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Knowledge Capabilities, Communication and Innovation in Beef Cattle Farm Enterprises

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Abstract

A capabilities perspective of farm level innovation in the beef cattle industry is presented using information economics. The knowledge capabilities of non-corporate beef cattle enterprises have two interrelated components: the knowledge generated from the activities that takes place during production; and the information channels that producers possess to source external information. Although both are important for analysing innovation, the external information sources relating to producers' knowledge are emphasised here. Emphasis on the path-dependent nature of knowledge focuses the discussion of innovation on the communication of information and how this affects the organisation of knowledge. The effects of differing knowledge capabilities are central to understanding the variation in innovative processes.

Preliminary results from focus groups and in-depth interviews of both producers and their nominated information sources in the New England area of New South Wales in mid-2009 provide evidence for the efficacy of information channels. Case studies of innovations exemplify how differing attributes of innovations combine with network structures and institutional factors to influence the processes of communication between producers and their information sources. Communication of high quality information is shown to be more involved than simple exposure and must be considered from the point of view of the user, allowing it to be reconciled with existing knowledge of the producer. Of importance to producers is the source, delivery and history of the information and these are reflected in the approach taken in this research. The outcomes suggest that producers should be making decisions on the basis of their self organised knowledge capital rather than following innovations fashionable in the industry at large. The role of policy makers is to complement this by providing favourable conditions for knowledge capital formation where high quality information flows are likely outcomes. Policy makers could look at improving the ability of producers to integrate new technologies and practices into their production indirectly rather than looking to directly persuade them to adopt individual innovations.

Introduction

The purpose of this research is to examine the effects of differing knowledge capabilities on innovation implementation in beef cattle farm enterprises, with particular reference to the influence of information sources external to the enterprise. Evidence about innovation and the role information plays in this process has been sourced from farm enterprises in the New England area of New South Wales. Alford, Griffith & Davies (2003) suggest that producers in New England may benefit from new innovations. Innovation is a concern for the farm sector of the beef industry and its adoption is considered slow and insufficient (Griffith, Clark, Parnell, & Timms, 2007; Guerin & Guerin, 1994). Frank (1995b), conversely, points out that non-adoption of innovations is often the rational choice producers should make.

Producers require knowledge to be able to make decisions. Quality information is transformed into useful knowledge through learning. The question examined here is

about the development of knowledge and how high quality information is acquired by producers so that decisions can be made. The point of view of the producer is an important factor in addressing innovation issues.

The research presented here uses *information economics* (Babe, 1994; Lamberton, 1996) to examine innovation in beef cattle farm enterprises. Information economics looks at the allocation and efficacy of information in relation to economic activity, based on the firm's knowledge capabilities which allow them to act. Theory about capabilities emphasises the knowledge of a firm about 'how' to produce (Loasby, 1998b). This is an alternative approach, although not necessarily an exclusionary one, to orthodox economics which emphasises prices, quantities and utility maximisation. Antonelli (1996, p. 286) suggests enterprises gain additional knowledge from either learning of people internal to the firm or from receiving information from external sources, such as other enterprises, which can be turned into knowledge. It is these two irreducible parts relating to the enterprise that make up the knowledge capabilities of the firm. Innovation undoubtedly requires learning within enterprises and substantial innovation takes place where the learner is the innovator (von Hippel, 1988). The focus in this research is to see how external information becomes knowledge capabilities of the firm.

Similar to the position of Llewellyn (2007), this study views producer learning as the core process. It addresses questions of quality of information and pathways of acquiring it. The beef cattle enterprises investigated here are family owned with relatively few participants in the internal aspects of production. They have family or individual based management with only a few decision makers. They are generally small or medium enterprises (although some participants are larger) consisting of approximately fifty to one thousand head of cattle and possibly other stock if they run a mixed enterprise. Given that new technology, broadened here to include all innovation (see Macdonald, Lamberton, & Mandeville, 1983), is seen as the avenue of future development in the industry (Hammond, 2006; Liao & Martin, 2009), it is appropriate to consider what information and knowledge effects are taking place and how these relate to innovation.[1] Innovation refers to the introduction of something 'new' to the individual enterprise rather than the Schumpeterian view of 'newness' or 'entrepreneurship' at the industry or economy level (Schumpeter, 1950). The effect of 'newness' of an innovation is that its outcomes cannot be predicted prior to their happening.

The theory presented here has elements of both rural sociology and economics which, as Frank (1995a) points out, are required to understand innovation in beef cattle production. The task is to examine examples of innovation in the light of the issue of knowledge, the central aspect of economic activity (Hayek, 1945). It is timely to examine innovation using an information economics perspective because much of the analysis of innovation in agricultural economics has been to do with incentives and institutional factors such as land tenure, profitability and risk (Feder & Umali, 1993; Griliches, 1957; Liao & Martin, 2009; Sunding & Zilberman, 2001). Ruttan (1996) in reviewing theoretical progress noted that rural sociology has lost some of its vigour towards the subject.

[1] "[A]n innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 2003, p. 12),

Innovation is novel activity that people undertake without initially the knowledge to do so. Capabilities is a useful concept because it focuses on the knowledge that producers and their information sources possess to explain their economic behaviour. In dealing with knowledge, it is pertinent to ask how producers know what they know (Shackle, 1972). In orthodox economics, producers are assumed to have perfect knowledge. Where knowledge is imperfect, the concept of uncertainty is generally used to represent it. Uncertainty is a step back from the assumption of perfect knowledge where producers would be able to accurately predict outcomes. It is usually conceptualised as a complete set of alternative choices and/or outcomes with producers and information sources knowing the probability with which each outcome will occur (Arrow, 1996/1962). However, in reality determining the probabilities for all outcomes is not feasible (Knight, 2005/1921, pp. 197-232). This is not to say that models that have implied risk interpretations of uncertainty are incorrect because they are written from the standpoint of an observer, and uncertainty might well be a suitable tool for thinking about outcomes. But in terms of the decision maker, the limits of knowledge people possess need to be recognised, as does the necessary imperfection of that knowledge (Shackle, 1972). As an alternative to the theoretical position of perfect knowledge, this research asks what knowledge can be applied to a new state of production and looks at the processes producers used to obtain information to innovate.

External sources of information are effectively a set of knowledge capabilities that exist outside the borders of the firm. Knowledge capabilities refers to the knowledge that a firm possesses that allows them to make decisions. It is a *capital* concept as the knowledge structure within the firm is built in a path dependent manner over time.[1] The structural component of knowledge needs to be emphasised as well as the stock component because knowledge capabilities not only allow the firm's activities but may also be a limitation. They orientate the firm's activities into certain directions. That 'path' not only sets the present state the beef cattle producer find themselves in but also they affect the conditions that they operate under. As Frank (1995b, 1997) discusses, producers are making decisions according to the economic, social and natural environments instead of in isolated and inert spaces. The focus on external information sources shows that as they contribute to knowledge capabilities, they influence the way innovation takes place.

Research Conceptualisation

Beef cattle producers operating small and medium enterprises in the New England area of New South Wales and their nominated providers of information were invited to focus groups and in-depth interviews about innovations they had attempted in their beef production and about their sources and exchanges of information. Results from this research shows that almost all participants and producers are willing to provide information. At first glance this might suggest that the orthodox view of information being a public good, non-rival and non-exclusive, applies. However, distinctive patterns emerge about who is providing quality information to whom. Case studies of rotational grazing, improved pasture and Estimated Breeding Value (EBV)/genetic

[1] Coleman (1988, p. S100) stated "[j]ust as physical capital is created by changes in materials to form tools that facilitate production, human capital is created by changes in persons that bring about skills and capabilities that make them able to act in new ways".

database breeding have been constructed to exemplify the differences of information dynamics which lead to different network forms and different types of information being exchanged.[1] The differences come about because of the following 'capability conditions':

- the attributes of particular innovations;
- institutions present prior to and during information exchanges (including social relationships between people);
- the circumstance that information can be communicated through; and
- prior knowledge producers possess.

These criteria suggest that the selected innovations should be associated with particular information channels (Arrow, 1974). It is unlikely that information in the industry is exclusively divided along these lines but there is a clear indication that 'useful' information does follow distinct patterns.

The difficulty of implementing innovations in beef cattle farm enterprises stems from the nature of production involved. Like many forms of agriculture, beef cattle production has to deal with complexities arising from biological and natural origins which can only be partially mitigated by production techniques. Complexity is a barrier to implementation (Vanclay, 1992) and by changing the existing production process, innovation increases this difficultly (Pannell, 1999). Elemental effects such as the weather, hydrological and landscape forms are largely beyond the control of producers to manipulate in the clean mechanical vision of theoretical production functions. Beef cattle production, in common with other livestock industries, also has the complexities of animal health and behavior to manage, and there are long temporal horizons for many processes to come to fruition. Production is complex, multi-dimensional in nature, and interrelated. The possibility of making substantial changes to production independently of other systems is generally not feasible. For example, if someone changes their grazing pattern, this affects the quality of their pasture, their water resources, and the behavior and health of their animals. It is very difficult to distill these uncertain inputs generating variation into precise recipes for production.

In order to illuminate the process of innovation, we have to move beyond a mechanistic production function, albeit one with uncertain and complex attributes. The evolving knowledge of the producer is missing from such an account. Producer knowledge is not a simple 'truth' of the enterprise's workings: instead it is an 'image' or 'representation' of how aspects work, including how they can be changed (Boulding, 1966). It is built from information available to the person who integrates it with their existing knowledge, and applies it as the need is perceived. Producer knowledge is not simply piled together and applied to problems all at once. Only a small subset of knowledge is in use at any one time (Mokyr, 2002). There is a structure to knowledge that precedes and guides its use. There are preconditions, situations and attributes to knowledge that are in use prior to and during the application of new information.

[1] Other innovations have not been excluded in this research. Often participants bring up interesting discussions of other innovations they have made or looked at. These have not been ignored and will be used elsewhere to verify more widely the theory presented here.

Local conditions, social, economic and natural, create conditions that production and the accompanying knowledge reside in. The structure of a producer's knowledge has local flavors that determine how it is used.[1] An identifiable locality maybe as little as a few kilometres wide, with both similarities and differences between properties within it, such as soil, topography and weather conditions, and access to infrastructure such as communication and transport facilities. Producers operate in particular ways that reflect the knowledge each holds in relation to their local circumstance. Thus there will be a common understanding between producers in these areas and similarities in production techniques, albeit with refinements specific to their own property.

Farmers value information that has been adapted to local conditions more than broad generalized knowledge and are more likely to use it (Llewellyn, 2007). But local dynamics including *local knowledge* generation is not a sufficient tier of analysis to explain how farmers use information to implement innovations. Such an explanation requires further relevant knowledge of their farm and the factors that could affect it. *Specific knowledge* is knowledge that is held by a firm that other firms or organisations do not possess (Hall, 1970). It is conditional on *local knowledge*. For example, farmers understand that the surrounding district is likely to experience the same seasonal weather conditions but they also know which paddocks will respond with strong growth in some grass types if it rains. *Specific knowledge* is the operational knowledge that consists of the relationships between components of local conditions as they relate to an enterprise. It covers the production system and idiosyncrasies of that enterprise, including the number of stock, grazing pattern applied to paddocks, financial constraints, size of property, resources such as rivers, dams, and springs and bloodline capital that are all specific to an individual enterprise. It is more explicitly time/history driven and has further value than *local knowledge* to farmers. A decision to adopt an innovation must satisfy the conditions imposed by the two types of knowledge, *specific knowledge* as well as *local knowledge*.

Producers build knowledge from their experience of running their own enterprise and from information from outside sources. External information sources for producers could be newspapers, television, radio, internet, advertisements, flyers, agronomists, consultants, vets, stock brokers, accountants, friends, family or even passing acquaintances. These are not equivalent sources of information[2]; different types of information have different economic values (Llewellyn, 2007, p. 149). Explanatory models have begun to move away from the idea that knowledge is simply transmitted to people who consider it on its objective merits. In examining information dynamics, it must be recognised that communication is more than the movement of data from one person to another. In order for it to be understood, the information communicated must relate to the existing knowledge of people receiving it and this transformation from information into knowledge is achieved through the act of learning. Learning

[1] "[L]ocal knowledge is both universal and specific and defies any simple essentialism. Local knowledge is neither indigenous wisdom nor simply a form of science, but a locally situated form of knowledge and performance found in all societies. It comprises skills and acquired intelligence responding to constantly changing social and natural environments"(Antweiler, 2004, p. 1).

[2] Participants in focus groups and interviews point out they have preferences in how information is delivered.

that occurs will be affected by the perceived differences of social status and individual cognitive qualities. Katz *et al.* (1963, pp. 276-277) suggests what is needed for effective communication is analysis of the interpersonal relationships to generate understanding of differential placement, i.e. their different perceived relative status. The differential placement of people communicating to one another has a significant effect on learning. This underscores the issue of the structure of knowledge and its role in innovation. Frank (1995a) discusses how knowledge is formed through processes of learning for beef producers and how this depends on their individual circumstance including a significant number of aspects such as attitudes, motivation, "the capacity to identify useful and fresh lines of enquiry" and a "perceived level of relevance to felt needs" (Frank, 1995a, p. 293).

Analysis of knowledge requires some understanding of learning processes. Learning has been considered in economics in a number of ways (see the survey provided by Dosi, Marego, & Fagiolo, 2005). But the process of learning has generally been reduced to learning-by-doing (Arrow, 1962) and learning-by-using (Rosenberg, 1982, pp. 120-140). As Arrow (1962, p. 155) points out, learning is at some level a product of experience. But this does not really explain the phenomenon. Education and extension disciplines have concerned themselves for some time with the ideas that it is not only what is learnt but how learning occurs that matters. The essential point that needs to be understood about learning is that it takes place in a socially conditioned environment through the interaction the learner has with the source of information. People apply their existing knowledge not only to the actual subject, but also to how they interact with the environment. For example, the issue of reading literacy has emerged in this study where information sources have been rendered less effective because some participants are less inclined to use print media than other vehicles for information. People use their reading skills as *mediational means* (Wertsch, 1985) to develop knowledge to interact with a problem. This requires their personal active involvement in a learning process. When participants of this study were asked to describe and explain their preferences for receiving information, they often responded with the idea that 'demonstration' was preferable so they could manipulate the learning situation to their needs. This can be interpreted as a positional outcome for personal gain (which there is some relevance to an extent) but they also talked about it in an experiential way, where senses such as touch, sound, smell and taste are considered important because they yield important information. This goes to the heart of the matter: the attributes of innovations and communication are complementary and are determinant factors of actual learning, but some means of communication appear to be more effective than others for representing the attributes of innovations. Tacit knowledge (Polanyi, 1967) is a prime example where codified forms of communication do not pass the much needed information from one person to another. For example, producers value tacit knowledge when evaluating stock which would suggest that simply printing a 'how to' guide would only provide minimal support for them to make decisions.

The model of learning based on the *social constructivism* of Lev Vygotsky (1896-1934) provides an intuitive reasoning for the learning process (see Daniels, Cole, & Wertsch, 2007; Rogoff, 2003; Valsiner & Van der Veer, 2000; Wertsch, 1985). Learning takes place in the social environment where interaction between the source of a concept or information and the person trying to understand the concept takes place.

By having someone to help understand a problem, the possibility of learning is greater than if the information is simply given to a person. Central to the process is the *zone of proximal development*, which is defined as the "difference between a [person]'s actual level of development and the level of performance that [the person] achieves in collaboration with [another more knowledgeable person] (Rieber, 1987, p. 209).

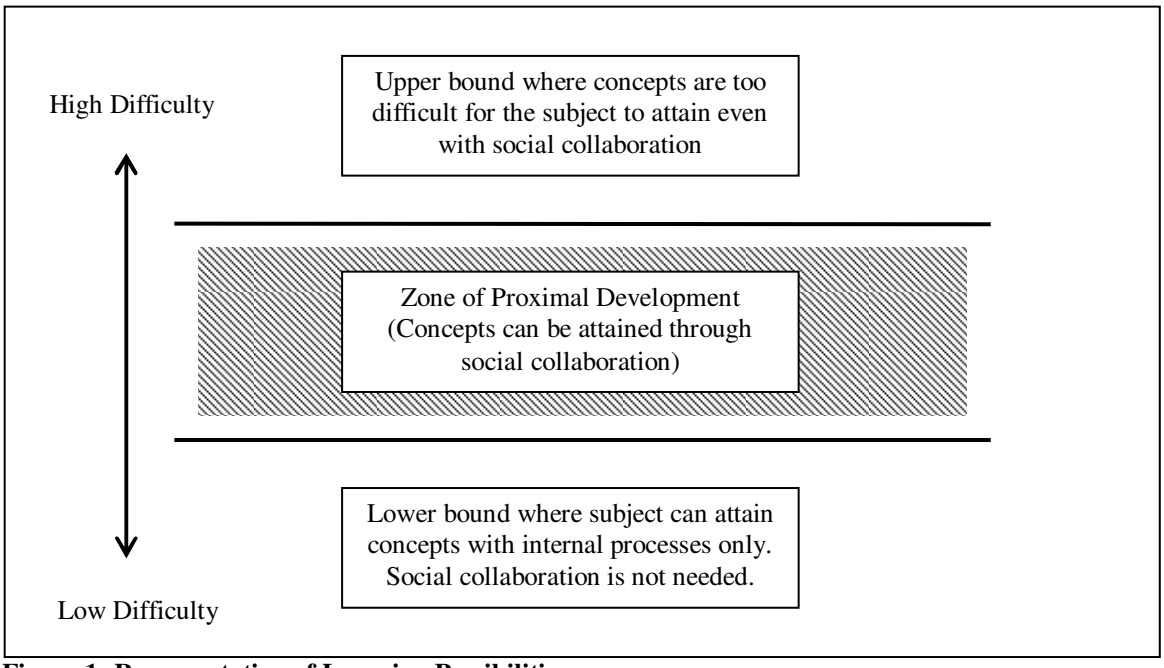


Figure 1: Representation of Learning Possibilities.

The three zones outlined above represent the learning outcomes for an individual in a particular instance. The lowest zone represents understanding of concepts which the person already has acquired or can obtain without interaction in the social environment. The middle area represents the 'actual' *zone of proximal development* where with the assistance of other people, or tools and media at their disposal, people have the potential, based on their current knowledge to acquire new knowledge. This allows a person to learn through social collaboration with other people or tools in the social environment, concepts that they otherwise could not learn. The upper area represents concepts with the current level of knowledge development, the person cannot learn, even with the help of social collaboration because the new information is too far away from their existing schema. Note that the scale of difficulty applies only to the individual. This is not a ranking system of concepts, more a tool to think about how an individual can learn with the help of the social environment.

There is another point to be made with this framework. People employ *mediational means* to reconcile their existing knowledge with new information. *Mediational means* are the strategies and tools employed by a person to interact or manipulate the information so as to understand it. This could be through the use language to talk to people, the use senses such as touch to examine something like soil or pasture, feeling the response through a hand tool, or just drawing a rough diagram to explain stock movement. It is important to recognise that it is through the use of these tools to gain the understanding of a concept that these *mediational means* provide the experience

that a person learns from. Thus people who are used to understanding in a visual and tacit manner may not find information in a codified print form as easy to understand. That is, the information is presented in way that even though they can read it, is not organized in a way they prefer to extract information and build new understanding.

Another key point about this process is that those providing information and assisting learners also use *mediational means* in the social environment. The affect of other people on a person's learning needs to be recognised. Other people who are trying to communicate information are using *mediation means* in the social environment; they are influencing the learning situation. If someone writes to the local newspaper, they convey a message in a particular way. If they talk to someone face-to-face they can manouevre the situation and explain in response to the conversation taking place. Combined both parties contribute to *socially shared cognition* (Resnick, Levine, & Teasley, 1991). This emphasizes that learning is contingent upon the people and the environment present.

The reason for employing this *constructivist* framework is to move beyond the notion of information channels being simply a connection between a source of information and someone who needs it. This framework adds purposeful interactivity and depth of relationship to the connections so that an understanding of what constitutes quality information for an individual can be formed. It allows the four 'capability conditions' initially stated to affect information dynamics to be placed into learning theory that is intuitive and is generalisable, which means that it does not lose validity from application to different modes of thinking or different concepts. This is advantageous because of the heterogeneity in the beef cattle enterprises and between producers themselves, and it allows comparison of different innovations using the same learning theory. The other advantage is that it accounts for institutions present during these occurrences. Because learning is contingent upon the activity of people present, institutions that are affecting the social environment, e.g. commercial relationships, will affect the learning outcome because it will change the activity people are undertaking and their interactions between one another.

Information channels can be conveniently collected together and conceptualized as networks where communication between any number of participating producers and information sources can be built into an overall schema. Models of these networks can provide an indication of how information travels between people in them. By characterizing the network with communication and learning between participants, the way that knowledge is built up in the system and who has access to this knowledge can be demonstrated. This view of the system, in which knowledge and information are moving, diffusing or created, shows that there are multiple connections from information may come. Thus the knowledge capabilities of a producer include not only the internal knowledge that they have at their disposal but also the knowledge they can acquire through the network. Even though in many networks people do not have direct access to everybody in the network, they can still benefit from the knowledge that the people who are indirectly connected to them possess (Loasby, 1998a). There are limitations on the use of indirect knowledge because it must travel through another connection first before it reaches the producer. It means that the producer is reliant on the interaction between other people. In some cases this is quite reliable and useful, particularly when there are strong institutional conditions to coordinate the interaction between people, such as a commercial basis. In other cases,

where there is weaker institutions regulating interaction and exchange of knowledge, the indirect functions are less likely to be reliable.

Methodology

To examine some of the information channels and test some of the propositions discussed above, a series of focus groups and semi-structured interviews were conducted. A total of thirty three participants took part in three focus groups (Stewart, Shamdasani, & Rook, 2007) and a number of semi-structured in-depth interviews (Minichiello, Aroni, & Hays, 2008). Each focus group consisted of six beef cattle producers who discussed in general the role of information, knowledge and innovation in their experience as producers. The in-depth interviews consisted of two types of interviews: firstly, with individual producers looking specifically at how they have gone about implementing a change to their enterprise; secondly these interviews were followed up with interviews of the producers' own nominated information sources. By having both producers and their information sources discuss their roles and thinking in implementing particular innovations, a more complete picture of occurrences, information flows and knowledge applied can be built up. Producers were selected as an opportunity sample, and approached either by face-to-face encounters or by phone. Opportunity samples of producers were generated by targeting producers at gatherings such as livestock auctions; enquiries to breed societies; breed society web pages; suggestions from producers of other possible participants; and contacting producers who were advertising in print media. The decision to approach a producer to participate was either based on opportunity or, where prior information about their production was available, on the possibility of relevance to this study. Face-to-face encounters were superior for generating a sample with a higher rate of participation and understanding about the research.

Three broad categories of innovations, namely rotational grazing, improved pasture and genetic/EBV-based breeding, were targeted to provide data for analysis as these emerged from the focus group discussions as likely to be relevant to many producers. Discussions of these three innovations exhibited enough variety to indicate that depth of understanding could be gained from pursuing these three innovations. They are sufficiently different in attributes that differentiating effects on innovation can be identified.

Questions in in-depth interviews were designed to allow participants to build up stories of the process of how they went about implementing their innovations. This included where they received important information from and under what circumstances this occurred. Likewise information sources were asked for their account of the situation which included what knowledge they applied and how they went about communicating it. Participants were also asked who they provided information to so that a network diagram could be constructed of information flows.

Case studies of innovations were built from the stories provided during the in-depth interviews. Participants could provide detailed accounts of the process they went through in implementing change. In instances where information important to innovative process involved learning, participants were able to provide detailed responses when questioned about their activities (Nisbett & Wilson, 1977; Smith & Miller, 1978). Their accounts included where they received information and the

circumstances it was obtained. This allowed mapping of networks of information including depth of communication and learning required so that the importance of these network connections could be understood.

For the purposes of reporting results participants have been coded with the prefix 'P' for 'producer' and IS for 'information source'. Then a two letter code is given to each participant to identify them individually.

Results

In the agricultural context, information is considered more a private good than a public good depending on who possesses it (Marsh & Pannell, 2000, p. 606). Public goods are usually defined as non-rival and non-exclusive; private goods usually have some property right attached to their usage. In addition, there are barriers to producers acquiring privatised information due to the context the information is produced in. Barriers to access to private information could include tacit knowledge, there being limited physical access, language factors or cost of obtaining information. The effect of privatisation is similar to exclusivity of resources since producers can not gain use of knowledge easily. Information channels function differently in public or private manners because exclusivity is present. In the case of hiring an advisor or labour the producer has access to that person's knowledge exclusively under the agreement. In many cases producers will seek or use a public source of information initially. Results from the focus groups and interviews indicated that producers seek out public sources of information such as observing neighbours, talking to friends, free leaflets or simply looking at the side of the road, before seeking out privatised sources such as agronomists or consultants.

The most distinctive outcome of this research is that several types of network forms can be distinguished amongst participants and these forms have different effects in innovative activities. It was found that most topics relevant to the beef industry could be brought up by any participant, but where deep knowledge about a topic was held the information provided displayed some systematic tendencies. Specific types of networks were aligned with different innovations. EBV/Genetic-breeding exhibited a linear 'top down' network; improved pasture showed that information was received by either a 'star' network or an enclave network. Communication about rotational grazing showed traits of being in a disparate network that provided irregular information. As will be discussed, these forms can be attributed to the four points on external information described above.

Improved Pastures

Information for producers on improved pasture came from two sources: local suppliers of pasture products and services, possibly an agronomist to advise customers; and friends/family connections who supplied knowledge based on their experience with products. Networks from suppliers/professionals take the form of a 'star' network while friends/family networks generally take the form of an enclave model.

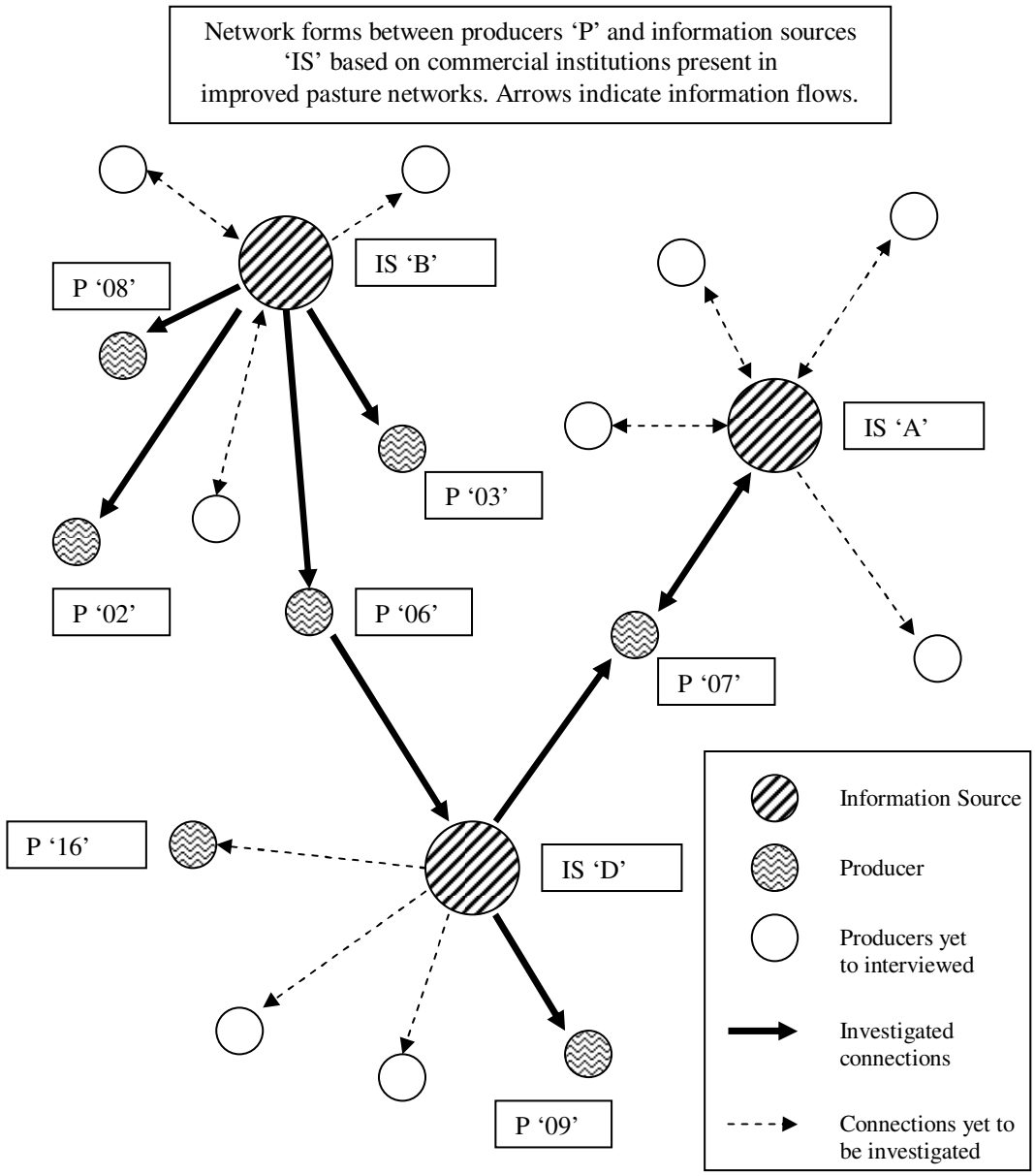
Improved pastures come in many different forms and can be implemented using diverse methods and there is a wide range of species and mixes of pasture available

and associated management practices. Pasture relies on the conditions that it is placed in, for example, the timing and method of sowing, hydrological considerations, temperature, grazing intensities and soil qualities. Most of the improved pasture instances described by participants were aiming to provide high quality 'soft' fodder for stock, with one participant using lucerne as winter storage fodder. Participants indicated they had both favourable and unfavourable outcomes from implementing various improved pasture schemes. This suggests that the information and knowledge that participants held was not sufficient to make certain the outcome of implementation. Unsatisfactory outcomes occurred for many reasons such as a lack of performance by the pasture compared to expectations; producers not being able to identify the plant species properly; and inadequate of understanding of how to feed pasture to stock.

Two different forms of network were found among producers who had introduced improved pasture to their system. Although other sources were discussed such as flyers and web sites, most participants attribute their understanding of the innovation to either networks of peers, or professionals such as agronomists. These two sources provide different types of information which have different purposes.

Much of the information provided by agronomists is scientifically-based on outcomes they have seen in other cases of implementation. Soil tests are an example of the scientific based information that agronomists provide producers. Most producers are not in a position to produce this information because they do not have the knowledge and physical capital to produce it. In terms of plant biology they have limited opportunity to discover concepts that are not visible to the eye, or they may misattribute cause and effect e.g. the pattern of dominance and regression of pasture species in a mixed pasture. The knowledge producers possess on many of these aspects frequently comes from commercial/professional sources such as suppliers of pasture inputs, agronomists and consultants. Other producers pass on different types of information because their knowledge of the pasture is different. Instead of having scientific knowledge, they have experiential knowledge that has been formed from their own experiences and observations over a significantly longer length of time. Thus, although they might not have as many instances of implementation to draw their understanding from, other producers have an in-depth and tacit understanding of their own particular implementation. It was seen in many cases to be information that has the local and specific dimensions. These dimensions are valuable to farmers just as is scientific type information. Advisors who were interviewed were conscious of the role of experience in production themselves and suggest it is an advantage they possess over other advisors that do not possess it. 'Star' network and 'enclave' networks were found to have developed to communicate different forms of knowledge.

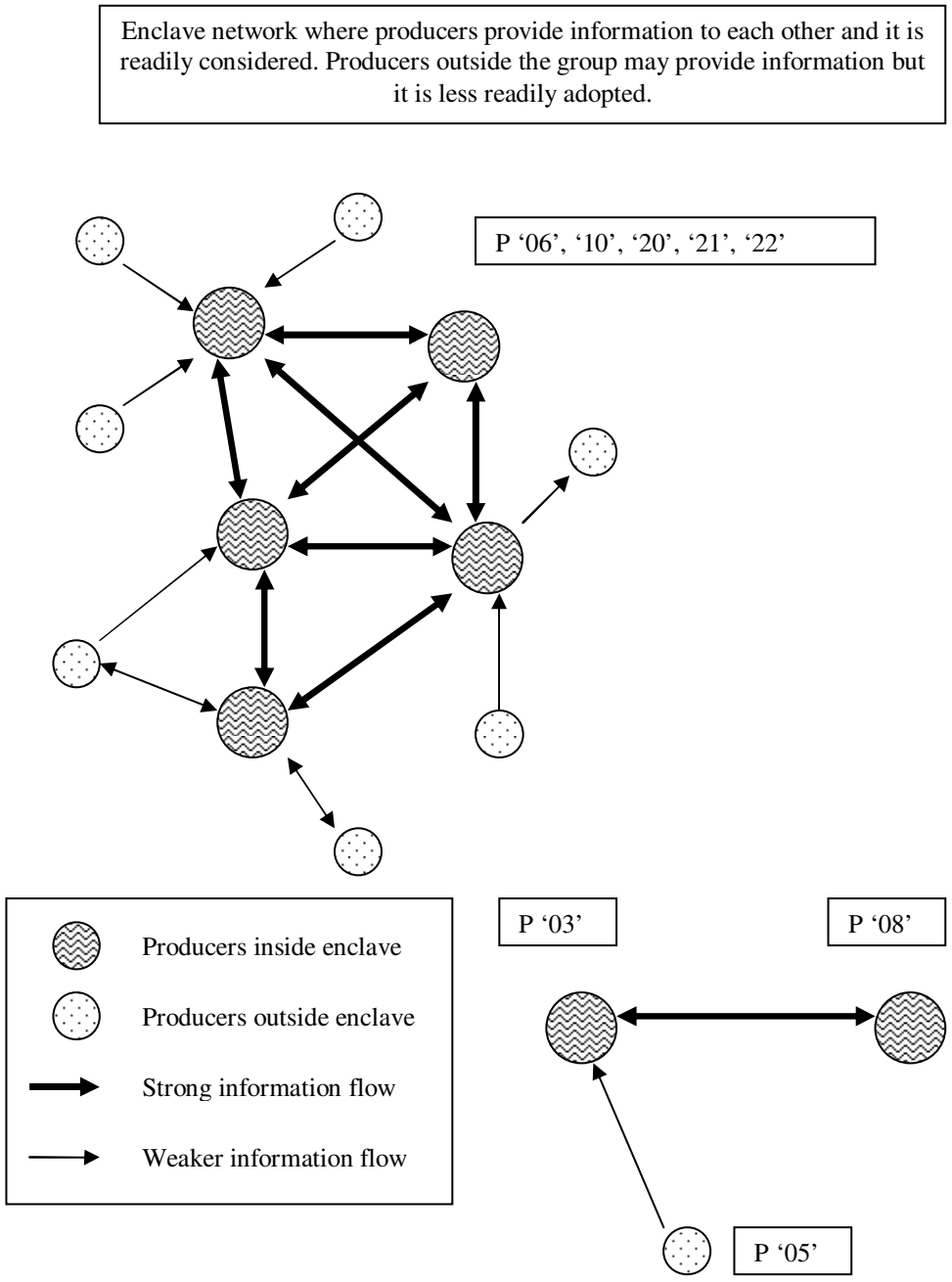
Star Networks of Participants



The 'star' network emerged as a prominent feature in the pattern of information communicated about pasture improvement. The commercial nature of information about improved pastures arises because of scarcity, both of the tangible inputs and also the labour involved such as that supplied by an agronomist. The restriction of a private good is shown in the network diagram by its dynamics of dealing with one customer at a time around a central node (the advisor or specialist). Activity occurs iteratively in one-to-one situations (Black, 2000), and as it revolves the network is formed in the 'star' shape. Knowledge accompanies the product so that there is a substantial complementarity in the flow of information and the tangible good. As this process progresses the information source in the centre of these 'stars' gains additional knowledge. This is then reemployed on future encounters with producers. The net effect is that considerable knowledge is collected in the central node where it

is continuously evolving and producers have access to this if they are participating in the network (commerciality and scarcity being a restriction). There are two advantages for the producer; firstly, they receive indirectly the benefit of the experience of all the other producers activities in the network. In essence they have access to more experience then their own personal dealings with the advisor; this means that their knowledge capabilities are enhanced. Secondly, this is a learning process in a network which means the network has the ability to grow its knowledge via the feedback the agronomist receives. When a new problem arises, the producer concerned consults the agronomist, and a solution is devised. Other producers in the network benefit when the agronomist draws on this new knowledge if they encounter this new situation in their enterprises. Continued evolution of knowledge allows the network's ongoing functioning rather than it dissipating with time. The functioning of the network changes slightly with the activity of the central node. Participant IS 'A' is less experienced than IS 'B'. As a consequence IS 'A' has a greater interest in the outcomes of advice they have provided to producers. IS 'B' still gains information from producers, but it is more through new occurrences than learning existing knowledge that they increase their knowledge. There are some limitations of this network in its effectiveness for innovative outcomes. Information sources at the centre are limited in their labour (time available) and two observed outcomes result: firstly, the size of the network is limited to the amount of labour that can be supplied; and secondly, like all cases of learning, knowledge is limited by the experience and interaction that is taking place. Here the limitations of labour reduce the potential information gained and distributed. Also information provided is less likely, because of the small amount of time with anyone person, to have significant tacit components. This leaves some gap for other forms of networks to be of value.

Enclave Model of Producers



The enclave network appears to exist between people who have social or family ties prior to its use as a network with productive information. Family and social ties provide channels of highly trusted and relevant information. It was observed that information is provided along one of these channels was readily considered by producers.

The group is not isolated from the rest of the world but connections with outsiders surrounding the group are not as strong and their information will be regarded as having less efficacy. Within such groups understanding of each member's production

by others in the group is quite detailed. Participants claimed to have knowledge of each other's practices and this has been verified with participants providing details of others operations independently in interviews. This *specific knowledge* other members possess reinforces the possibility over time that good quality information will be transferred. The high quality connection has the implications that information will have strong relevance and acceptability because it fits with the receiver's production. Both parties will have the ability to communicate well. The information will be stylized by the person who provided it. In the case of P '03' and P '08', information is readily shared between them to the extent that they use even the same idiosyncratic phrases to talk about similar ideas. When knowledge on implementing improved pasture is exchanged not only the composition of the improved pasture was suggested but also the method of sowing suited to the producer's paddock, in this case tilling with plate plough. Information, because it is *specific,* includes an understanding of how the suggested practice will interact with other aspects of the receiver's production.

The enclave network from first observation appears to act similarly to informal 'know-how' trading (Carter, 1989; von Hippel, 1987). Producers share tips and techniques readily without any prior formal or contracted organisation. No record is made determining the cost or benefit of the information each member provides another. Braguinsky *et al.* (2009) has called this the neighbouring farmer effect and has suggested that trading information is the result of weak competitive effects. The cost to the individual for supplying competitors with information is small compared to the benefit received if lots of people contribute. Thus innovation is occurring similarly to how Antonelli (2000) suggests collective innovation is occurring; lots of disparate pieces being brought together collectively. What are missing from these explanations of competitors' behaviour are the institutional factors that intervene and condition the learning environment. The institutions that facilitate communication in the network are that people that are nearly always friends and family before they become important sources of information. This suggests that the nature of competition is not a strong reason for explaining this behaviour. The people involved are interested in the quality of information, and these people are trusted, understood and have experience that is going to be helpful. General comments by participants suggest that farmers will supply information to people if they are approached, so it would seem that the explanation of producer behaviour is not one of competitive barriers but of relevance of information to their understanding. These institutions are not generally contingent upon production as they can be maintained whether or not these producers continue to produce. Like the 'star' network, there is a certain sustainability that allows these networks to continue functioning.

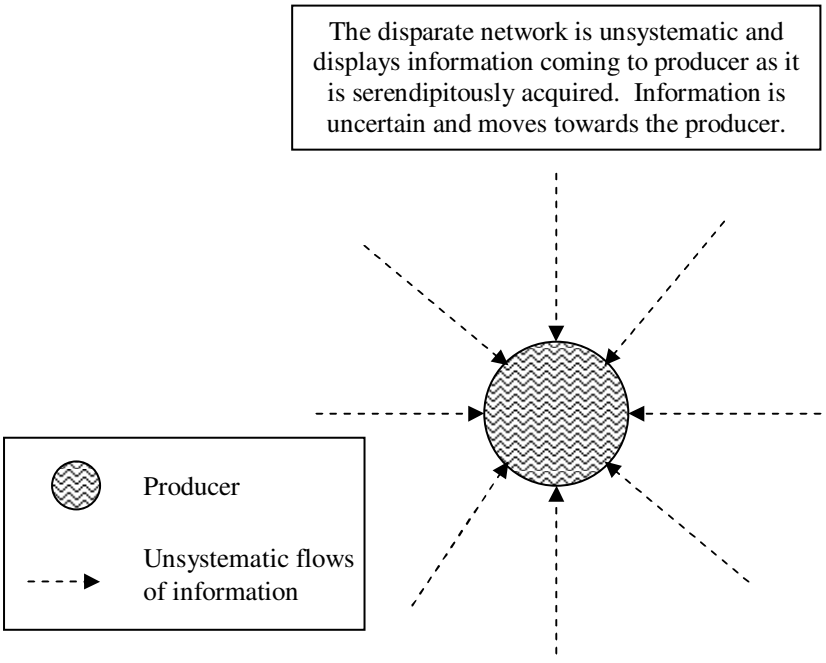
Rotational Grazing

Rotational grazing systems come in various forms; the idea of most is to move stock from area to area frequently rather than allow stock to graze on larger paddocks for a longer time period. This intensifies the use of an area at any one time. It is a management system rather than a good, service or isolated technique. A rotational system is not a tangible product and the knowledge involved is likely *specific* to their particular enterprise. These systems usually evolve over time rather than being planned exactly from the beginning. Implementing rotational grazing requires overcoming the complexity of running a dynamic system and reorganising much of

the tangible resources to synchronise their use. Participants indicated that they garnered information on rotational grazing systems from many different sources. It seems that a general understanding of the principle is provided in a disparate network that is unsystematic. Some participants suggested that they have received the initial idea from a certain source, such as a seminar, field day, observation over-the-fence or peers they know. The general comment when asked where they sourced information was 'bits and pieces, here and there'. What they had in common was that the information was sought and received on their own terms, often it serendipitously presented itself to them, but in a way that they could control the situation. The change in knowledge of the producer was the important outcome because the information could be reconciled with existing understanding. Given the complexity of the innovation and the *specific knowledge* needed for its implementation, it is likely that the only people with sufficiently in-depth knowledge are the producers themselves.

Producers are 'user-innovators' (von Hippel, 1988) with rotational grazing systems. Participants report that the implementation of a rotational system takes several years and generally they have to restructure their entire enterprise. Participant P '10' reported that their system required ten years to perfect and they also reported that during this time there have been periods where success has been quite limited. P '03', P '06' and P '01' have ongoing innovations of various rotational systems that are taking a matter of years to implement. P '02' discussed how during this process certain discoveries were made about the system that had been implemented unintentionally and only later recognised. In terms of the framework presented here, the attributes of the innovation are decisive in how producers have approached it. It is intangible in itself which means that it is difficult to convey to others, especially because of its *specific* nature. It is also complex and it takes time to implement: only by reconciling new ideas with the producer's current knowledge does successful change occur.

Disparate Network of a Producer

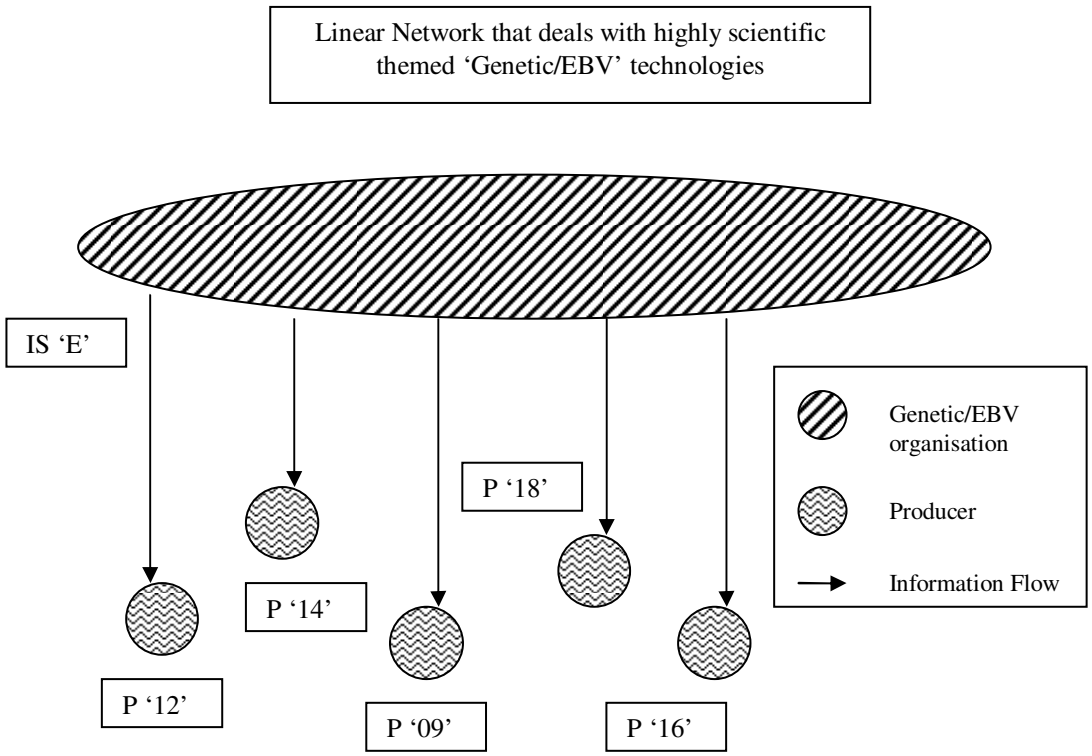


Estimated Breeding Value (EBV) and Genetic Innovations

Estimated Breeding Value (EBV) and Genetic technologies have been available to producers for a significant time. They are designed to provide measurement to traits in cattle that are of value to producers. BREEDPLAN is a program administrated by the Agricultural Business Research Institute (Graser, Tier, Johnston, & Barwick, 2005) that is most commonly used in Australia to calculate EBVs. Other genetic technologies are available such as marker assisted selection and embryonic technologies designed to assist in breeding traits into producers' herds (see Pollak, 2005). These technologies are presented to users in a 'top-down' (Black, 2000) fashion largely due to the nature of the innovations being implemented. These innovations are highly scientific involving specialist knowledge; most farmers do not have this nor do many other agricultural organisations. Because they are measuring concepts that cannot be readily seen and interacted with by producers, i.e. genetics occurs at the cellular level and EBV's rely on aggregated physiological measurements of a large number of cattle, producers cannot look directly at the sources and gain a strong understanding of occurrences. Institutions such as research organisations have the ability to do this instead, because they have equipment, financial resources and human capital to look the sources of cattle traits of interest. Producers then utilise their services to gain use of the innovation. Producers are in the position that they can not interact with the sources of knowledge and much of the literature and information that is available provides only a surface level understanding. Scientific literature is technical and jargonised which means that many producers are not familiar with the language used.

Participants trust these organisations for value of the services rendered but some express frustration about their involvement in the information process. The information exchanged is less specifically situated than in other network forms. Producers provide their information to the service provider; the service provider runs various tests or computations that apply industry wide. Service providers then return the results pertaining to the producer who uses them to make decisions on their breeding strategy without further input from the information provider. The process leaves producers with abstracted results which relate to their stock but require interpretation from a process they do not fully understand. Participants have suggested that they do not know what or how processes are being conducted, only that they receive the results to act upon. No participants used these results exclusively and all employ visual means as well as EBV or genetic testing to make final decisions. This system with little interaction between producers, or between information supplier and producer/client, to operationalise the information received, represents a 'top-down' method of service provision. Organisations providing these technologies are interested in communication with end-users of their services (see Bindon, Burrow, & Kinghorn, 2001) but the mediation of the high level science and computer algorithms in the information process introduces an indirect and isolated process for use to sustain innovatory activity. The science involved in development of improved pastures or rotational grazing is also highly complex, but in terms of the implementation and interaction by the producer in these innovations there is less of a 'black box' effect. Producers have limited ability to interact during use of genetics/EBV technologies.

‘Top Down’ Linear Network



Implications

Information sources are often agents of change that introduce new ideas to the knowledge producers possess. Knowledge developed elsewhere is useful to producers to change their production systems. Acquiring new knowledge is not a matter of *transmission*: producers need to be able to learn concepts to use them. Most innovations have complex attributes, and this research indicates that where an information source external to the enterprise has been involved in the process, they often have *specific knowledge* of the producer’s situation. This involvement varies with the type of innovation, but with complex and often radical changes, useful information sources consistently provide the opportunity for producers to interact. In terms of knowledge capabilities these information sources allow producers to use other people’s knowledge in their production.

The effect of being able to utilise knowledge capital can best be seen in contrast where a producer had no information sources. One participant interviewed provided this scenario where the style of production had not changed substantially in a lengthy period of time, although industry conditions have changed. They did not have substantial external knowledge capabilities. This was not to say that the producer was secluded; they had participated in other occupations over the duration of their beef cattle production and knew many people, but they did not make complex changes to their production system or seek out knowledge that had been created elsewhere. This

producer's experience suggests that it is a significant advantage to producers to have external knowledge capabilities because they have a greater capacity to change their production beneficially.

As local knowledge is introduced into a theoretical model, a case is generally made for a policy to be less intervening to allow producers to make their own decisions. Hayek (1945) states that when individuals make their own decisions at the local level they make the most efficient use of knowledge. To a certain degree this is the case here, but it would seem folly to disregard the notion of policy as a tool for improvement of innovative outcomes. A policy must be flexible because the industry displays a wide range of heterogeneity (Vanclay, 2004). Firms have some similarities depending on their local circumstance, but the situation of producers is almost always unique. Instead policy should be aimed at the indirectly influencing innovation implementation. This can be achieved by establishing and improving the quality of networks, such as by making sure that networks have access to relevant information and that connectivity within networks is frequent. Setting and institutional conditions should also be conducive to high quality information being exchanged. Providers of information need to ensure that their information is delivered in a way that producers can explain it to each other (Keogh, Watson, Bell, Cobon, & Dutta, 2005).

Information networks take many different forms such as linear, web, enclave, star, rings, irregular and disparate patterns. They represent the shared organization of knowledge and its path between people and enterprises. The focus on individual interactions allows us to understand the point of view of the individual (Vanclay & Lawrence, 1994). But recognizing the network extends beyond the individual, an opening for policy to be enacted is provided. Those charged with implementing policy should look at the functioning of the relevant networks and improve the potential for learning to occur and the flow of information. This would provide an indirect way of improving innovation conditions. Producers would be able to make more informed decisions. It should enhance the 'indirect' knowledge capabilities (Loasby, 1998a) instead of trying to influence direct capabilities. By allowing people to make their own choices, the model reduces the pro-innovation bias evident in diffusion literature (Rogers, 2003) is reduced.

Top-down extension is appropriate when the attributes of the innovation preclude the ability of producers to feasibly generate the technical knowledge on their own accords. Providers of such services must provide sufficient information of their processes to producers so that based on the understanding they develop, some form of localised decision making can be achieved. In the case of genetics/EBV's, producers need to know how to interpret information, what level of reliability they should place on the information, and what are the assumptions and context that lie behind the information and its interpretation. The greater the interaction of producers in knowledge processes the better as interaction allows them greater opportunity to understand and apply concepts related to the attributes of their particular enterprise.

Establishment of a variety of networks is recommended because different innovations and different information comes from various sources and in a range of formats. This will allow producers the best opportunity to develop enterprise specific information they desire. Additionally, networks that have sustainability would be superior to those that do not. While a significant number of external sources are available for use, not

all of these are sustaining, either by institutions, such as friends or family, or by the nature of production itself where reliance on new information comes from the continuing need to deal with change. If a network is sustainable the chance of creating beneficial relationships between people is increased. Existing knowledge held by people could be utilised iteratively and built upon instead of having to search and find new relationships to gain information once they recognise the need.

Different innovations require different techniques to allow appropriate build up of knowledge. Different techniques for *learning* will be displayed by producers: they have different goals, experiences, production constraints and connections to other people. Networks allow these factors to be substantially reconciled, providing a functional means to acquire quality information to generate essential knowledge.

Conclusion

Frank (1995b, 1997) discusses that cattle producers employ their own individual rationale to adopt innovations. Often adoption literature emphasises the notion of imitation or copy. Incorporating learning into this approach is an attempt to move away from simplified devices that do not show process. Conceptualising learning allows explanation and includes producer's heterogeneous circumstances. Beef cattle production is evolving continuously and theory that can include a variety of situations is required for effective discussion of innovation.

The distinct forms of networks discussed here can be attributed to the 'capability conditions': the attributes of particular innovations; institutions present; the media of communication; and prior knowledge and experience that producers possess. These factors in the development of knowledge shape how producers organise themselves and the qualities of information they receive.

Information should be provided at the local level to meet producer's needs. This can be achieved by having quality information, such as local research stations and local professionals, making material available. Specific information needs can be addressed by making sure that networks exist and that the information that is provided to a network fits the patterns of interaction between participants in the network. This allows policy and high level scientific research to make important contributions to the industry through information channels rather than impose subject matters. Decision making is left to each producer which means they can utilise their understanding of their enterprise in an effective way.

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