve regulatory approval and safe operation in a low-capital.

Methodology

To assist in performing an evaluation of the quality of pesticide storage on the two farms in question, the author will use checklists based on literature review. The checklist is not definitive but provides a useful working basis for criticism and is based on regulation and best practice documents set out in Appendix One.

There are several aspects to pesticide storage on farms and these can be examined in turn:

Legal

Various different pieces of legislation affect farms storage of pesticides in different ways. There is no single piece of EU or UK legislation specifically covering pesticide storage on farms – there is no 'Pesticide Stores Act'. However, those supplying and selling agrochemicals are governed by the following legislation.

- Control of Pesticides Regulations 1986 (amended 1997)

- The Plant Protection Products (Basic Conditions) Regulations 1997

- Control of Substances Hazardous to Health Regulations 1994 (COSHH) (made under the Health & Safety at Work Act 1974)

Very large pesticides stores (such as factory depots) are covered by the Control of Industrial Major Hazards Regulations 1984. However use – and storage – of pesticides on farms is subject directly and indirectly to other areas of law.

The principal risks posed by agricultural pesticides:

Environmental pollution

- Damage to biodiversity, habitats.
- Contamination of groundwater – and therefore human drinking water.

Human health

- Damage to human health through exposure to concentrations of harmful chemicals e.g. organo-phosphorous insecticides like anticholinesterase inhibitors, or by pesticides entering drinking water

Animal Health

- Damage to animal health through exposure to concentrations of harmful chemicals, and potential for chemicals to threaten human health via animal tissue entering the food chain. This would constitute a breach of Food & Feed Law (Statutory Management Requirement 11 under cross-compliance rules) even if no animal health symptoms were obvious.

The EU Water Frameworks Directive states that no single pesticide should be found in drinking water in concentrations greater than 0.1 micrograms per litre (expressed as ųg/l) or 0.1 parts per billion. In Britain, drinking water quality is regulated by the Drinking Water Inspectorate

The 'polluter pays' principle

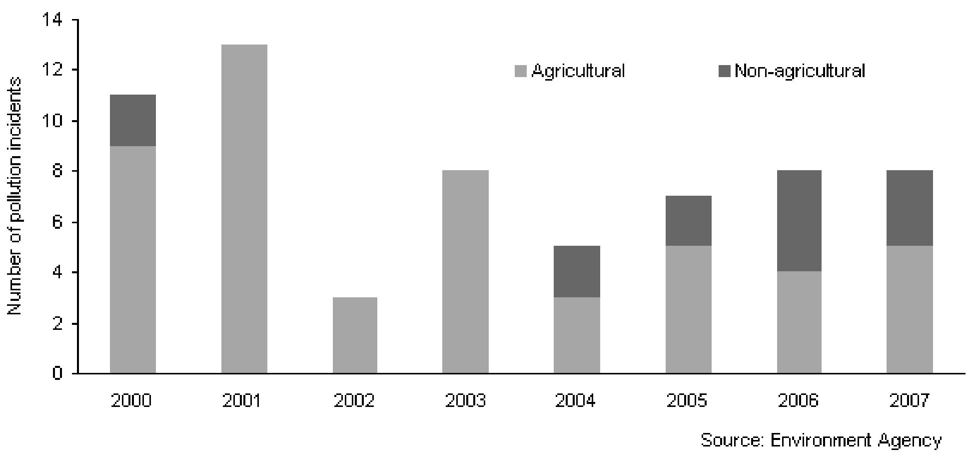
The so-called 'polluter pays' principle is adopted by most OECD (Organisation for Economic Co-operation & Development) and European Union countries. This means that the party responsible for causing pollution is responsible for paying for the damage done to the natural environment.

Pollution of watercourses or groundwater by agricultural pesticides takes two forms:

> *Diffuse pollution* – where contamination may occur gradually over time, or where no defined event is identifiable as the cause. In the context of agriculture, most diffuse pollution is caused by small quantities of agrochemicals or nutrients in surface or groundwater either running off the soil surface or leaching through the soil structure into watercourses.
>
> *Point Source* – where a single action or event can be explicitly said to have caused contamination. In the context of agriculture this can often be either from a concentrated chemical product being tipped directly – or allowed to fall – into a drain or watercourse, perhaps from a chemical during filling operations for the sprayer. A common incidence is through failure to retrieve foil seals from product containers; one foil seal can contain enough pesticide to contaminate 30km of stream (Voluntary Initiative, 2010).

Although increased legislation, better industry awareness of the need for careful pesticide use, and the efforts of the Voluntary Initiative have helped to

Figure 1: Serious Plant Protection Pesticide pollution incidents (Cat 1 & 2) 1999-2007.



significantly decrease the incidence of pollution from agricultural pesticides, the threat of a ban on certain chemicals or a pesticide tax remains real.

Instead of direct legislation, farm practices are subject to detailed guidance issued by the relevant authorities. Compliance with these best-practice guidelines is often included in other legislation affecting farmers. Therefore, although it remains 'good practice' it is important that farms remain compliant with these standards in order to avoid breaching other legislation.

For example, cross-compliance regulation is part of EU law, requiring farmers to obey cross-compliance regulations in order to receive Single Payment Scheme support from Europe. Cross-compliance regulations directly affect storage and use of pesticides, as they require farmers to comply with the DEFRA, HSE and Chemicals Regulation Directorate (formerly the Pesticides Safety Directorate) Code of Practice for Using Plant Protection Products.

Pesticide stores: What should a modern, legal, safe store look like?

Location

A store used for agricultural pesticides should:

- Have convenient access for delivery of products and collection of waste material

- Be sited away from watercourses, drains, wells, boreholes or areas liable to flood.

- Be separated from buildings housing combustible materials such as hay and straw, fertiliser and fuel, cardboard of plastic wastes.

Ease of use

A store should have:

- Easy access for sprayer operators.

- Adequate lighting so product labels can be read.

- Comfortable shelf heights.

- Sufficient capacity for stocks of pesticides at peak times in the season.

- Additional capacity for rinsed plastic cans awaiting disposal.

- Plenty of ventilation but remain dry and frost-free.

- Protection for containers and labels from sunlight.

Security and Safety

A store should:

- Have adequate bunding to retain spills and leaks. Bunding should be able to contain 110% of total volume of pesticides held by the business, or 185% if in environmentally vulnerable areas (eg close to watercourses).[1]

1. The Environment Agency can advise on the location of stores which may fall into this category – for instance if they are within a Groundwater Protection Zone. In any event, stores should be at least 10 metres from a watercourse, 50 metres from any borehole or well, and away from known flash flood routes, farmyard drains or busy farm traffic routes. [Voluntary Initiative Best Practice Guide on Pesticide Handling Areas, 2005]

- Be lockable.

- Be marked with a warning sign. Most general danger warning signs depict a black exclamation mark against a yellow background.

- Be constructed from fire-resistant material. Timber sheds are therefore not suitable. Timber doors are equally unsuitable.

- Have provision to securely separate particularly hazardous chemicals such as organo-phosphorous insecticides – locked in a cabinet for this purpose.

- Have safety equipment close at hand including fire extinguishers and materials for containing spills such as absorbent granules or sand. There should also be a shovel for removal for disposal by a licensed waste operator.

Management

Pesticide stores should:

- Have set procedures for operation, emergencies, spills and disposals, in place and understood by farm staff plus any contractors who may have authorised access to the store.

- Be accessed only by trained staff.

- Have emergency contact telephone numbers for business managers or owners, emergency services, pesticide supplier, waste disposal contractor, Environment Agency, all clearly displayed.

- Be available for and subject to regular inspection. The Health & Safety Executive should be informed of any new stores, as well as local fire authorities, in writing. Guidance should also be sought from the Environment Agency or in Scotland, the Scottish Environmental Protection Agency.

The above points are adapted from the Crop Protection Association's *Best Practice Guide on Pesticide Storag*e (Crop Protection Association 2006). The VI guidance is, however, not exhaustive. The Health & Safety Executive (HSE) issues its own guidance (HSE 2006).

This document makes the following additional points:

- Check where contaminated fire-fighting water will drain to.

- Put 'No Smoking' and 'No Naked Flames' signs on the exterior of the store

- Highly flammable materials should be kept in a container which can withstand the effects of fire for more than 30 minutes.

It is worth noting that the Rural Payments Agency's Cross Compliance guidance specifically refers farmers to the information within AIS 16.

It is also good practice for stores to include the following points:

- Roof should be collapsible – in the event of fire or explosion it will not carry fire or chemical beyond the structure itself.

- Store should be vermin proof

- Wall and floor meeting points should be sealed with a suitable masonry sealer (if brick/cement/block structure)

- Floor surface must not be permeable.

- Adequate shelving should be provided – pesticide containers should be off floors.

- Shelving must not be porous, absorbent or flammable (therefore timber shelves not adequate)

- Different classes of chemicals should be kept separated – insecticides, herbicides, fungicides

- Chemicals in powdered or water-soluble granular form should be stored *above* those in liquid form.

- Stores should have direct access – not through another structure.

- There should be no mains services (eg water) running through the store

Also near the store but not in it (Octopus Agronomy Training, 2010):

- Lighting – internal lighting should be operated by an external switch.

- First aid kit

- Eyewash equipment

- Locker for personal protective equipment (PPE) eg overalls, gloves, rubber boots

- Pesticide stock records

In addition to these points, the *Safety Equipment Handbook*, published by the British Crop Protection Council (2002), adds the following:

- Clean water supply must be available *nearby.*
- In the event of a fire, tell the fire officer what pesticides are involved.

It also makes the obvious, but rarely explicitly stated, point that stores should include product labels. This should not be removed and store elsewhere e.g. the farm office.

The DEFRA, HSE and Chemicals Regulation Directorate (formerly the Pesticides Safety Directorate) *Code of Practice for Using Plant Protection Products* (DEFRA 1998)makes the following additional points:

- "You must only store approved pesticides in the original container with the approved product label.
- "When you have mixed a pesticide with another substance such as a dilutant, carrier, marker or adjuvant, you are strongly recommended to use the mixture as soon as possible and not to store it for a long period – you should only have enough mixture to use in a day.

"Practice good store management by ensuring that you:

- Do not have unapproved or unwanted pesticides in your store.
- Remove waste packaging and dispose of it legally.
- Use the oldest stock first.
- Deal with damaged or deteriorating containers.
- Have an up to date stock record easily available, and, in case of emergency, keep a copy away from the store for safekeeping.

In the context of all the above, this article will now begin to evaluate two real-life examples of on-farm pesticide stores against the following checklist, developed from the material covered in the previous chapter:

Table 1: Example checklist for use in assessing chemical storage

Criteria	Yes	No	notes
Location			
Convenient access?			
Away from watercourses?			
Away from fertiliser, fuel, straw, etc			
Construction			
Fire-resistant construction?			
Collapsible roof?			
Fireproof door? (>30 minute burn life)			
Walls-floors sealed?			
Impermeable floor?			
Light switch outside?			
Ease of use			
Adequate shelving?			
Capacity for peak stocks?			
Adequate lighting?			
Rinsed cans and cardboard separated?			
Capacity for rinsed cans and cardboard?			
Products out of direct sunlight?			
Clean and clutter-free?			
Clean water available nearby?			
Adequate ventilation?			
Security & Safety			
Bunding for 110% stock capacity?			
Lockable?			
Warning sign?			
Vermin proof?			
Segregated storage for harmful chemicals?			
Safety equipment close at hand?			
Management			
Set procedures for emergencies, spills, in place?			
Emergency contacts clearly visible?			
Different chemical classes separated?			

Case Study 1: Overbury Farms, Overbury, Gloucestershire.

Overbury Farms is the in-hand farming operation of the Holland-Martin family's Overbury Estate on the Glos/ Worcs border. Principal crops are cereals with a high proportion of milling wheat grown. Land is also let for potatoes, field vegetable and peas. There are also significant Entry Level and Higher Level Stewardship scheme interests. The author visited the farm in December 2010 to record its pesticide storage.

Figure 2: Sprayer preparation area at Overbury Farms

Figure 2 shows the sprayer preparation area at Overbury Farms. The chemical store itself is through the green door on right of the picture. Note the bunding around the sprayer area and the 'speed bump' walls of the bund allowing the sprayer to enter and exit. Any chemical spillage here would need to be collected with absorbent granules and disposed of by a licensed waste contractor.

The store is of cement and block construction with a sliding steel door. Its location is suitable as it is some significant distance from watercourses, drains or dwelling houses.

Figure 3
Steel door
displaying warning sign

Figure 4: Steel door with circular padlock, switch for interior light on exterior of store.

Figure 5: Interior of store

Figure 5 shows the interior of store, with adequate shelving and products segregated. Note the pallet truck for handling large quantities of chemicals – this should be stored elsewhere to reduce the risk of contamination if used elsewhere. The red circle indicates two shortcomings – the ceiling is constructed of a flammable material, in this case Oriented Strand Board, and equally is a collapsible roof. Also discarded cardboard creates clutter and makes working environment awkward increasing risk of spills when handling/ moving chemicals. On the right, liquids appear to be stored above a dry or soluble material in the paper sack – although this may be absorbent granules.

Figure 6: Interior of store showing wide, lockable steel doors for delivery/ removal of products and wastes on pallets.

Figure 7: Notice board showing emergency contacts, relevant notices, best practice guidelines for some pesticides (in this case metaldehyde)

Figure 8: Unsuitable shelves

Figure 8 demonstrates unsuitable shelves for a pesticide store – chipboard, although cheap, is both porous and flammable. Supplies like nylon twine and spare drive belts should be stored in the workshop, not the chemical store.

Figure 9: This simple, DIY-built system allows plastic chemical containers to be triple-rinsed and drained with the run-off collected in separate vessels.

Figure 10: storage of empty containers

Figure 10 shows rinsed, dried and crushed plastic containers stored in empty polypropylene bags, ready for disposal by a licensed waste contractor. These should additionally be placed in a secure store so they pose no risk to children or the environment. A supply of clean water is available in the green tank.

Table 2: Overbury Farms' Chemical Store – how compliant is it?

Criteria	Yes	No	notes
Location			
Convenient access?	✓		
Away from watercourses?	✓		
Away from fertiliser, fuel, straw, etc	✓		
Construction			
Fire-resistant construction?	✓		But wooden roof
Collapsible roof?	✓		
Fireproof door? (>30 minute burn life)	✓		
Walls-floors sealed?	✓		
Impermeable floor?	✓		
Light switch outside?			
Ease of use			
Adequate shelving?		x	shelves unsuitable
Capacity for peak stocks?	✓		
Adequate lighting?	✓		
Rinsed cans and cardboard separated?	✓		
Capacity for rinsed cans and cardboard?	✓		
Products out of direct sunlight?	✓		
Clean and clutter-free?			
Clean water available nearby?		x	
Adequate ventilation?		x	Not obvious
Security & Safety			
Bunding for 110% stock capacity?	✓		
Lockable?	✓		
Warning sign?	✓		
Vermin proof?	✓		
Segregated storage for harmful chemicals?		x	Not evident
Safety equipment close at hand?		x	Not obvious
Management			
Set procedures for emergencies, spills, in place?	✓		
Emergency contacts clearly visible?	✓		
Different chemical classes separated?	✓		

Summary

Overbury Farms is more or less compliant and observing the HSE guidance in AIS 16 and the other detailed guidance discussed earlier in this paper. But there are areas for improvement.

- Steel shelving would be more suitable as it is neither flammable nor porous.

- The only evident ventilation to the store was the gaps around the rims of the steel double-doors.

- The location of eye-wash and first aid equipment was not immediately evident.

- Used cardboard boxes need to be folded or crushed and stacked neatly in the store

- The ceiling construction of OSB is unsuitable as it is flammable although this may have been disguising a roof of more suitable material.

Case Study 2: Farm in north Wiltshire

This farm is a small, 375-acre arable and sheep farm. It falls within a Nitrate Vulnerable Zone and the North Wessex Downs Area of Outstanding Natural Beauty. Soils are heavy clays over deep chalk with occasional areas of exposed pebbly gravel. It is not farmed intensively and pesticides are not used in great quantities; most field operations are carried out by contractors. Nevertheless, its chemical store is operational.

The store is adapted from former dairy buildings (it was the plant room) and is of blockwork construction with a steel-supported asbestos sheet roof. It is between a workshop with a heavy, sliding steel door and the former bulk tank/ washroom.

Figure 11: Chemical store

Figure 11 shows the chemical store adjacent to main farm thoroughfare. A warning symbol is displayed but the door is timber and badly rotted. It should be noted that when the black corrugated workshop door is fully open it obstructs entry to the chemical store. Immediately outside the store is a sloping area of concrete leading to a drain. Access to the store is also obstructed by sheep fencing materials.

Figure 12: Chemical store - interior

Figure 12 shows the store to be unlocked, dirty and cluttered. The floor is obstructed by detritus, a welder, and compressor material. Pesticides are crammed into available floorspace – in this case glyphosate in the green plastic cans. The floor is of tamped concrete. There is no bunding to speak of. Already it is evident this is wholly unsuitable as a chemical store.

Figure 13: light switch

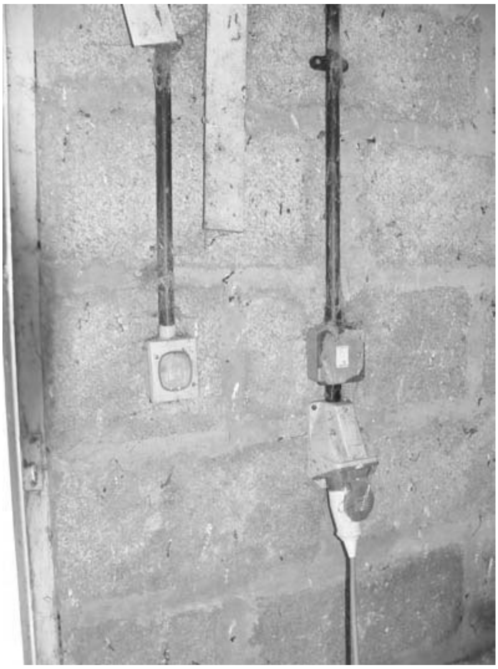


Figure 14: empty chemical containers (1)

Figure 13 shows the electric light switch to be on the inside of the store. Mains power and an extension lead run through the store. Bird muck everywhere indicates the store is far from being vermin-proof.

Discarded plastic chemical containers (pendimethalin) lie with discarded cardboard among the bird muck (Figure 14). It is also evident that some chemical has been spilled when the container was used. The product label indicates that it is a substance harmful to the environment.

Figure 15: empty chemical containers (2)

Figure 16: Shelving

More discarded chemical containers lie among the debris (Figure 15), in this case a container for a NuFarm product Swipe P, a broadleaved weed herbicide containing ioxynil, bromoxynil and mecoprop-P. Swipe P no longer has approval for use and its final use-up and storage date was 31/8/10. Shelving would still be unsuitable even if cleared of clutter (Figure 16) – the old, home-made timber shelves are both flammable and porous as well as being considerably rotted.

Table 3: Case study 2 chemical store – how compliant is it?

Criteria	Yes	No	notes
Location			
Convenient access?		x	
Away from watercourses?		x	
Away from fertiliser, fuel, straw, etc	✓		
Construction			
Fire-resistant construction?	✓		
Collapsible roof?		x	
Fireproof door? (>30 minute burn life)		x	
Walls-floors sealed?		x	
Impermeable floor?	✓		
Lightswitch outside?		x	
Ease of use			
Adequate shelving?		x	
Capacity for peak stocks?	✓		
Adequate lighting?		x	Lighting inoperable
Rinsed cans and cardboard separated?		x	
Capacity for rinsed cans and card-		x	
board?		x	
Products out of direct sunlight?		x	
Clean and clutter-free?		x	
Clean water available nearby?	✓		But entry for vermin
Adequate ventilation?			
Security & Safety			
Bunding for 110% stock capacity?		x	
Lockable?	✓		
Warning sign?	✓		
Vermin proof?		x	
Segregated storage for harmful chemi-		x	
cals?		x	
Safety equipment close at hand?			
Management			
Set procedures for emergencies, spills,			
in place?		x	
Emergency contacts clearly visible?		x	
Different chemical classes separated?		x	

Summary

This building is totally unsuitable as a pesticide store.

It is:

- Unsecure (never locked)

- Dangerous/ hazardous to work in
- The farmer is in breach of cross-compliance regulations and will be risking significant deductions to single payment income if inspected. The risk of water contamination from pesticides is significant.

Even benefitting from a good clean up and disposal of unwanted chemicals, plastics and cardboard packaging by a licensed waste disposal contractor, this building would still be unsuitable for use as a pesticide store, since it is:

- Constantly passed by farm and residential traffic.
- It has mains services running through it
- Its roof is not collapsible, and fire may spread to it from buildings on either side.
- It opens onto a rainwater drain.
- It has an inadequate door made of flammable material.
- There is no bunding to contain any spillages
- Or clean-up materials to cope with them
- Pesticides are stored on floor and spillages have not been cleared.
- They are not segregated and there is no separate, secure storage for particularly harmful chemicals.
- There are no stock records.

Conclusions

By reviewing the legislation that affects pesticides storage on farms, the guidance issued by the relevant authorities, and by examining two real-life case studies, it is possible to draw the following conclusions.

- Careful planning is required when preparing or selecting adequate pesticide storage
- It is often difficult to adapt existing farm buildings for use and chemical stores
- Not any building will do

- Best practice does not cost significantly more to observe
- Cutting corners increases the risk of serious environmental damage and legal action
- Safe, tidy storage means fewer hazards – therefore fewer risks to farm staff and sprayer operators

Recommendations

However, in the second case study there is no obvious alternative. It is a tenanted farm with poor quality buildings and the current store is the only building with a lockable door. Few tenants will either have the funds or the inclination to invest in building new stores from scratch, nor will a landlord consider this an attractive option as it will yield no obvious extra return on investment.

A suitable alternative chemical store for the second case study farm is one that is growing in popularity on many farms, not just smaller or tenanted units. Steel shipping containers are strong, cheap, mobile (they can often be moved with farm machinery). They are secure and come ready-assembled. Some suppliers offer tailor-made converted shipping containers as chemical stores, with bunding and ventilation.

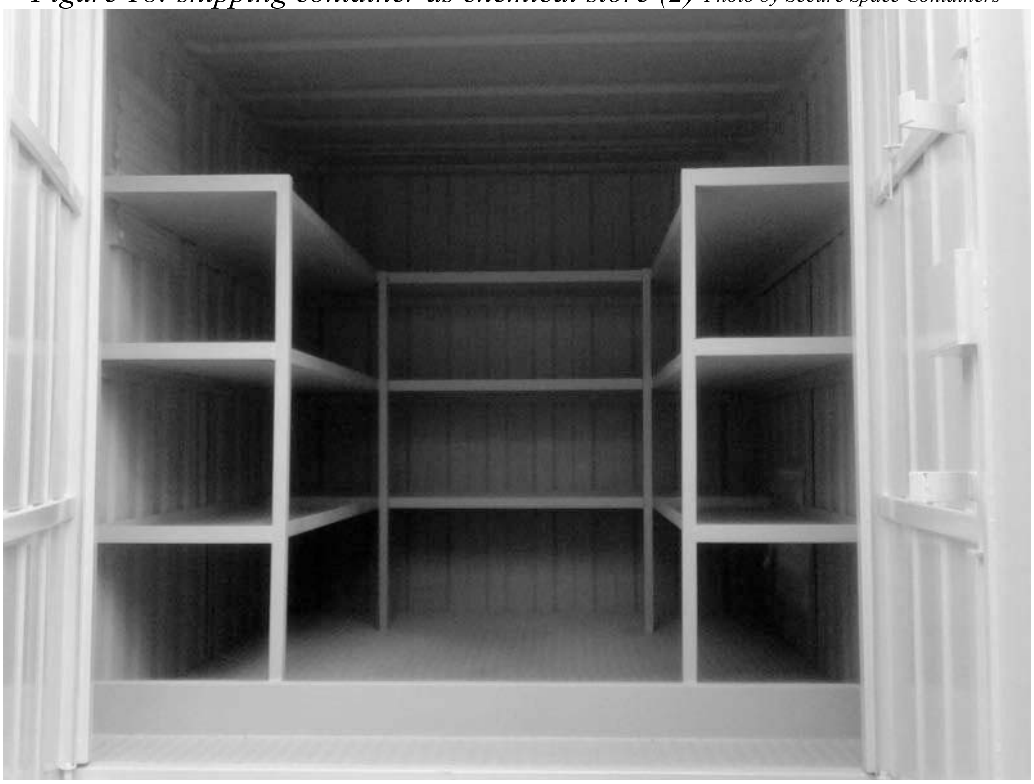
In the Figure 17, adequate bunding (110% of contents) has been achieved through welding a steel plate inside the door.

Figure 17: shipping container as chemical store (1) Photo by CS Shipping Containers

To determine the amount of bunded space needed, it is important to calculate the total quantity of pesticide likely to be on the farm at peak time (be generous). It is also worth allowing some extra space should stocks rise unexpectedly – eg running down stocks of chemical products within their use-up periods or to cope with holding additional quantities delivered in error.

Another example of a steel shipping container adapted for use as a chemical store is shown in Figure 18. The bund is clearly visible in the foreground. Steel shelves provide easy access and segregation for chemical groups. Louvred ventilation (top left).

Figure 18: shipping container as chemical store (2) *Photo by Secure Space Containers*



Shipping container stores can be easily sited away from watercourses, etc. Planning permission may not be necessary but advice should always be sought. The Health & Safety Executive and the local fire authority should always be notified in writing of any new pesticide store. The roof is not collapsible – but since the structure should maintain its integrity in most incendiary situations this may not be critical. Steel roofs can absorb heat and may cause temperatures inside the store to alter the chemical products properties or even lead to fire. Placing the container in a shaded spot, or obscuring the roof surface from the full force of the sun are useful ways to avoid this. Wooden pallets are a favourite option for this purpose.

One drawback to the ease of access to this store is the steel plate which serves as the bund's 'dam'. This, at ankle or knee height at entry to the store, could constitute a hazard under COSHH assessment, particularly as sprayer operators or other staff are likely to be carrying chemical cans on entry to or exit from the store.

The HSE guidance – AIS 16 – makes the following recommendations on DIY bunds for chemical stores:

- The bund should be soundly constructed of non-fragile materials resistant to the permeation of liquids, e.g. metal (not foil).

- The bund should comprise, or extend around, the whole periphery of the Bunding may be achieved by standing your pesticides in a metal container, e.g. a redundant water tank.

The shift in the EU's approach to approving agricultural pesticides from risk-based to hazard-based threatens the use of many key tools used in crop management, and makes responsible use and storage of pesticides ever more important. Much can be achieved by a professional approach to managing the chemical store. In many cases there is no building suitable and/or available for this purpose, and here the adapted shipping container offers a relatively cheap way of putting in place a compliant structure for pesticide storage that meets HSE, CRD and cross-compliance requirements.

About the author

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CONFERENCE PAPER

ONLY CLEVER SCIENCE WILL YIELD CROP RESULTS

Bill Clark

This conference paper highlights the essential part that must be played by scientific and technical advance in the fight against hunger in the poorer parts of the world. Modern advances, including those using increased fertiliser, crop protection and genetic modification, should be embraced by governments and funded accordingly. The author argues for 'sustainable intensification' of agricultural production – i.e. growing the highest yields possible on the least amount of land, whilst protecting valuable biodiversity elsewhere.

Key words Crop yields, genetic modification, fertiliser, crop protection, hunger

Chinese proverbs can be deeply philosophical or downright idiotic. I have a favourite which sums up why I work in agriculture and why I get irritated by debates about skin blemishes on apples, EU pesticide reduction policies and organic farming feeding the world.

> *"A person who has food has many problems. A person who has no food has only one".*

A more recent quote is less eloquent but equally stark:

> "*We have more hungry people in the world today, than we ever had in the history of human kind."...* . Kostas Stamoulis, Secretary General of the Committee on World Food Security.

This is not just because the global population is rising and hungry people represent a proportion of the population – the hunger rate has also begun to rise, meaning the number of hungry people is growing at a faster rate than world population.

A Cabinet Office document, nicknamed by Tim Lang, Professor of Food Policy at City University, the 'Leave it to Tesco Report', argued that we are a rich developed nation which could buy its way out of any supply crisis on the global market. The UK produces about half of the food consumed here, and is about 60% 'self-sufficient'. Most UK food imports come from elsewhere in the EU (68% in 2006) and the UK considers itself well placed to access the food it needs from world markets, where required (The 'Leave it to Tesco' approach). Global grain stocks are high so why worry? However, many of these stocks are strategically stockpiled and not available on the world market - so when Russia decides to ban exports of grain (August 2010) this sends prices skyward. Of course we in the West can survive such price hikes but in developing and emerging economies the challenge is in some cases a matter of life and death. In these countries food represents a much higher proportion of

1. This paper was originally presented at The Oxford Farming Conference, January 2011, and is reprinted by kind permission of the author and the Conference Secretariat.

household budgets than in the West, and they are less able to withstand such shocks.

Words such as 'local', 'seasonal' and 'organic' have become very fashionable and have, in the UK, been referred to as the 'holy trinity' of food production. But these are merely lifestyle choices for the affluent middle-classes of Europe and will never begin to tackle global food insecurity.

Increasing yields will also be needed if agriculture is to meet world demand for both food and energy. Any number of estimates of global population growth exist but as reliable as any is that of The World Bank – which estimates that cereal production needs to increase by 50% by 2030 to meet food demands. This is a massive challenge. The same estimate has been used by Professor John Beddington, the UK Governments' Chief Scientific Adviser who qualified this estimate by adding limitations on the use of inputs:

> "We need 50% more production ….on *less land*, with *less water*, using *less energy, less fertiliser* and *fewer pesticides*...by 2030" – an even g reater challenge.

So how can science help?

We can increase crop yields in 2 ways:

Increase the *attainable yield* of crops by reducing losses due to pests, diseases and abiotic stresses.

Increase the *potential yield* of the crop.

Reducing losses due to pests, diseases and weeds is what we have been very successful at over the last 30 years. The crop protection industry has consistently delivered more and more effective products, tackling the problem of resistance development, discovering new areas of chemistry – all within increasingly stringent legislation to improve safety and protect the environment. We have also learned how to optimise those inputs and developed decision support systems to help growers and advisers to implement what is often termed 'integrated pest management', but what is really just modern farming methods including the use of resistant varieties, adjusting sowing rates, nitrogen doses, using thresholds etc. I believe that the agrochemical industry is now beginning to struggle to deliver ever more active (and yet environmentally benign) products and we cannot expect them to continue to deliver as they have in the past.

In the UK we have had dramatic yield increases in crops in the last few decades. Over the last 60 years we have doubled average yields of wheat twice – from just over 2 t/ha in the 1940s to 4 t/ha in the 1960s and now at just over 8 t/ha. These increases came about from investment in production-orientated research delivering high yielding varieties which responded to increased inputs of fertilizer and pesticides. The best UK wheat growers now routinely achieve yields of 10-12 t/ha. The limitation on these growers is now water availability and the amount of solar radiation that is available to the crop. The varieties currently grown are clearly capable of much higher yields – they have a higher potential yield that is not attainable in the UK. Take these varieties to New Zealand, give them sufficient nitrogen and water and they will deliver yields almost double our national average. The current theoretical yield potential of wheat is estimated to be close to 20 t/ha. This target of achieving wheat yields of 20t/ha is one of the strategic goals of Rothamsted Research.

The largest contribution to the increased yield potential of modern wheat varieties came from the increase in harvest index. There was a quantum leap in harvest index from the introduction of dwarfing genes into varieties developed the 1960s. These varieties also allowed higher rates of nitrogen to be used. Breeders will claim much of the glory for the dramatic yield increases but increased nitrogen use and crop protection products undoubtedly played significant roles. Currently, fungicide use in official Home Grown Cereals Authority CEL (Crop Evaluation Ltd) trials delivers on average a 20% yield response. This dependency on fungicide inputs is a feature of wheat production systems, wheat breeding and climate in the UK. The yield of wheat and its response to fungicide use in other EU countries is considerably less.

Further increases in yield potential depend on an increase in canopy photosynthesis per unit of intercepted light or a decrease in the metabolic costs of synthesis and maintenance of carbohydrates, proteins, and lipids. To date there is little evidence that plant physiologists or breeders have been successful at increasing the assimilatory or metabolic efficiencies of the major cereal crops. Therefore, the most likely scenario for yield potential of the major cereal crops is one of small, incremental increases during the next three decades, and these modest improvements will require considerable research investment. Even with investment in applied science this incremental increase in yields will not allow us to reach the challenging targets imposed upon us by increasing global population.

The global demand for wheat is predicted to increase at a faster rate than the annual genetic gains that are currently being achieved. Consequently it is generally agreed that improvement in genetic yield potential will need to be accelerated in order to avoid the otherwise inevitable destruction of sensitive ecosystems. Those production targets demand radical change to our crops and cropping systems.

Targets for change:

Increasing attainable yield: The 12 t/ha wheat crop

Wheat crops of 12 t/ha are not uncommon in the UK. Good growers on good land would expect average yields in the order of 10-12 t/ha. Clearly the genetic potential for such yields already exists but the average UK yield of just over 8.0 t/ha seems tenaciously difficult to move. Many farmers and advisers are now well-qualified technically (many BASIS-qualified) but there must be scope for increasing the technical knowledge of farmers and advisers. Beyond raising the technical level of training of those involved in farming there is still scope to achieve increases in the attainable yield by further research into optimising inputs (water, nutrients, pesticides), and delaying senescence (by reducing disease effects and maintaining canopy growth).

Clearly the genetic potential for 12 t/ha yields exists in our current varieties as the current world record wheat yield of 15.6 t/ha was achieved in New Zealand using the variety Einstein (a Nickersons variety, almost 10 years old!). The world record crop was grown on deep silt soils in New Zealand with high radiation levels and no water deficit – conditions we cannot reproduce in the UK.

Increasing potential yield: 20 t/ha wheat crop

To begin to tackle the targets imposed by global population growth we must be more radical than just tinkering with inputs. To meet a production target of 50% yield increase by 2030 we need to alter the fundamental biology of the crop.

Radiation use efficiency

The yield potential of a crop (YP) can be expressed as a function of the light intercepted (LI) and radiation-use efficiency (RUE), the product of which is biomass and the subsequent partitioning of the biomass to yield, i.e. harvest index (HI):

YP=LI x RUE x HI

There are already some good indications that we can increase yields significantly by increasing the radiation use efficiency of the crop. There is increasing belief that wheat may be ‘sink-limited’, i.e. the crop may be able to produce more biomass but there is insufficient storage capacity for the carbohydrate. More grain sites per ear (bigger ears) would help increase that storage capacity. Thus, improving the balance between source and sink is a highly promising approach for raising RUE, biomass and yield.

Carbon Fixation/Drought tolerance

C_4 plants such as maize have a competitive advantage over plants possessing the more common C_3 carbon fixation pathway under conditions of drought, high temperatures, and nitrogen or CO_2 limitation. Increasing photosynthetic capacity, either by modifying wheat to C_4 metabolism or selecting for C_4 traits, must be a major target for breeders. Under the same growth conditions, C_4 grasses lose less than one third of the amount of water per CO_2 molecule that is fixed, compared with C_3 grasses. This increased water use efficiency of C_4 grasses allows them to grow for longer in arid environments. Forty-six percent of grasses are C_4 including maize and sugar cane. Introducing this trait into wheat could increase yields dramatically. Even in the UK, 30% of wheat is grown on drought-prone land, equating to potential losses of up to £60 million/ year. This situation is only likely to become worse with climate change. A simpler but more radical approach may be to select for existing C_4 plants such as maize which are adapted to UK climatic conditions.

Broadening the genetic base of wheat is also often quoted as a necessary route to achieve these targets. To achieve these targets will require a multi-disciplinary approach and close co-operation between fundamental and strategic research on the one hand, and applied plant breeding on the other.

Timescale for crop changes

The timescale for yield improvement is critical. Many of the traits or characteristics that are desirable for increased crop yield are difficult to achieve and without biotechnology (genetic modification of crop species) are unlikely to be achievable in the short to medium term. The suggested time-scale for potential crop changes is outlined below. Many of the short to medium term solutions are increasing the achievable yield. Increasing the potential yield is a much more challenging target and is on a much longer timescale.

Short-term solutions (less than 5 years): (Increasing achievable yield)

New approaches to crop management. New pesticides that directly affect crop physiology. Better fungicide programmes, disease reduction. Im proved input management. Seed treatments to protect against pests and diseases.

Medium-term solutions (10-15 years): (Increasing achievable yield)

Breeding and genetic modification of new varieties of crops that are re sistant to disease, drought, salinity, heat.

Longer-term...speculative (> 15 years): (Increasing both potential and achievable yield).

Development of nitrogen fixing cereals. Perennial crops which won't need frequent replanting. Development of C_4 crops which would boost the efficiency of photosynthesis. Breeding existing C_4 crops to adapt to different climates. Improving hybrid crops and apomixis (maintaining hybrid vigour without the need for parental crossing).

Tools for research and technology

The research tools are either for genetic or phenotypic analysis of plants. The genetic analysis targets their DNA whereas the phenotypic investigations involve their biochemical, physiological or morphological characteristics. Complete genome sequences of crop plants and microbes are particularly important because they provide detail about all of an organism's genes and the proteins that the organism can synthesise. Genes or combinations of genes affecting crop production can be easily identified using genomics. In genetic improvement strategies these genes can be targeted in breeding programmes or they can be transferred into crops by genetic modification (GM).

Non GM Approaches

There are three distinct phases in conventional breeding – creation of variation, selection and then evaluation. Conventional crossing of crop varieties or breeding lines can get you so far but creating greater variation from which to choose can be challenging. This is long been achieved by the use of chemical mutagens or radiation. Radiation has long been used to produce mutations in a significant proportion of the world's crops, including rice, wheat, barley, pears, peas, cotton, sunflowers, peanuts, bananas, cassava and sorghum. These crops are now widely grown and 'conventional'. The FAO has promoted the application of nuclear technologies in agriculture since 1950. So far, more than 3,000 new varieties have entered mass production worldwide for commercial purposes.

There is a view that the major world crops have reached a genetic 'glass ceiling', meaning that no matter how much more conventional crossing is done there is simply not enough genetic diversity available to significantly improve their agricultural value. This view is not held universally but it seems clear that conventional breeding techniques are not currently delivering the yield increases demanded by population growth.

GM Approaches:

In genetic modification (GM), novel genes are introduced, either individually or in small groups, into a crop plant. The genes inserted may either be:

from the same species (cisgenics) or
from another species (transgenics).

Genetic modification can produce a plant with the desired trait or traits faster than classical breeding because the majority of the plant's genome is not altered. GM-based methods are used widely as a routine tool in research and they have greatly facilitated major advances in plant biology over the last 25 years. In the USA, Argentina, Brazil, India and Canada, GM crops are grown widely (134 million ha in 2010), whereas in Europe and Africa (except South Africa) they are largely absent. The majority of these GM crops are insect resistant (Bt crops) or herbicide tolerant (HT crops). Such GM technology can have dramatic effects on the attainable yield of crops and can have environmental benefits in terms of reduced pesticide and nutrient use. This relatively simple technology is often referred to as 'first generation' GM. Second generation GM crops under development aim to improve yield by improving salt-, cold- or drought-tolerance. The same technology may also begin to increase water-, nutrient- and radiation-use efficiencies. Only second generation GM crops will have a significant impact on the potential yield of crops.

Targets for GM approaches:

Modification of photosynthetic efficiency (C_4 v C_3 crops).
C_4 photosynthesis is more efficient than C_3 and is found in drought-tolerant grasses such as maize and sorghum, but not in wheat and rice. This is, like many research targets, a 'Holy Grail' target as it would increase the potential crop yield.

Perennial crops.

These are often talked about and may well offer environmental benefits because of reduced tillage and hence reductions in greenhouse gas emissions but they are unlikely to increase yields *per se*.

Nitrogen fixation in non-legumes.

Again a 'Holy Grail' target for researchers. This would reduce the huge energy demand of producing nitrogen fertilisers but again is unlikely to increase yields. In fact there is very likely to be a yield penalty for the introduction of such a process into a plant species.

Abiotic stress tolerance.

Abiotic stresses are those derived from non-living factors such as drought, salinity, heat. Increasing water uptake from soils (while ensuring that water is available at critical developmental periods) can be a useful strategy, which is why phenotyping of root characteristics is receiving so much research attention. This would almost certainly increase yields dramatically. World-wide, drought stress is probably the number one restriction to growth of crops.

Biotic stresses.

These are the pests, diseases and weeds that steal so much crop yield world-wide. For that reason there has been intensive research into genetic and crop management strategies to mitigate these losses. In many respects this research into plant defence has been highly effective and there are many examples of current and emerging crop protection strategies. However, complete success is impossible because weeds, pests and pathogens continue to evolve to over-come plant defence systems and agrochemical interventions.

Plant breeding for disease resistance.

It is not immediately obvious but most plant species are completely resistant to most diseases. Pathogens are generally specialised to infect only certain plant species and cannot infect the vast majority of other plant species. This is termed 'non-host resistance' (NHR). For example, rice is resistant to cereal rusts, and tobacco is resistant to potato late blight. Understanding the molecular basis for NHR could enable more durable resistance to be engineered into crops.

RNAi and Gene silencing.

RNA interference (RNAi) is a vital part of a plants normal immune response to viruses and other foreign genetic material. This can be induced in plant material – making the plants immune to certain diseases – much like vaccination in animals. In this process no new genes are introduced, not even from same species . However, this can currently only be done with GM technologies.

Introducing novel genes (Transgenics).

The wider deployment of GM approaches will be needed for the introduction of novel genes from diverse sources. The constraints on regulatory and consumer acceptance of GM are still considerable in many parts of the world (particularly Europe). Consumer acceptance may be greater and regulatory approvals simpler in future where plants are transformed with cisgenic vectors in which only host gene sequences are used.

Hybrid vigour (Heterosis) and Apomixis.

For inbreeding species such as rice and wheat, hybrid vigour can theoretically offer very large (<50%) yield increases. However, there are many challenges and constraints to this technology and as such it is not yet fully developed in a wide range of crops. The next step in developing hybrid vigour would be apomixis, where plants produce seed without the need for fertilization. This allows hybrid vigour to be 'fixed' so that crops do not need to be bred from different parental lines.

Crop protection chemicals.

Pesticides (Perhaps we need a better name?) are used widely to protect against weeds, pests and diseases. These compounds are the mainstay of global crop protection and they are likely to remain so for the foreseeable future. New chemistry resembles chemicals present in plants that activate natural resistance mechanisms and, because they do not target pests and pathogens directly, they could have environmental advantages and be perceived by the general public as 'safer'.

Chemical modification of plant metabolic processes is now commonplace. 'Fungicides' no longer just control fungal diseases – they can also control viral and bacterial diseases via host defence triggers. They can increase nitrate uptake, increase root activity and water use efficiency, delay senescence. These are not fungicidal products *per se* but fall into that category of EU pesticide legislation.

A New Language and a New Approach

We need to develop and promote terms that the general public are comfortable with (but may not understand, any more than they understand 'GM'), such as 'vaccination' or 'immunisation' rather than 'genetic modification' or 'gene silencing'. 'Biotech crops' may be more acceptable than 'genetically modified' 'Natural defence promoters' may indeed currently be called 'pesticides' and yet they may have no direct toxic effect.

Scientists need to be much more careful about promoting their science and they need media training so that they can manage the way their science is promoted. All too often scientists are lulled by the media into promoting the bizarre – taking about jelly-fish genes and genes from spiders being incorporated into plants and animals – whilst completely failing to explain any benefits. They use inappropriate language, concentrate too much on the science without thinking about benefits and end up falling into the trap of scaring the general public.

Conclusions

Research is essential to ensure that yields are at least doubled in the next 50 years. The research dilemma is that we have to feed a rapidly increasing world population – there are only two choices: increase yields or plough up land with high biodiversity – accepting an almost certain acceleration of climate change with the latter.

Achieving these scientific advances is possible, but present levels of investment in these specific research areas are currently not adequate to meet the challenge. Public investment in scientific research is key but we are rapidly losing skills in the industry through an historic lack of investment. This includes key research skills but also the skills of knowledge transfer which many researchers lack. The ability to translate research findings into key messages for industry is a skill that is important if research is to have social and economic impact.

Much of the technology to produce much higher yields is currently scientifically possible but is not being applied as much of it relies on genetic modification procedures. The confusion around the use of the term 'GM' is undoubtedly a hindrance to progress. For example, should a food from soya be labelled 'GM' if it has been genetically engineered to have a gene from another soya plant or only when it has a gene from another plant species? Equally, what if the GM product (e.g. vegetable oil) is identical to the non-GM version (i.e. there is no 'foreign' DNA present? This is the argument for concentrating on the product and not the process by which it is produced.

All technology should be adopted provided that it is safe and sustainable. The concept of 'sustainable intensification' of agricultural production should be accepted and promoted – i.e. growing the highest yields possible on the least amount of land, whilst protecting valuable biodiversity elsewhere.

Finally, a thought from a modern philosopher:

> *"We live in a society exquisitely dependent on science and technology, in which hardly anyone knows anything about science and technology".*
> Carl Sagan

About the author

Bill Clark (bill.clark@bbsrc.ac.uk) is the Director of Broom's Barn Research Centre, based near Bury St. Edmunds in Suffolk. The centre is devoted to applied crop science research, mainly in arable crops and specialising in sugar beet. Broom's Barn is part of Rothamsted Research.

Formerly the ADAS National Cereal Pathologist, his expertise spans arable crops pathology and during the last 20 years, almost exclusively cereal disease control. He is well known for his knowledge of disease control strategies, fungicide activity, physiological effects of fungicides, fungicide resistance issues and seed health.

His arrival as the new director in 2007 changed the direction of research at Broom's Barn that traditionally had a sole reputation for research into sugar beet. The research centre now has an increasing focus on all major UK arable crops. Examples of new work areas include cereal disease control, fungicide resistance, new fungicides effects on host physiology and biofuel production.

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CONFERENCE PAPER

WHERE NEXT FOR LIVESTOCK INNOVATIONS?

Chris Warkup

After a brief survey of innovations in livestock production in recent history, this paper highlights selected current innovations and their potential future impact.

Key Words Livestock production, breed improvement, advanced reproductive technologies, genetic modification.

There is no doubt that the tremendous developments in the biological sciences will provide many opportunities for innovation in livestock farming. Innovations currently underway include speeding up the process of selective breeding and delivering new and better diagnostics and vaccines. We have already seen development of GM farmed species and some of these are likely to get to market somewhere in the world in the next few years. In the medium-term there will be innovations from combining cell and genomic technologies. The developments we see today are just the beginning of what will be possible and are unsophisticated in comparison to what will be possible in the longer-term. Biology and biotechnology (with a little help from the disciplines of engineering) offer practically unimaginable potential to improve the efficiency of food production from livestock; to reduce environmental impact per unit food produced; to reduce the impact of disease; improve animal welfare; to enhance product quality and nutritional value, and to safeguard human health.

Innovations in livestock farming will be needed to address the growing global demand for animal protein from a growing and more affluent population and to address the other challenges of the 'Perfect Storm' (Beddington, 2009). The research and development to deliver these benefits does of course take time (in some cases decades), but in Europe the speed at which these innovations will be delivered is, in the short-term at least, likely to be more a function of politics and policy than the ability of science to deliver innovative solutions.

Recent innovations

Looking back at recent decades we can see that global livestock production has already benefitted from a wide range of innovations (see Table 1 for some examples) Overall these innovations have helped deliver considerable improvements in the productivity of many livestock systems. Indicative progress between the 1960s and the early part of this century was reviewed (Van der Steen *et al*, 2005) and is summarised in Table 2. Several innovations contribute to the improvements seen, but it is generally accepted that the largest single factor is the impact of improved genetics (breed substitution and selective breeding). These improvements in production efficiency in turn

1. This paper was originally presented at The Oxford Farming Conference, January 2011, and is reprinted by kind permission of the author and the Conference Secretariat.

Table 1 Application areas and example innovations						
Breeding and genetics	**Reproduction**	**Animal health**	**Growth modifiers**	**Nutrition**	**Other biotechnologies**	**Post-farm gate**
Breed substitution	Oestrus synchronisation	High-health stock	Hormone implants	Formulation to requirements	Multiple ovulation and embryo transfer	Meat quality standards
Within breed improvement	Induced parturition	Improved diagnostics	In-feed growth modifiers	Synthetic amino-acids / micronutrients	Semen sexing	HACCP
Wider use of breeding values	Wider use of AI	New and better vaccines	Injectable productivity enhancers	In-feed enzymes	Vaccine immune-modulators	Novel processes & packaging
Use of DNA diagnostics	Embryo transfer	*Salmonella* vaccination		Pre- and pro-biotics	SCNT cloning	Traceability systems
Genomic selection in dairy cattle	Pregnancy scanning	Selection for disease resistance		Modified product composition via diet		

provide other benefits. We recently used the Life Cycle Analysis (LCA) models of UK agriculture developed by Cranfield University to estimate the effect of past selective breeding on the emissions from UK livestock production. Genetic trends from breed improvement programmes were fed into the LCA model along with estimates of the uptake of improved breeding stock (DEFRA 2008). The results show that the intensive poultry breeders have reduced emissions (in terms of Global Warming Potential) by over 1%

2. Improvements in livestock productivity over the last 40-50 years				
Species	**Trait**	**Indicative Performance**		
		1960s	**2005**	**% Change**
Pig	Pigs weaned/sow/year	14	21	50
	Lean meat %	40	55	37
	Feed conversion ratio (FCR)	3.0	2.2	27
	Kg lean meat/tonne feed	85	170	100
Broiler chicken	Days until 2 kg are reached	100	40	60
	Feed conversion ratio	3.0	1.7	43
Layer hen	Eggs per year	230	300	30
	Eggs/tonne feed	5000	9000	80
Dairy cow	Kg milk/cow/lactation	6000	10000	67
Modified from van der Steen et al. (2005)				

per year for the last 20 years. These improvements are from selection for efficiency and are not from any direct selection for reduction of emissions. Pig and dairy industries are not far behind these reductions, but beef cattle and sheep production has changed little in the genetics of emissions per unit product. This is in part due to the biology of the species (longer generation intervals and fewer progeny per male), but also reflects the facts that feed efficiency is not a measured trait in these industries and that the uptake of improved stock by commercial producers has been poor.

Table 3. % change in gaseous emissions and global warming potential achieved through genetic improvement (1988-2007)

	Methane	Ammonia	Nitrous Oxide	GWP_{100}
Chickens – layers	-30	-36	-29	**-25**
Chickens – broilers	-20	10	-23	**-23**
Pigs	-17	-18	-14	**-15**
Cattle – dairy	-25	-17	-30	**-16**
Cattle – beef	0	0	0	**0**
Sheep	-1	0	0	**-1**

GWP_{100} = the global warming potential over 100 years in CO_2 equivalents

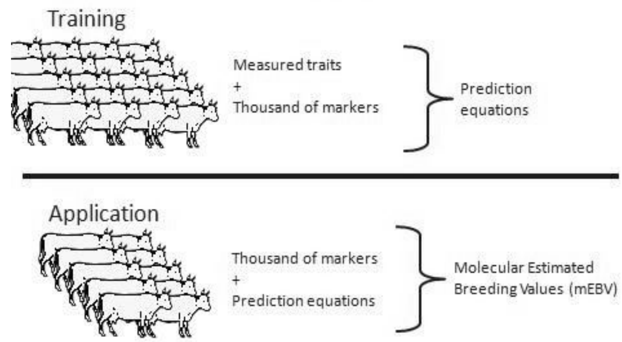
These calculations illustrate that there are win-win scenarios where production efficiency can be improved at the same time as improvements in environmental sustainability. These types of calculations can be done for other innovations; for example, researchers in the US (Capper *et al,* 2008) have calculated the impact of using recombinant bovine somatotrophin (Posilac™) to boost milk yield in dairy cows. The 'layman's terms' way of expressing the impact was that for every one million cows treated the carbon footprint of milk production is reduced by the equivalent of taking about 400,000 family cars off the road in the US. Similar calculations might be done for innovations that control endemic disease, for feed additives or even GM livestock.

Breed improvement

Innovations currently in progress are changing the way that animal breeders undertake breed improvement. Some of these changes are about the quantitative analytical techniques applied to existing trait data; such as taking group effects into account and seeking to select for the best group of animals rather than the best individuals (Muir, 2005). However, the most dramatic recent changes have come from a technique called Genomic Selection (Meuwissen 2001) (GS) that is significantly speeding up the rate of progress in global dairy cattle breeding. GS uses a very large number (in the range of 50,000 to 800,000 currently in most species) of DNA markers (anonymous differences in DNA sequence located throughout the genome that in most cases have no known functions) that have been derived from the reference cattle genome sequence.

In dairy cattle GS allows prediction of the genetic merit of young animals (long before bulls will have daughter records available) from statistical associations of these DNA markers with trait measurements on past generations, which is referred to as the 'training' data set (see Figure 1). This

Figure 1. The Principle of Genomic Selection



technology is now being widely applied and has reduced generation intervals in dairy cattle from over five years to under two years. Even though it is less accurate than progeny testing, the faster generation interval is estimated to increase the annual rate of progress by about 60% (for a recent overview see Goddard *et al,* 2010). Faster progress can be beneficial, but it can also result in unforeseen consequences being seen more quickly than would otherwise have been the case. This potential risk reinforces to breeders the need for balanced selection goals that take proper account of fitness traits and the need to be vigilant for unforeseen consequences. If selective breeding does cause unintended harmful consequences then selective breeding is also the means to put things right. Genomic Selection has the added advantage that it results in lower rates of inbreeding than conventional selection (based on information from an animal and its relatives) and provides new information that can be used to monitor, manage and, where appropriate, conserve biodiversity within a population.

One of the disadvantages of GS is that very large numbers (thousands) of animals with trait measurements are needed in the 'training data set' to deliver accurate prediction equations. So while this approach works well for Holstein dairy cattle it is (currently) less feasible or cost effective in other breeds or species with smaller numbers of measured animals. It has great potential for impact in some of those difficult or expensive to measure traits such as meat quality or feed efficiency, but this potential can only be realised by significant investment in trait measurement in large numbers of animals (most likely of each breed and quite possibly also in the relevant environment). Potentially the training of GS can be done for a customer's specific production environment and needs, and sires that best meet those needs would then be selected. This approach is already being considered in dairy cattle.

Other opportunities from genomics

There are many other benefits to be delivered for animal breeding and animal health from the availability of reference genome sequences of livestock species (we have all the major species sequenced), the genome sequences of pathogen species, and the ever decreasing costs of DNA analysis. Some examples that will not be considered in any detail in this paper include:

- Improved diagnostics
  - Speed, specificity, sensitivity, quantification
- Molecular epidemiology – e.g. tracking a disease outbreak to its source
- Rational vaccine design
  - Subunit, rationally attenuated, recombinant and DNA vaccines
- Host–pathogen molecular biology
  - Breeding for disease resistance – e.g. scrapie resistance or *E. Coli* resistance in pigs
  - Immune potentiators including improved vaccine adjuvants
  - Optimal breeding stock/vaccine combinations
  - GM disease resistance
- New therapeutics – including the development of performance modifiers
- DNA tools for traceability, parentage assignment/verification and authenticity testing

Advanced reproduction technologies

There is a history of innovations in reproductive technologies that were pioneered in livestock now demonstrating benefits in human medicine; including artificial insemination, embryo transfer and *in vitro* fertilisation. Some of these technologies have had enormous impact on livestock production and others have played only a small part in accelerating selection and dissemination of elite animals.

The same will be true of recent innovations. Technologies for semen sexing (separation or concentration of X or Y chromosome carrying spermatozoa) are already having a significant impact in altering sex ratios. It is estimated that by the end of 2011, 10% of replacement Holstein heifers in the

US will be born from sexed semen (de Vries and Nebel, 2009). There is ongoing research seeking to deliver sex ratio control in pigs and poultry and the potential benefits to sustainability and animal welfare are likely to be substantial.

It is less likely that somatic cell nuclear transfer cloning (SCNT cloning – the "Dolly the sheep" technology) will have a dramatic impact in the short-term. It is however now approved in the US and in use in South America and elsewhere. It has application as: i) an insurance policy to 'copy' very high value individuals such as dairy bulls; ii) a means of disseminating more genes from very high merit individuals (e.g. in pigs where the number of doses of semen from an individual male are more limiting); iii) a way to increase the numbers of animals in highly endangered breeds (it has already been used this way twice); iv) as a means to recover breeding animals from stored tissue or from animals too old or otherwise incapable of breeding (again this has been done); v) an improvement to biosecurity of international trade in genetics (cell lines can carry fewer diseases than imported eggs or semen); vi) potentially some niche uses in breeding programmes e.g. selection for meat quality, and of course, vii) as a research tool. Cloning is not yet possible in poultry and it is likely to be many years before we can contemplate seeing herds or flocks of cloned pigs, cattle or sheep, if ever, largely because the costs of cloning are simply too high. It also needs to be emphasised that animal breeding is a continuous process reliant on variation from which to select. Clones of today's best animals would soon be seen as outdated - as better animals are produced through selection.

Other biotechnologies

Cloning is of course also useful as a way of disseminating GM animals or generating live animals from cells that have been modified, such as through GM. Note however that it might also be possible to select multiple generations of cells *in vitro*, by combining GS with cell technologies (Haley and Visscher, 1998). The proposal is that cells in culture might be induced to divide to produce (through meiosis) the equivalent of eggs and sperm, and that fusing these cells in the lab would create new cell lines that might be evaluated by GS to select the best; these would then be induced to generate new eggs and sperm (or equivalent cells that could be fused) and the process would repeat. This could reduce the generation interval of any species down to less than one month. After a series of generations of selection, cloning would be used to produce and evaluate the live animals. There are, of course, a number of risks with this proposed process that would need to be evaluated and mitigated.

Perhaps the most dramatic innovations will be possible through genetic engineering and it's more recent offshoot, synthetic biology. Genetic Modification (GM) is often seen as a single technology when in fact it covers a whole spectrum of ways to increase biodiversity in a farmed population. The tools available to the DNA engineer now include the ability to make very small changes in precise locations (Zinc Finger Nucleases[2]). These tools

2. http://en.wikipedia.org/wiki/Zinc_finger_nuclease
3. http://www.imugene.com/tech_adenoviral.asp

might, for example, be used to correct an inherited defect in an elite family of animals (rather than losing diversity by breeding it out). Technically these animals would still be GMOs, but clearly no foreign DNA has been used so they do not qualify as transgenic.

The term for moving DNA around within species by GM is called cisgenesis (producing cisgenic organisms) and other examples might include: a) increasing the number of copies of a gene (already done for milk protein genes in cattle: Brophy *et al*, 2003); b) deleting a gene; c) changing the regulation of a gene so that it is expressed less or more or at different times or in different tissues (or combinations of these); d) moving the location of a gene in the genome to change its expression (for example putting it on a sex chromosome so the effect is different in males and females); e) moving a version of a gene from one breed within a species to another to convey a particular trait variation (much faster than breeding that gene in through multiple generations of crossing), and f) reengineering a gene (for example changing the structure of a protein to alter its function or behaviour). This last example is where biology meets engineering – protein engineering or by some definitions synthetic biology.

Existing examples of transgenesis (moving DNA between species) in livestock include; the Canadian Enviropig™ (Golovan *et al* 2001) that has been engineered to express the enzyme phytase (from *E. coli*) in its saliva, thus enabling it to extract more phosphorous from the cereals in its feed and consequently pollute less; and dairy cows that expressed a compound in their milk (lysostaphin - produced by one *Staphylococcus* species) were effectively protected from mastitis infections cause by *Staphylococcus aureas* (Wall *et* al, 2005). There is other research underway on diseases resistance through GM that will be mentioned in the conference talk.

The final technology to mention here is one that it is hoped will have considerable potential in human medicine – gene therapy. Various methods are being explored to change gene expression in target tissues to alleviate or cure disease. These therapies commonly seek to carry novel DNA into cells and get that DNA expressed. In livestock, modified viruses have been used to deliver vaccines, but they have also been modified to deliver gene therapy in the form of additional copies of target-species own genes that then help improve immune function. Development is underway for such therapies for improvement of gut health of pigs and poultry, but such products have not yet reached market.[3]

Conclusions

We have been innovating in livestock production since we first domesticated the species we now farm. The main changes we have made are to the animals themselves. Breed improvement and effective dissemination (e.g. via reproductive technologies) has been, and remains, one of the most effective ways to feed more people from the same or fewer resources. Modern biology has accelerated the process of breeding better animals and rapid further acceleration can be expected. In addition, innovations in the way we manage the performance and health of livestock will be delivered by advances in our ability to understand and control reproduction, productivity and health.

Technologies can have both positive and negative effects simultaneously (for example improving disease resistance may improve productivity and welfare, but at some cost to efficiency in the absence of disease) so we need systems approaches that enable us to measure (or ideally forecast) the balance of the impacts – examining benefits, harms, risks and the trade-offs between them. At the same time we must have a rational approach to risk in our regulatory processes – there are, after all, many risks to inaction and stagnation.

Selective breeding technologies in use or near market can deliver a large part of the improved efficiency of food production needed to meet growing global demand for foods of animal origin and do this with fewer resources and lower environmental impact (per unit food produced); and with better animal welfare and human health. Even greater net-benefits will be achieved, or will be achieved faster, in those countries that have an enabling regulatory environment for biotechnologies.

I'm one of those people that believe there is no such thing as a bad technology; it all depends what you do with it and whether the balance of the outcomes (for us, for the animals and for the planet) is good or bad. That is of course, in the end, a value judgement driven by many things; including whether or not you live in feast or famine. It's normal for young technologies to improve with development work and our experience of them. Biotechnology will be no different. I suspect those who were unimpressed with, or even critical of, Stephenson's Rocket (1829) would, had they lived a long time, have been rather impressed by the Flying Scotsman locomotive (1923). Biotechnology developments will, by comparison, be quite a lot faster.

About the author

Chris Warkup (chris.warkup@genesis-faraday.org) is from a farming background in East Yorkshire. Since graduating in Animal Science from London University in 1984, he worked for two international pig breeding companies before joining the Meat and Livestock Commission (MLC) in 1988 and working in various technical roles.

In 2003 he was seconded from his role as Livestock and Meat Science Manager at MLC to be Director of the Genesis Faraday Partnership working with industry and the research base on genetics and genomics of farm animals. In 2009 he was appointed the Director of the new Technology Strategy Board Biosciences Knowledge Transfer Network that serves the Agriculture, Food and Industrial Bioscience sectors.

Chris is a member of the BBSRC Bioscience Skills and Careers Panel and from 2004 to 2008 was a member of the BBSRC Sustainable Agriculture Strategy Panel. He was also formerly a member of two Food LINK Committees. His current appointments include; membership of the National Standing Committee on Farm Animal Genetic Resources, a Trustee of the Roslin Foundation and Chairman of the Genomia seed-fund.

He still manages to enjoy some involvement in science through being the coordinator of two large EU research consortia working on livestock genomics.

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CONFERENCE PAPER

MANAGING CHANGE AND MAKING THINGS HAPPEN[1]

John Shropshire

This paper is a case study of a family business which has succeeded through innovation, and has not been afraid to venture into other countries in Europe to secure competitive advantage and to raise quality. A high value is placed on managerial excellence, and the willingness to learn from mistakes.

Key words Change, innovation, growth, Spain, Czech Republic, Europe, vegetables

In this paper I have been asked to talk about the development of our business since 1952 (when my father bought 120 hectares in the Fens) through to the present day. Despite some jumps (and bumps) along the way, progress has been continuous over that period, and today we farm 12,000 hectares in the UK, Czech Republic and Spain, turning over nearly £300m and employing over 4,000 people.

The drive and ambition came originally from my father. He has two values that he constantly repeats:

> "*The customer is always right*" (not a commonly held value amongst UK farmers during the second half of the 20th Century!)

and

> "*Do unto others as you would be done unto*".

Both very simple and uncannily similar to the Tesco values.

Fundamental to our success has been the development of our marketing skills and our relationship with supermarkets. We focus on customers who can develop and who are profitable and forward-thinking. We try to understand their needs and wants and are single-minded about providing them.

Getting in and investing ahead of the curve has been our obsession; it has consumed a large amount of money but has driven long-term growth. Only a 'family business' playing the 'long game' would contemplate doing what we do at times

I'm going to give you five marketing-led examples of where we invested ahead of the curve:

- Firstly, Father started washing and packing celery back in 1957, yet it wasn't until 1961 that M&S started buying from us.

1. This paper was originally presented at The Oxford Farming Conference, January 2011, and is reprinted by kind permission of the author and the Conference Secretariat.

- Then, in the early 1970s, he invested in cold storage for onions so he could supply year-round – something that was unheard of in the UK! It was phenomenally profitable for nearly 20 years.

- In 1987, we bought a prepared-salad business that supplied McDonald's and started supplying bag salads to supermarkets. It was two years before the business took off. However, in 1990, we sold a majority stake in that business for a substantial profit, exiting it completely in 1996.

- Then, in 2004, we got into prepared salads in the Czech Republic and only now are we starting to make profits.

- Finally, in 1985 we started to grow salads in Spain for the UK markets in the winter, thinking customers would want one supplier year-round. Fifteen years later, the supermarkets wanted exactly that, and we had cracked Spain!

I'm going to use Spain as a case study because, although we've had much success there, we have also made many mistakes.

The coastal strip of Murcia (where our farms are based) is the *only* place in Europe with a climate that can reliably produce salads and broccoli in the winter – so we potentially have 500 million customers. However, land and water are very expensive, labour is highly unionised and the draconian labour laws in Spain make change extremely costly. Also, the competition is ferocious. The past 25 years have been like the First World War; we have 'ground out' our position and poured tens of millions of pounds into it.

We started in 1985 with 30 hectares in the wrong place and with the wrong soils. By 1992, we had grown to 100 hectares, and by 2001 to 2,000 hectares. A year later, we bought a major competitor, Pascual Hermanos, for €41m, which doubled our cropping area to 4,000 hectares, and added tomatoes, citrus and 1,200 hectares of land. To succeed in Spain, you have to take advantage of the different micro-climates – from sea level to 600 metres – and only the Aguilas Valley can reliably produce salads in the depth of winter. We took a huge risk in buying Pascual Hermanos but, as a result, became the biggest land owners in the most important salad growing valley in Europe.

Within a few years, the price of land and property in Spain started rising very quickly and that's when the problems set in. The immense *value* of the property was extremely damaging to the 'business of farming', as nobody looked any more at the losses they were suffering by growing more and more lettuce and broccoli. The unions got very difficult and when we tried to shut and sell our tomato packhouse we had to spend €7m closing it down.

At the start of the recession in 2007, every farm in Murcia lost money – we lost over €10m. But the worst was to come when the property bubble burst. The sale of the tomato packhouse site and of land we had lined up for development fell through, just after we had bought another farm at the top of the market. We found ourselves €23m short of our business plan as we went into 2008. The banks stopped, yes, completely *stopped*, all lending against property in Spain – just as we needed the money!

We managed to refinance Spain from the UK, with the use of a personal guarantee from myself. So why do that? Well, if we are serious about being the leading farming company in our chosen products, we have to back our vision and our judgement. The positive thing about the property crash is that we are able now to attack the key issues of farming – making the operations more efficient and profitable – back to reality!

In *Good to Great* (a book I'd highly recommend)[2], Jim Collins talks about the main drivers of success. 'Good leadership' and 'Getting the right team of people' are obviously important. So too is 'Confronting the brutal facts'. In our case, these are that: 'the supermarkets are *powerful'*, 'the market *does* change' and 'currencies *do* move'.

Collins also stresses the importance of 'discipline'. Lack of discipline and administration can be a real weakness in farming, but we are, in some ways, very good on control and have an enormous amount of detailed analysis of every activity. One of the key factors of our success has been our complete refusal to adopt gross margin accounting. When I came home from Newcastle University in 1976, we adopted fully absorbed costings and net profit accounting for every activity and every single cost, including a charge for family time.

Most of the bankrupt businesses we have acquired over the past 23 years did not have a clue what each activity was making or losing. They knew the *gross* profit but not the *real* profit.

So wherein lie our strengths? In the south level of the Fens we have a range of soils, an excellent supply of water and the driest climate in the UK. These factors give us a competitive advantage in lettuce, celery and onions; they do *not* give us a competitive advantage in broccoli, certainly not over the Lincolnshire silt or Scotland. It took us 20 years and a few million pounds to work that out!

In the 70s and 80s, it was onions and potatoes that provided the money for investment. In the last 20 years, it's been celery and lettuce. Along with our core activity of Fenland farming, we have a number of complementary and synergistic businesses. These include our Czech Republic operation which supplies customers in the summer, most notably Tesco Central Europe (which our Spanish operation supplies in the winter). Another example is our farming business in Warwickshire, which produces salad onions, part of the same supermarket category as radishes, beetroot and celery.

Now, what about technology? To quote Jim Collins again, 'technology, by itself, is never a primary root cause of success'. It does, however, assist in providing the competitive points of difference through cost control and by improving our products.

My father has been a great innovator. He developed new ideas and machinery and had them built in our own workshop right up until a few years ago. He won awards in the 1970s for developing straw planting to prevent wind erosion, and ten years ago his rubber-tracked innovation for planting

2. Collins, J (2001). *Good To Great: Why Some Companies Make the Leap... and Others Don't.* Random House Business.

salads provided annual savings of £0.5m. Similarly, in the 1980s, my brother, Peter, introduced land levelling and water table control for sub irrigation, saving cost and winning environmental awards.

We pushed the packing of salads to the field in the 1980s and 'invented' just-in-time and LEAN with this innovation. The salads are packed, labelled and date-coded on rigs in the field in Spain and are then, via cold chain, delivered directly to supermarket depots in the UK.

With our beetroot business, the whole success is built on our technical ability to develop new and better tastes, whether through control of the cooking and marinating process or through the development of exciting new (or old) tastes and recipes. We bought a loss-making beetroot business with £600,000 of sales in 1990. My sister, Annabel, ran this business and, by using a Mrs. Beaton's malt vinegar recipe, transformed it by focussing on taste and quality. In 2000, sales were £3m and now, through further growth, new product development, the acquisition of three competitors and a brand new £15m factory, we have a business with £20m sales, with a wide range of delicious premium products. If you haven't *yet* got the message: *beetroot is one of the most healthy foods you can eat and it's now the best tasting as well!*

Seed varietal development is still a key factor for our business and we work with the seed breeders to find new varieties that can give us a competitive edge. There's always the threat of a competitor gaining an advantage with a variety we cannot buy. Some USA farming companies have their own breeding programmes but we have stuck with developing partnerships with seed breeders in the UK and abroad. This could turn out to be a mistake – it's a difficult decision. The big seed breeders have the scope, expertise and focus and we hope that, as the biggest grower, they will bring their best new varieties to us.

Looking at the business as a whole, there have been a number of turning points or breakthroughs that have helped us jump forward. Mostly, though, it's been a steady, cumulative process of persevering, investing, improving visual quality and taste, cutting costs and acquiring new businesses. Jim Collins likens this phenomenon to a 'giant heavy flywheel' which "builds momentum, eventually hitting a point of breakthrough".

Business academic, Larry Greiner, describes the 'five phases of growth'[3]and I can very closely identify with these, as our business has gone through several 'revolutionary' periods of substantial organisational turmoil and change. These bumpy periods always involve profit (or lack of it) and usually involve people, management and structures. For instance, centralised structures can lead to demands for de-centralisation and then for the reverse a few years later! For me personally, it has meant changing and adapting my role, which has often been difficult and painful. It has meant parting company with people whom I like and who have contributed a lot – it's tough.

For some people, an inability to delegate can be a problem, but not for me - it's easy to find people who are better at managing than I am! Another big

3. Growth through **creativity**, growth through **direction**, growth through **delegation**, growth through **coordination and monitoring**, growth through **collaboration**. See 12 Manage, *Growth Phases model (Greiner)* http://www.12manage.com/methods_greiner.html [Accessed 21/4/11]

enemy is 'complacency'. During the smooth 'evolutionary' growth phases, big decisions need to be made to help mitigate the 'revolutionary' bumpy patch which might be just around the corner.

For the past seven years, I have used non-executive directors, and for the last five years a non-executive, non-family, Chairman. They have been a great help in this process and we should have done it before.

Procurement is another key component of our success. Over half of what G's Marketing sells is provided by other farmers worldwide. Also important was the formation of the growers' co-operative in 1984. G's Growers has 19 members (including our own farming operations) and its purpose is to market members' products for mutual benefit of the members. G's Marketing Limited provides the co-operative with marketing and managing services, this being reviewed annually by the growers.

The purchase or rent of key farms has been essential to our business. For example, in 1968, Father bought one of the best Fen farms for a record price, creating the platform for our onions and celery business. Prior to that, in 1955, he acquired a 180 hectare farm in Wissington Fen. We struggled there until my brother, Peter, took it on at 23 years of age in 1980. Over the next 20-odd years, he turned it into a 1500 hectare powerhouse, with land levelling, drainage and outstanding conservation and wildlife habitats.

As already mentioned, our acquisition in Aguilas Spain in 2002 solved our mid-winter supply. Four years later, we rented a 300 hectare farm in Campa Cartagena and, with the investment in a desalination plant, we cracked another weakness of producing quality celery in May. Prior to that, we had to import celery from California or grow inferior quality product in UK glasshouses.

Many of our products are very labour intensive. The traditional source of labour in the Fens dried up in the 1970s/early 1980s and we have developed purpose-built facilities for housing the 2,000 seasonal workers we need in the summer. We could not have developed our business without the student permits we managed to acquire in the early 90s. In Spain, we rely on Moroccan and Ecuadorian seasonal workers and they are readily housed in empty summer holiday accommodation on the coast.

In 23 years, we have bought 20 companies. Not all have been a success but most have added market share, notably Hasse Limited, Pascual Hermanos and Bomfords. We have paid a lot of money for some businesses, but mostly specialise in buying businesses that are in trouble.

How are decisions made? Firstly, the willingness to invest and take risk is vital and several times in our history we have bet the company on new ideas and ventures. We calculate the risk carefully. I studied Economics and Maths with Statistics both at school and in my Agriculture course at Newcastle, and that has been extremely valuable to me. Within the company, we generate ideas by allowing people freedom and a sense of ownership.

We are a fully integrated organisation and our business structure is horizontal.

Each function makes a satisfactory profit with targets based on risk, ROC, and margin on sales. They pay an economic rent for property and there is a strong, commercial interface between parts of the Group.

With this structure, local management have a high degree of autonomy and, in some cases, have shares in the business they run. On the downside, this can lead to a 'silo mentality' and lack of inter-team co-operation, but the upside of a motivated team is immense. Ideas flood in and our biggest problem is sifting out the better ones.

Our business is, of course, driven by the market and the market constantly changes – over the past few years it has been bewildering! Four years ago, the whole market was going organic. Unusually for us, we were late in and over-compensated by investing too much, only to be absolutely hammered in 2007. That year, the market shrank by up to 50% (our business plan said it would double) and we experienced the wettest summer since 1912, leading to the destruction of many of our organic crops. These factors contributed to a £5m loss on our organic business that year.

'Local' soon took over as the 'new organic' and we reacted quickly to that, launching a wide range of local products from several different growers. This movement towards 'local' produce, however, is a threat to us; we are a UK producer supplying the whole of the nation from efficient large-scale production points. We cannot afford to lose parts of our market to local producers.

As for the future, I don't worry about going broke, but I do worry about failure. I want to succeed and this is a big driver.

Without growth, the business goes backwards. Twenty-five years ago, my brother said that we need to grow at 4% to stand still, so in 15 years' time, when I'm 70, our sales will have to be over £500m. In food and farming, prices tend to *fall* rather than *rise*, so the growth will have to come from increased sales and by adding value to our products. That is going to be tough!

We have the next generation of the family coming on, plus a strong, professional management team to help achieve that. The European market is enormous and, as Central Europe gets wealthier, they will buy more fresh produce. Every time we hit another bumpy 'revolution', I say "NEVER AGAIN" – but we shall see!

About the author

John Shropshire, OBE (John.Shropshire@GS-Marketing.com), is CEO of the Shropshire Group of companies which now has sales of £300m per annum in the UK and throughout Europe. Integral to its business is its expertise in growing with its own farming operations in the UK, Czech Republic and Spain producing over 9,000 hectares of salad and vegetable crops supplying half of group sales. The remainder is sourced from 30 other committed growers world -wide. The Group employs over 4,000 people and has won several national industry awards recognising its progress in technical and product innovation, exports and environmental management. After gaining a BSc Hons in Agriculture at Newcastle University in 1976, John joined the family farming and marketing business that had been founded by his father in 1952. He is married to Trish, and they have four children, three of whom work in the business with the fourth still in full-time education.