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The Future of Farming: Strategic Intent, Technology Diffusion and Precision Farm Management

CEMI Discussion Paper 0201

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CEMI Discussion Paper Series

ISSN 1448-2541

Discussion Paper 0201

Sneddon, J.N., and Mazzarol, T. (2002) "The Future of Farming: Strategic Intent, Technology Diffusion and Precision Farm Management" CEMI Discussion Paper Series, DP 0201, Centre for Entrepreneurial Management and Innovation, www.cemi.com.au

NOTE:

This paper was originally published by CEMI when it was part of the Graduate School of Management, The University of Western Australia, 35 Stirling Highway Crawley WA 6009.

THE FUTURE OF FARMING: STRATEGIC INTENT, TECHNOLOGY DIFFUSION AND PRECISION FARM MANAGEMENT

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ABSTRACT

This paper examines the application of new technologies to precision agriculture, with specific reference to the wool industry in Australia. It argues that the adoption of new innovation is essential to the long-term sustainability of the industry, but cautions that the diffusion of such technologies is likely to depend on the strategic intent of the wool producers. Multiple case studies are presented to illustrate how the strategic management approaches adopted by wool producers will influence the potential adoption issues facing such new technologies. Propositions for the future diffusion of new technologies are outlined.

Key words: strategic intent, innovation diffusion, farming enterprises.

RESPONDING TO THE MARKET WITH INNOVATION

Against a backdrop of declining terms of trade and increasing competition it has become increasingly important for Australian wool producers to adopt innovations that will have a positive impact upon enterprise productivity and profitability (Beare, 1999). Although innovative technologies are available to help wool producers become more productive and profitable, change in the wool industry is slow compared with other broad acre enterprises (McLachlan, 1999). Wool producers have traditionally relied upon wool prices to lift profitability, rather than introducing innovations that will help reduce production costs or increase fibre quality (Burbidge 1999).

The relatively low cost of managing pastures is considered to be of great international competitive advantage to Australia's wool industry (Chapman and MacMillan 2000). However, much inefficiency exists within the Australian grazing system with the average wool producer utilising around 30 per cent of green feed, compared with 80 per cent of feed utilised in intensive farming operations (Grimm 1998). The optimal green feed utilisation level for the average wool enterprise is around 60 per cent indicating a great potential for producers to graze more sheep and grow more wool (Grimm 1998). The general under-utilisation of pastures is a result of producers stocking their wool enterprise to survive the poorest growing season rather than stocking to a rate that maximises the conditions of the actual season. This conservative approach to feed utilisation is largely due to the lack of reliable and timely pasture management information available to wool producers.

In response to the underutilisation of green feed among wool producers, CSIRO and WA Department of Agriculture (WADA), in conjunction with the Western Australian Department of Land Administration (DOLA), formed a research consortium to develop remotely sensed pasture management technologies for wool producers and other extensive graziers. The main objective of the consortium was to develop and deliver technologies that quantify green feed available to livestock. This data will enable producers to budget their feed during the winter growing season and adjust stocking rates to maximise seasonal conditions. To date research and development has yielded methodologies to derive Pasture Growth Rate (PGR) and Feed-on-offer (FOO) from remotely sensed satellite images and other spatial data at the regional, property and sub-paddock level. FOO quantifies the green feed available in kilograms per hectare. PGR estimates net pasture growth at a specific location in kilograms per hectare per day. Together these data allow producers to accurately budget green feed and manage intake per grazing animal. These technologies may be used to reduce production costs by increasing feed utilisation and stocking rates and to increase the value of wool fibre grown by manipulating fibre design through managing feed intake.

Although there is evidence that lower costs of production and improved fibre quality are rewarded by the market it is uncertain whether wool producers will bear the production and market risks associated with adopting such innovations. Therefore an understanding of the factors affecting adoption was required to aid the development and commercialisation of these technologies. The issue of innovation adoption by farmers has been explored in numerous studies focusing on establishing a relationship between farm and farmer demographics and their propensity to adopt innovations. However the high level of diversity among Australian wool producers and the complex nature of the wool enterprise require greater exploration of the internal and external factors influencing adoption.

TECHNOLOGY DIFFUSION AND INNOVATION

The diffusion of innovations has been examined from both an individual and organizational perspective. Rogers (1962; 1983) 'diffusion of innovation theory' and Davis, Bagozzi and Warshaw (1989) 'technology acceptance model' are examples of individual innovation and diffusion models. According to Rogers (1962) the diffusion of an innovation is contingent on five perceived attributes: relative advantage, complexity, compatibility, trialability, and observability. The adoption of any new technology is likely to be influenced by these five attributes, with end-users accepting or rejecting the innovation in terms of how well it satisfies these criteria in various combinations. By contrast the technology acceptance model has only two perceived attributes: usefulness and ease of use (Davis, Bagozzi and Warshaw, 1989). Research into organizational adoption and diffusion of innovations has identified a two-stage process involving first a decision by the firm's management to adopt the technology, then the implementation stage in which the end-users are engaged (Zaltman, Duncan and Holbeck, 1973; Leonard Barton and Deschamps, 1988; Lucas, Ginzberg and Schultz, 1990).

In many cases the failure of a new innovation to be adopted is due to an inadequate understanding of the dynamics associated with the technological feasibility and the market demand for the technology. Innovation is a multidimensional concept that can involve product or process, technological or administrative, and incremental or radical changes (Cooper, 1998). The fact that a new technology is technologically feasible and may fill a particular need within the market does not mean that it will be readily accepted by the end-user if that party is unwilling to adopt it (Price, 1996). Resistance to technology adoption can be attributed to factors inherent within the organization such as structural or systems issues impeding innovation and change. It can also be found within the individual and can involve psychological and emotional factors. According to Gallivan (2001) the success a new innovation has in becoming adopted and diffused is likely to be adversely affected in circumstances where: 1) 'adoption occurs within an organizational setting where users are mandated to use the innovation'; 2) 'adoption is subject to heavy coordination requirements or strong interdependencies across multiple adopters'; 3) 'adoption requires extensive, specialized training to learn the principles underlying the innovation, in order to overcome knowledge barriers to use; or 4) 'adoption and use occur within an organizational setting, but only a single respondent is available to vouch for the innovation use of many other employees in the organization'.

Within the wool production enterprise the decision to adopt a new technology such as remotely sensed FOO and PGR data for application in precision farming likely to be taken more at an individual than an organisational level. However, the farm enterprise is typically comprised of a family unit with the economic context surrounding the farm household and the level of knowledge and understanding possessed by the potential adopters of the technology and its benefits (Neill and Lee, 2001). A comprehensive review of farming innovation adoption carried out by Guerin and Guerin (1994) found that such factors as farmer isolation from field days and demonstrations, the absence of group leaders, an aversion to technology and limited education were all highly likely to serve as barriers to innovation diffusion.

The Role of Strategic Intent in Innovation Adoption

The concept of 'strategic intent' has been recognised in the strategic management literature as important in order to understand the general direction in which a business is headed (Proctor, 1997). Hamel and Prahalad (1989) argue that 'real' strategy requires an understanding of strategic intent. According to this view strategic intent is a clear expression of the general goal or aim of the organization that assists in guiding it forward. It is wider and stronger than a vision statement and defines the purpose of the organization. It serves to unite or rally all members of the organization. For strategic intent to be effective it should be stable over time and focused on the competition and the market (Przybylowicz and Faulkner, 1993). Strategic intent defines the overall purpose and orientation of the organization and can be used to create a common sense of urgency to improve competitiveness and transform behaviour and structure. For strategic intent to be a positive force it should be focused on competition and how to enhance the overall competitiveness of the organization. Marketing theory defines this as adopting a 'marketing orientation' in which the organization places its focus on the needs of customers and adapts its operations to best respond to these needs. However, this is only part of the strategic intent process. Also required is a constant examination of what competitors are doing (Hamel and Prahalad, 1989). Managers seeking to adopt competitive strategic intent should look for innovations that enable their organizations to define new rules for doing business and to encourage all employees and other relevant stakeholders to accept the challenge posed by this ambition.

Within the wool industry, the ability of wool production enterprises to align their strategic intent with the adoption of technologies and practices can have a critical impact on their ability to achieve sustainable competitive advantage. Collier (1985) and Hatfield (2001) identified the development of a long-term, technology strategy as a key-influencing factor in the adoption of new technologies by organisations. However, the link between strategy and adoption of innovations on farms is not considered in the body of agricultural innovation adoption research. This may be because as Mesiti and Vanclay (1996) point out, the farming enterprise is considered by many researchers to be a social rather than business system. Farm management decisions are not therefore considered to be economically rational but are largely governed by social and cultural constraints. Developers of new technologies such as satellite imaging data for measuring pasture growth rates must therefore have an in depth understanding of the wool producer's social context, attitudes and strategic management approach.

Methodology

The methodology for this research involved a multiple case study design comprising four wool producers in Western Australia. Yin (1994: 13) defines a case study as "an empirical inquiry that investigates a contemporary phenomenon within its real life context; especially when the boundaries between phenomenon and context are not clearly evident." Its value as a research tool is its ability to measure and record behaviour at close range, thereby enabling the researcher and participants to interpret the reality of their experience, and develop a grounded understanding of how that behaviour has taken place (Chetty, 1996). Case study method is considered a more appropriate strategy where the research is seeking to answer questions associated with the 'how' and 'why' and where control over events is not possible or essential.

The case study approach was employed in this research study as an appropriate method of exploring the interaction between wool producers and the remotely sensed FOO and PGR technologies during a technology field trial in 2001. As case study design employs 'replication logic' rather than 'sampling logic' each case was viewed as an independent study with the researcher seeking to identify patterns across the cases to reveal new theory or support existing theory (Yin, 1989). The multiple case study approach allowed similarities and differences to be examined across four cases, with the primary wool producer selected as the unit of analysis. These wool producers were members of WADA's Precision Wool Production project and technology field trial participants. The case study participants were selected to represent northern, central and southern areas of the WA wool-belt. Table 1 outlines the four cases examined in this research study.

Semi-structured interviewing techniques were used to collect case study data. These interviews were carried out with case study participants over a period of five months in conjunction with the FOO-PGR field trial. Interviews were conducted with the wool producer, lasting between one and two hours. Question guidelines were forwarded to producers prior to the interviews to enable them to consider their responses and prepare any supporting evidence required. However question schedules were used only as a guide in that they provided a framework for the interview. Documentation relating to the producer's enterprise type and management techniques was used to triangulate interview responses. This documentation was provided by the WADA and described the producer's enterprise type, structure, management and performance over time. Each case was analysed independently and in relation to the other cases, so that key themes could be identified, and conclusions drawn as to the factors potentially affecting to adoption of remotely sensed FOO and PGR technologies.

TABLE 1: CASE STUDY PROFILES

Case Study	*One*	*Two*	*Three*	*Four*
Location:	Jingalup	Dandaragan	Brookton	Dandaragan
Size of Property:	1,852 hectare	2,700 hectare	1,270 hectare	2,000 hectare
Land use:	Mixed Wool and Crops	Mixed Livestock	Mixed Wool and Crops	Mixed Wool and Crops

Yin's (1994) pattern matching approach was used to analyse each case and seek patterns for generalisation across the cases. The findings from each case were reduced to key issues in key categories depending upon the frequency that they arose in the discussions in order to determine the factors most likely to affect the adoption of FOO and PGR technologies.

RESULTS

ENTERPRISE STRUCTURE

Four dimensions relating to enterprise structure were found to occur frequently across the case studies. These were: level of sensitivity to external forces, extent of enterprise diversification, access to on-farm resources and grazing management tactics. Impacts of external forces such as commodity price volatility and adverse seasonal conditions are not within the control of the wool producer but need to be managed effectively for profitability and sustainability. Sensitivity to seasonal conditions and commodity prices may provide some clues as to whether producer's are likely to adopt an innovation as, the more sensitive the enterprise is to external forces, the greater the need to adopt innovative practices to overcome production and market risk (Chapman and MacMillan 2000).

All cases were sensitive to external conditions but seasonal conditions were most likely to affect case one and case two because they were farming as close to maximum pasture utilisation as possible within their existing enterprise structure. These enterprises had sought to maximise pasture utilisation by increasing stocking rates beyond the district average (case one) or by rotating livestock frequently for maximum grazing coverage (case two). Therefore late season breaks or poor winter rains may leave these farms without access to feed for their stock.

All four cases were affected by the fluctuating price for fine wool but each had adopted a slightly different enterprise structure in response to this situation. Case three had committed to a long-term breeding program aimed at growing finer, higher value wool fibre, making the wool enterprise vulnerable to price fluctuations in the fine end of the wool market. However, this reliance on the price of fine wool was balanced by an extensive broad acre cropping program. Case one had also introduced cropping into their farm system. This approach was used to reduce market risk in terms of shifting reliance away from wool income and also production risk in terms of providing additional feed for livestock during the summer months. In contrast case two and case four had been able to counter volatile market conditions by diversifying into prime lamb and sheep meat production and maintaining a medium wool merino flock. There was a greater felt need for remotely sensed pasture management information among case studies with high stocking rates or rotational grazing systems than those with fine wool breeding programs and large meat enterprises. This may be because of the greater reliance that these producers have on converting pasture into profitable wool fibre.

All four cases had limited access to farm labour and considered themselves 'time-poor'. Case two had deliberately moved towards a less labour intensive operation to reduce labour costs and to free up more of the farm family's time, therefore labour saving technologies were highly valued by this producer. In case three, the producer felt that he was constrained by a lack of time to trial new ideas and was concerned about the difficulties of employing good quality labour. The lack of access to on-farm labour is a problem for many wool producers and has been attributed to poor profitability and returns on investment (Beare 1999) and to the general increase in farm size (Craik 2000). Without the being time available to trial and evaluate innovations it is unlikely that the case study producers would be able to adopt new technologies.

While cases one, three and four used the Internet to access a range of information including weather and market data and for email communication; case two struggled to access information via the Internet due to a lack of knowledge. Although this producer had access to both a computer and the Internet on the farm lack of computer skills and confidence with these technologies acted as a major barrier to use. Although three out of four of the case study producers were comfortable accessing data via the Internet, without adequate training it is unlikely that producers like case four would be able to use technologies such as FOO and PGR delivered via the Internet.

The Influence of Task Networks

Task networks are made up of customers, suppliers, colleagues and employees (Gibb 1996). The attitude of producers towards innovations can act as a major constraint in the adoption of innovations (Guerin and Guerin 1994); producers tend to work closely together in producer groups and are likely to be influenced by the attitudes of their peers. The level of influence that task networks have over producers depends upon the nature of the network relationship (Lowenberg-DeBoer and Swinton 1995) and the value of those relationships as perceived by the producer. The case studies demonstrated the strong influence of producer groups in the acceptance of innovations. A recurring theme in network relationships was the importance of meeting with other like-minded producers with whom information and experiences could be shared. For example, case one felt that learning independently of others was 'worth only half its cost'. The high value that this producer placed on interaction with his peers was evident through his participation in a number of different producer groups, including WADA's Precision Wool Production and the local Holistic Management group. The other three cases also described interaction with like-minded producers through groups, such as the WADA's Precision Wool Production, as valuable.

Although these case studies highlighted the high value placed on peer relationships, they did not provide evidence of valued relationships with suppliers and buyers. Case one and four felt that the wool supply-chain was not sophisticated enough to support the adoption of innovations that would improve the design of their fibre. These producers described transaction based relationships with brokers who are responsible for 'marketing' their wool. Although case four had encouraged her clients to establish direct relationships with wool buyers, there was no evidence of such relationships among the case study producers. Without clear market demand for 'designed' fibre, producers such as those represented by the case studies are more likely to focus upon reducing costs of production than increasing wool value through technologies such as remotely sensed FOO and PGR.

STRATEGIC INTENT

As noted earlier, the ability of firms to align their strategic intent with the adoption of technologies is likely to impact upon their ability to achieve sustainable competitive advantage (Collier 1985; Hatfield 2001). Given the long-term nature of breeding programs and grazing system establishment, producers need to be able to plan strategically for their enterprise. All four case study producers carried out some form of strategic planning that could respond to seasonal condition changes. For example, case one planned annually for a late season break. Interestingly, while all four producers were engaged in a trial of the FOO and PGR technologies only case two undertook formal feed budgeting for the growing season. This may be attributed to the use that this producer made of satellite derived FOO maps, which enabled him feed budget for 2001 in spring 2000.

The strategies of case one and two could be best described as maximizing pasture utilization for production cost reduction. To this extent both were largely cost focused in terms of their strategic intent. In contrast case three and four were committed to increasing the value of their wool through long-term breeding programs. Genetics, rather than remotely sensed pasture management and feed manipulation were viewed to be the key to fine wool production. Therefore the case study producers had varying needs for remotely sensed FOO and PGR data depending upon their strategic intent. Those producers with a cost focus may be more likely to use the technology to increase feed utilisation, whereas these producers with a fine wool focus may be more likely to use the technology to enhance breeding programs with the manipulation of fibre design through feed management. Despite the potential to use the remotely sensed technology to manipulate fibre design, there was a general concern by all cases that the wool market – particularly – brokers was not sophisticated enough to value precision grown wool.

DISCUSSION AND RESEARCH PROPOSITIONS

Enterprise structure which involves the level of sensitivity to external forces, extent of diversification, access to on-farm resources and grazing management practices were found to impact upon the likelihood of producers to adopt remotely sensed FOO and PGR technologies. Results from the four cases indicated that the more sensitive an enterprise is to both adverse environmental and market conditions, the greater the need for accurate and timely management data across the whole farm. Therefore the need for FOO-PGR technologies is likely to be greater for these enterprises.

Producers whose enterprises were highly sensitive to environmental forces were more likely to respond by adopting innovative grazing practices across their whole enterprise to maximise pasture utilisation, whereas producers with ‘slack’ in their pasture system would be slower to adopt these practices. This suggests that producers with enterprises structured to maximise pasture production will be more likely to adopt remotely sensed FOO-PGR technologies than those producers who are yet to realise the opportunities for increased utilisation within their pasture system.

With regards to strong strategic management capabilities, this study found that producers actively forward plan yet three out of the four cases based plans upon intuition rather than robust management information. Strong strategic management capabilities are evident among the case study producers but formal planning is rarely undertaken. This lack of formal planning may be caused by a lack of accurate and timely management information, lack of time or lack of formal planning capabilities. Therefore it is critical that remotely sensed FOO-PGR technologies be developed as both a tactical and strategic management tool, providing the information to plan feed budgets in advance and monitor progress with accurate and timely data.

Peer group participation was found to be a key source of influence for the case study producers. This indicates that the developers of remotely sensed FOO-PGR technologies should look to producer groups for technology champions, ongoing innovation development and an effective means of disseminating marketing messages. This study also found that relationships along the wool supply chain are perceived by producers to be poor and that the lack of communication between purchasers and suppliers has prevented market demand information regarding wool quality attributes from reaching producers. Poor supply-chain integration is impacting upon the producer’s desire to grow quality fibre and is likely to impact upon the producer’s likelihood to adopt FOO and PGR technologies as a quality management tool.

Finally, the utilisation of the FOO and PGR technologies is likely to be influenced by the overall strategic intent of the wool enterprise. As noted in the case study results, enterprise structure, strategic planning and approach to the wool market reflect the underlying strategic intent of each enterprise, with the cases represented in this study reflecting either production or market oriented strategies. These findings have resulted in the following research propositions for further exploration:

P 1: *The propensity for wool producers to adopt remotely sensed FOO-PGR technologies is contingent upon the structure of the enterprise.*

P 2: *The propensity for wool producers to adopt remotely sensed FOO-PGR technologies will be contingent upon strong strategic management capabilities.*

P 3: *The propensity of wool producers to adopt remotely sensed FOO-PGR data will be contingent upon their participation in producer groups.*

P 4: *The propensity of wool producers to adopt remotely sensed FOO-PGR data will be contingent upon their access to market demand information.*

P 5: *The propensity of wool producers to adopt remotely sensed FOO-PGR technologies will be contingent upon the attributes of the innovation.*

P 6: The adoption of remotely sensed FOO-PGR technologies will be influenced by the strategic intent of wool producers.

Conclusions

Wool producer's adoption behaviour is likely to be affected by a range of both internal and external factors. The key factors affecting the adoption and diffusion of innovations such as remotely sensed FOO and PGR technologies are likely to be enterprise structure, enterprise strategic intent, participation in producer groups and access to market information. This study suggests that producers with enterprises structured to contend with adverse environmental conditions are more likely to rely upon accurate and timely pasture management information. These producers tend to be operating towards optimal pasture utilisation and therefore the felt need for remotely sensed pasture management technologies is more evident within this group. However there is also a market opportunity for FOO and PGR technologies among wool producers whose intent is to increase the value of their wool through breeding programs. To diffuse the remotely sensed technologies among this group of wool producers, technology developers may need the support of brokers, buyers and processors to create market pull for the data. Therefore it appropriate to segment the market for remotely sensed FOO and PGR technologies along the dimensions of enterprise structure and strategic intent rather than along largely demographic lines Market segmentation strategies based on the factors underlying the potential adoption of remotely sensed technologies can be used to package and disseminate FOO and PGR technologies to meet the diverse needs the wool producer market.

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