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**Internal Innovation and Informational Dynamics within
Small and Medium Beef Cattle Farm Enterprises**

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Chris Noble

Abstract

The internal knowledge capabilities of small and medium beef cattle farm enterprises are examined using information economics to gain an understanding of how these organisations approach innovation. Enterprises are viewed as being embedded in the wider industry and are subject to both external and internal influences. However the discussion here is focused on internal activities in order to consider how enterprise specific knowledge is constructed allowing innovation to occur. Innovation is an incremental and continuous process because of the endogenous origins of the internally developed knowledge used to enact it. Learning theory is incorporated into this analysis to elucidate this connection between production undertaken and the historical shaping of knowledge capabilities into enterprise specific knowledge.

Routines are introduced as units of analysis to show how resources are internally organised according to the knowledge producers possess. Routines provide a method of looking at processes by explicitly considering the time dimension while including the complex farming environment as a physical and biologically conditioned system. Analysis of changing routines through learning theory shows there are internal motivations for innovation directly attributable to the internal productive nature of beef cattle farm enterprises. Data has been sourced from in-depth interviews and focus groups conducted with producers in the New England area of New South Wales. Results show that much innovative activity is informal and not recorded; producers develop extensive knowledge in accordance with the physical capital they possess; and individual innovations should be considered as collections of on-going refinements.

Introduction

This investigation of internal innovation looks at how beef cattle producers gain and use knowledge from internal activities to change their production. Much of the innovation in beef cattle enterprises can be attributed to the efforts of producers using the enterprises' already existing resources to enact purposeful change. Antonelli (1996) explains that enterprises can gain information from either internal or external sources for the use in production. As enterprises frequently use both they are embedded in the wider context of the local environment and the beef industry at large, suggesting the internal activity that takes place inside the enterprise takes into account events beyond the 'farm gate'. The focus here on internal sources provides new understanding of how the resources that an enterprise possesses, producer's knowledge and the nature of beef cattle production influence the innovation taking place.

The nature of beef production is that it is ever-changing; conditions are never exactly the same although internal patterns do emerge that afford some predictability to producers who productively arrange resources. Production within beef cattle farm enterprises is complex, meaning that new outcomes cannot be predicted easily before decisions are enacted. Producers do not have complete control of many of the resources and instead they attempt to develop complementarities between resources and during which they develop their own

complementary knowledge. Innovation takes place where producers are knowledgeable and can manipulate resources. As production takes place producers learn more about the activities they have undertaken allowing further innovation to take place.

The capabilities view used here emphasizes the knowledge component to undertaking innovation and that the process of gaining that knowledge is not automatic; there are limits to the development of knowledge. Neo-Vygotskian learning theory is utilised to look at the cognitive means producers have to recognise problems and attempt to solve them. Producers employ cognitive *tools* and *signs* as means to mediated between the productive situation they face and their knowledge. Where producers possess the necessary means they can interact and solve the problems within their enterprise. Neo-Vygotskian theory allows analysis to show how producers cognitively labour within the productive environment gaining understanding of some aspects while other areas of knowledge remain less developed.

The producer's knowledge is further conceptualised in terms of organisation of the enterprise. Routines provide a unit of analysis for conceptualising activity oriented around the productive cycles of the enterprise. Routines provide a useful way of conceptualising productive activities and simultaneously show producers using their knowledge to undertake this activity. By describing the organisation within the enterprise, the way that everyday activities contribute most to producers' knowledge is shown to contribute to innovation. The role of seemingly mundane activities and routines points to the conclusion that beef cattle farming enterprises will follow incremental innovation rather than more radical forms.

Three examples of innovations commonly implemented in enterprises in the New England area are provided to show the informational processes that producers use in attempting to successfully innovate. Rotational grazing systems, high performance pastures, and estimated breeding value (EBV) and genetic breeding technologies have different traits as technologies and practices but in each case producers modify their implementation to suit their individual preferences and context. Producers' productive knowledge will incorporate elements of these innovations but there is more than a simple conglomerate of ideas placed into use; producers will have their own idiosyncrasies which show perceived connections between parts of their personal knowledge and the activity they undertake to implement them.

Theoretical Background

The capabilities approach (Loasby, 1998a, 1998b; Richardson, 1972) to examining production involves looking at the possible outcomes producers can achieve with their knowledge and resources. This includes recognising that people do have limitations to their knowledge and that they require an intimate understanding of their productive context if the processes they attempt are to be undertaken successfully. Capabilities theory recognises the importance of knowledge of how to produce over and above simply knowing what the resource endowment is. Capabilities are conceptualised as a cognitive problem as well as a problem of deployment of tangible resources such land, capital and labour, and are central to determining what beef cattle producers will produce. Just as the physical and biological attributes of beef cattle enterprises are diverse so too are the capabilities of producers who are making decisions about organising their enterprises' resources (Loasby, 1999). The internal knowledge capabilities of an enterprise refer to not only the knowledge that the firm currently possesses but also future possibilities to create knowledge (Loasby, 1999).

Productive knowledge is formed through learning involving the cognitive processing of experience and acquired information. From the information economics perspective

(Lamberton, 1996; Macdonald, Lamberton, & Mandeville, 1983; Macdonald & Nightingale, 1999; Rooney, Hearn, & Ninan, 2005), it is important to distinguish between information and knowledge. Information is a flow concept while knowledge a capital stock (Machlup, 1980). The communication of economic information (Babe, 1994) cannot be assumed between the source of information and the recipient, and the transformation of information to knowledge by the recipient is not automatic. Instead, information must be organised so that it is apparent and accessible to a producer and then reconciled with the producer's already existing cognitive structure to form knowledge. Neither this organisation nor the process of reconciliation can be summed up in simple terms as a number of visible and invisible effects and affects change how information becomes knowledge. The knowledge formed from a particular piece of information will be different for each producer.

The internal nature of beef cattle production is one of uncertainty, which presumes change. Most producers face different situations because they manage different and distinct enterprises. The knowledge each possesses will also be different due to their experiences and the way they employ knowledge will be unique.

It is difficult to directly attribute the origination of knowledge directly to one particular enterprise, partly because information and knowledge are frequently intangible and hence difficult to identify or measure, and also because the processes that contribute to the development of a producer's knowledge often rely on a number of experiences. For example, tacit and localised knowledge can be largely attributed to the historical development of resources internal to an enterprise, but there are influences through experience from external sources as well. The process of using knowledge over time suggests that producers use the means that are available according to their preferences, including ideas that have been historically developed both internally and externally to the enterprise. These ideas change over time as the enterprise and producer's knowledge change. In general, beef cattle enterprises need to be recognised as locuses of knowledge and information embedded within the industry. Development of internal knowledge and associated capabilities can be attributed to the on-going production and activity by producers sourcing information and experiences from the enterprise's resources.

The orthodox market-based view of information is limited in describing the internal innovation phenomena taking place. It has a tendency to focus directly on outcomes. Most of the information producers require to make decisions needs to have been assembled well before their produce reaches the market. Producers certainly are interested in market information and will act accordingly when they receive it, but the information used for internal innovation requires a different view. Instead information should be viewed as an input in production and that it has capitalistic qualities (Machlup, 1980b; Potts, 2003). "In its narrowest sense agricultural information can be regarded as a factor of production in the same context as land, labour, capital and managerial ability." (Davies, 1988, p. 156) When combined with other resources for economic activity, information is used to extend production. While information is often priced and traded in the market place, in this study it is contended that its most important purpose is its use in coordinating resources into useful systems and practices. Information contributes to knowledge cumulatively over time and, as a result, knowledge forms feedback loops and evolves. Its depreciation is not like other tangible goods which 'wear out' increasingly as they are used. Instead the quality of knowledge resulting from productive information increases the more knowledge is used. Information is a resource that defines the usefulness, relevance or appropriateness of current and future resources. It is a resource that has its origins before the beginning of a productive

period, but is continually generated and integrated as production takes place to ensure that production proceeds in accordance to the desires of the producer.

Processes of Innovation

The process of innovation consists of more than producers creating change in tangible objects (Macdonald, 1983) and includes other more intangible phenomena such as information, knowledge, relationships, ideologies, processes and organisation. Innovation requires 'newness' in the action of an individual (Rogers, 2003) which imposes 'novelty' on a producer's knowledge (Shackle, 1972) and the enterprise. The introduction of a novel situation requires efforts by producers to reconcile this 'newness' with their current understanding and to change their knowledge accordingly.

Change is a normal process from within a beef cattle system but not all change can be considered innovation. Innovation can be narrowed down to novel or new changes that producers are responsible for and which arise from their recognition and manipulation of the system. Innovation does not include all change to beef cattle enterprises because there are many sources of non-innovative change such as producers using contingent knowledge or those occurring without the interaction of the producer due to events external to the enterprise such as change in the weather or markets. Not all the contributing factors of change are controlled by producers, but often they have to act upon these external changes to maintain production. Adaptive and systemic changes are important sources of variation for innovation and they often precipitate producers' innovative efforts. Recognition and manipulation of resources takes place through the knowledge that producers have obtained, thus internal innovation in beef cattle enterprises, like all innovation, is influenced by the environment that producers are working within. Conversely, where knowledge is lacking, producers are less capable of making decisions that lead to their goals. Innovation will be directed toward areas in which producers have the ability to construct knowledge and away from areas they cannot construct knowledge in.

As the innovation is occurring internally, producers are 'learning by using' (Rosenberg, 1982), and that the user is the innovator (Von Hippel, 1988) rather than another entity developing an idea for beef farm enterprises to adopt. Robson (2008) suggests much of the innovative activities are undertaken incrementally in 'everyday life' and these are likely to be minor improvements. These make up a significant contribution to change within enterprises as producers utilize their own inventiveness and come up with ad hoc but effective solutions to problems and undertake 'production centered innovation' (Vincenti, 1992). They may not be recorded in surveys or innovation studies because they are not in the focus frame of the researcher (Chambers, 1989) because they are individually insignificant to production output or they are diverse and cannot be aggregated easily. Internal refinement is the normal mode of advancement because a majority of economic knowledge created is done so during production (Machlup, 1980a). As will be discussed, much of the innovative efforts of small and medium beef cattle enterprises are undertaken via this mode.

Internal motivation to innovate comes about through three distinct ways:

- Internal activities where the producer changes their everyday activities on their own impetus because they have either planned to change (such as a milestone) or changed their preferences.

- Responses to unanticipated activities (such as weeds or pests) in the system where an unpredicted event has occurred. The initial event is non-innovatory in the short term but causes the producer to react to form a satisfactory productive order by applying their own knowledge. If producers do not use contingent knowledge, they will have to use a novel solution. This could be extended to external influences on production such as the weather, markets, policies or activities of neighbours where the producer uses internally constructed knowledge to combat these impacts.
- An initial external innovation is presented to producers and they modify it to suit their purposes.

In each of these avenues new knowledge is derived from attempts to make a new productive system out of the previous productive order. The activities of producers are central to these innovation processes rather than external innovations being simply added into production. Innovation is an on-going complex process that producers undertake because they are innovative and the pursuit of beef cattle production provides an internal motivation for producers to do so.

Enterprise Specific Knowledge

Small and medium beef and beef-mixed cattle enterprises usually have only a small number of people whose labour is internal to an enterprise, particularly family and partnership enterprises which make up the majority of enterprises in Australia (Liao & Martin, 2009). Most of the decision-making is carried out by relatively few people, producers, who have to be in a position of knowledge to make high quality decisions.

Enterprise specific knowledge (Antonelli, 1996; Arrow, 1974; Nelson & Winter, 1982) is constructed through the experience of producers undertaking production. Enterprises are significantly different to each other and variation between enterprises occurs in many different ways. The complexity present in all enterprises decreases the likelihood of enterprises having identical productive processes even though they possess many of the same quantities of resources. The productive environment has a large bearing on the producer's knowledge, which means that a particular producer will have knowledge that is different and unique to other producers, while *local knowledge* ensures that enterprises not in geographical proximity may have quite different production methods. *Enterprise specific knowledge* represents the diversity to a greater extent the differences between enterprises. It is the operational knowledge that is of value only to an individual enterprise because other enterprises do not have the same features, and importantly, it includes the knowledge the producers possess in creating this diversity.

Neo-Vygotskian Approach to Learning

Innovation is a learning phenomenon because relating to a new situation involves forming new knowledge. Learning is a historical process because producers use their previous knowledge when trying to understand something new to them. They build up a stock of knowledge which is relevant to production. Prior understandings effect the new understanding because prior understanding affects whether something can be learnt, and also shapes perspective about that which is learnt. The stock of knowledge is not simply a collection of abilities but also a view point which orientates and predisposes producers toward their activities. The Neo-Vygotskian Theory (Daniels, Cole, & Wertsch, 2007; Karpov, 2005; Valsiner, 2000) of learning, sometimes referred to as 'Activity Theory'

(Valsiner, 2000; J. V. Wertsch, 1985a), shows how knowledge develops. It stresses the link between the social environment and the development of knowledge through people acting within this environment (J. V. Wertsch, 1985a; J. V. Wertsch, Minick, N., Arns, F. J., 1984). Producers making decisions on any aspects of innovation do not have automatic understanding but have useable knowledge and require 'activity' to relate to task and gain understanding. It follows that things affecting activity and the formation of knowledge potentially affect innovation. Commonly identified cognitive aspects which could affect activity and learning include prior knowledge, attitudes and beliefs, legal institutions, political persuasion and opportunity for experience. These change the how people will act toward a situation and this leads to change in the formation of knowledge.

Neo-Vygotskian theory uses *tool-semiotics* as the *meditational means* that people use to relate a situation and their knowledge. *Tool-semiotics* comprises of people employing *tools* and *signs* (J. V. Wertsch, 1985b) to mediate their interaction. *Tools* are the components of personal knowledge producers use to manipulate their situation according to their volition. *Signs* are the sources of feedback to producers that inform them about the effects of their action. The use of *tools* and *signs* simultaneously in the situation creates cognitive *interaction* as producers require both to 'negotiate' with a situation. Only *tools* and *signs* that have been acquired can be employed to gain further understanding. They are historically developed from previous situated experiences and then they are available to be employed to develop new knowledge.

When considering knowledge and innovation, producers can only innovate to the extent that they can voluntarily control the activities they are undertaking (Polanyi, 1967; Rieber & Carton, 1987), i.e. they must be able to exercise control of *tools* and recognition of *signs*. This voluntary control represents a producer's knowledge capabilities to innovate and the extent that new *routines* are formed. Based on their prior voluntarily controlled knowledge, they can learn new understanding which will enable them to innovate.

This frames innovation in terms of the extent producers can manipulate and voluntarily control their innovation rather than the present activities taking place. Differing use of *tools* and *signs* accounts for this variation because producers need to be able to apply tools and signs to innovate. This distinguishes people who can innovate from those that cannot introduce similar changes. Someone who is merely copying or imitating their neighbour will have less ability to innovate than someone who is able to apply their understanding to manoeuvre the situation. Producers possessing greater mastery or voluntary control of concepts or have appropriate *tools* available to collaborate with will be able to innovate where others cannot. Often a range of practices are employed by different producers rather than the latest development replacing previous developments (Rosenberg, 1979).

Cognitive artefacts (Norman, 1991) are a class of *tools* (and provide *signs*) that producers frequently use in productive activities. Cognitive artefacts could be physical implements such as shovels, picks and machinery which are available for producers. They can be as even as simple as a blade of grass used to check the power to an electric fence. Some authors have suggested less tangible forms of artefacts are also cognitive artefacts, such as sounds and even mental simulations. Physical implements have different qualities to other cognitive *tools* as they have a physical presence. Cognitive artefacts change the interaction and possibilities for producers to learn new concepts, often extending their abilities beyond what would otherwise be achieved.

Cognitive artefacts are abundant in beef cattle enterprises, for example, cognitive artefacts include physical implements such as shovels, vehicles such as tractors or computers for recording, analysing data, word processing and communication. Producer's knowledge is extended by the artefacts to the extent they can manipulate them and this knowledge includes the aspects they are using the artefacts toward, i.e. they know how to use hand implements and the hand implements are being used to manipulate some part of production which they will be knowledgeable about as well. These implements are providing two uses in their roles as *tools*: they expand the possible experience that a producer could have been exposed to and they complement the use of other *tools* (which may be quite intangible or cognitive *tools*), allowing them to be used.

There are some limits to the knowledge producers can develop internally. Many different aspects involved in production are not available to interaction for producers; they simply cannot see microbes and minerals at work and effects such as climatic patterns are difficult to predict precisely ahead of time. Where decisions would ideally involve such components, producers do not have the cognitive *tools* and *signs* to use. Frequently producers use cognitive artefacts to enhance their ability to interact with some productive aspects. For example, artefacts that measure quantities of interest such as rain gauges or devices for pasture growth. Information about other concepts will have to be sourced externally because producers do not have the capital to interact with these concepts. The required capital, used as cognitive artefacts, is not commonly found or even available to beef cattle enterprises. For example, small and medium enterprises do not have laboratories and associated instruments. The consequence is that producers will not develop these kinds of knowledge internally and this will limit internal innovation.

The activities undertaken in running an enterprise will shape this knowledge just as producers, who are making decisions, will transform the enterprise according to their knowledge. Knowledge capabilities are related to routines because people need knowledge to act and that knowledge comes from past activities. Producers look to innovate according to their knowledge developed from their production activities. They make decisions based on what they have learned about their enterprise in its particular setting and given its particular characteristics. Information derived from its internal characteristics and performance constitutes the knowledge capability of the producer that can be applied to make production decisions for the next production cycle.

It is argued that the nature of beef cattle production lends itself to cyclical behaviours that are important to the development of knowledge and allows production to occur even though it is a complex undertaking. Both the knowledge and performance of production seem to be conducive to iterative processes.

Routines as Unit of Analysis

Cyclical and daily occurrences can be described as *routines* (Nelson & Winter, 1982). "A routine is an executable *capability* for repeated performance in some *context* that [has] been *learned* by an organization in response to *selective pressures*." (Cohen, et al., 1996, p. 683) "They [routines] are a persistent feature of the [system]" (Nelson & Winter, 1982, p. 14) and are "processional in nature" (Becker, 2004, p. 649). *Routines* are conceptualised as the unit of analysis for internal organisation (Pentland & Feldman, 2005). Because they are a process they have a time dimension built into their conception, allowing activities not just to occur but to be organised in relation to other activities. Just as knowledge has the ability to enable action in some directions while obscuring others, routines as a performance of knowledge

also enable some avenues while hindering others (Feldman & Pentland, 2003). Routines are emergent phenomena which are born out of the previous iteration's traits (Feldman, 2000; Pentland & Feldman, 2005). The capital qualities of information and knowledge present in production (Machlup, 1980b) are exemplified by the influence of prior knowledge on subsequent routines. By considering the properties of routines as a process (Becker, 2004; Pentland, 1995), and how they can change, understanding of the innovation process is formed.

Routines provide a link between knowledge and productive activity. Most knowledge of production is developed internally to the enterprise, placing producers in a unique position of generating knowledge for decision making in their own enterprises. Forming routines has the informational advantage that producers can predict future and remember past occurrences (Hundeide, 1985) overcoming some uncertainty. Routines are carried out according to the producer's capabilities. They are predictable components because they are iterative in nature and increase the predictability of production. The long term nature of many production cycles and decisions relating to modifying them means that the 'horizon' when the final outcome presents itself may be some time away. Only at the final stages it is possible to draw conclusions about the success of processes used but the decision to use this process was made at the present. Once enacted the decision to use a process is not reversible. Using routines can be seen as a cognitive method of overcoming the uncertainty presented either through the complexity of tasks or long time horizons between decisions and outcomes.

Routines also provide a way of keeping track of stages in production. The production of beef cattle relies on different routines being used at different times with some shorter and others longer. Routines are often comprised of shorter subroutines which when added together create a longer productive cycle. By using routines, producers can keep track of which stage of production is happening. This also provides a method of accounting for the use of resources they have available and how many resources they have used, particularly when subroutines are involved in longer productive routines.

Routines in beef cattle production generally have their constituent activities undertaken in a relatively fixed sequence and time frame. These fixed qualities are derived from physical and biological aspects that *a priori* set the timetabling of activities. For example, the growth of pastures is dependent on the nature of the particular pasture species which a producer has limited ability to control. The producer has the ability to select or choose a pasture and methods to establish and maintain it, but ultimately they are adhering to the nature of the pasture. The fixed timing within these routines reduce the available options to producers to organise their resources. This provides a strong reason for routines because of the presence of cyclical influences within production.² They cannot change the timetabling easily because past decisions affect on-going activities and changing this on-going activity may not be possible or will cause substantial losses of production.

A productive order comes about within an enterprise because the resources are organised in way that they complement each other. Resources and routines are interrelated because of these complementarities so that a change in one routine or resource will affect the roles of others in production. When an innovation is introduced, the change accompanying it needs to be reconciled with other routines and resources to restore productive order. This suggests

² External Influences are also a contributing factor to the cyclical nature beyond the discretion of producers such as domestic and international markets (Griffith, 2002; Mundlak & Huang, 1996; Rosen, Murphy, & Scheinkman, 1994)

beef cattle production is more conducive to continuous innovation than radical or disruptive sorts of innovation, where the change has a greater impact on the current productive order. Each resource will dictate its use in routines to some extent because of its nature and the combination with other routines will have to be altered accordingly. As Narduzzo, Rocco & Warglien (2000) explain, complementarities protect the current arrangement of resources from change because changing one component means changing others; there is a localised 'inertia'. Because of the interrelatedness of components in this system, once a complex variable is changed through innovation other parts of the system have to be altered to make the change viable. This means, a collection of refinements and other minor changes have to be made, much of which will be internally originated. If a large, radical change is proposed, a substantial change has to be made to the rest of the system.

Simple Model of Routines in a Beef Cattle Enterprise

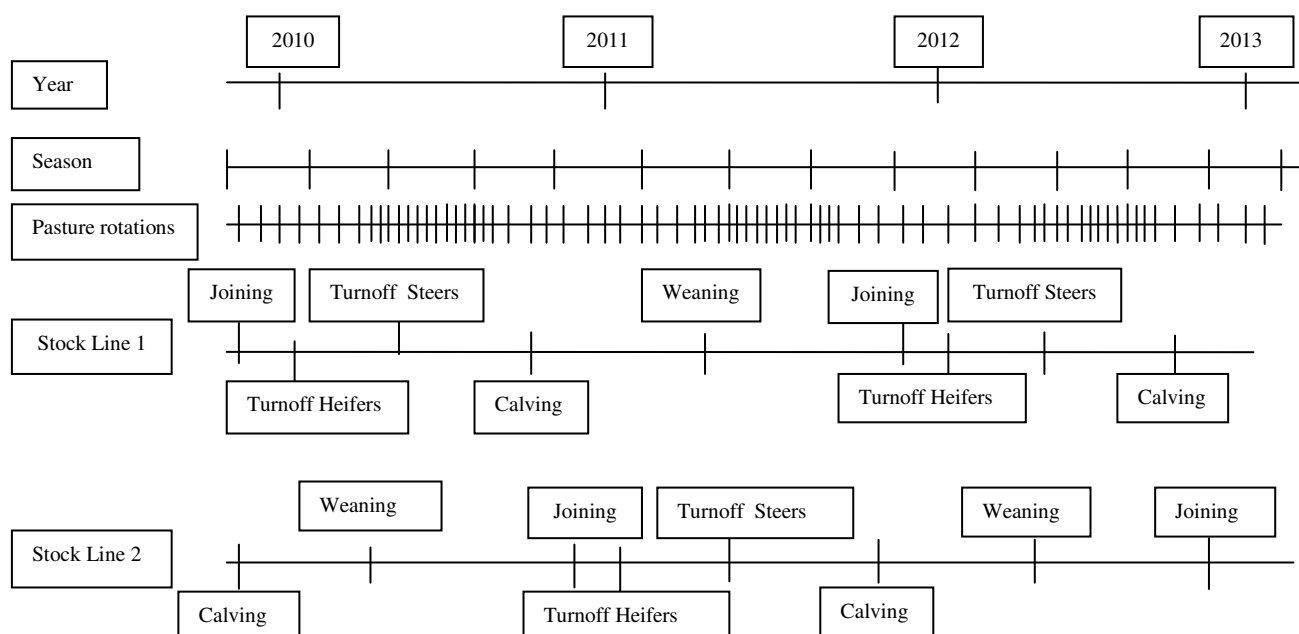


Figure 1. Simple model of a beef cattle enterprise with two lines of stock. It demonstrates the complexity of routines and the fixed timing of activities taking place. Routines do not align with others in a regular pattern and the change of timing of one activity will disrupt other activities and routines causing their timing to change as well. More in-depth modelling increases the apparentness of the complexity in an enterprise.

This focus of routines on everyday and possibly mundane activities as a unit of analysis for innovation moves the emphasis of innovation away from the extraordinary or exceptional behaviour and toward views that innovations are common and normal practice in small and medium cattle enterprises. The view of routines used here is one where routines change over time in accordance to what producers have learnt. Routines will change with collections of small continuous innovations allowing producers to manoeuvre resources towards the desired productive order.

Routines afford producers some regularity and are a cognitive method of dealing with uncertainty (Becker & Knudson, 2005) but routines are also susceptible to unanticipated changes from the productive environment. These are unsolicited changes that provide an avenue for emergent complexity to enter the productive environment. Activities on a day to

day basis involve sets of pre-conceived routines which are ordinary and other activities that represent maintenance of long term production cycles where producers try to modify unpredicted changes. Acting on the unpredictable unsolicited component relies on new information accessed by producers before they act. Usually the earlier information is received, the greater the benefit conferred, as this allows either for minimisation of deviation from planned production or later planning. Without disregarding the possibility of innovation, producers are committed cognitively to maintaining their routines, particularly long term cycles as they aim towards their goals. This must be so as they wish to act toward their goals with their knowledge. When these routines are disrupted, because producers are committed to their routines, they recognise that there is a difference (Hundeide, 1985). Producers, recognising this difference, can then engage to problem solve. Producers may resort to already acquired knowledge as a solution (contingency), or they may seek to use *tools* and *signs* to create a novel (innovative) solution.

Categorisation of Activity Internal to Beef Cattle Farm Enterprises

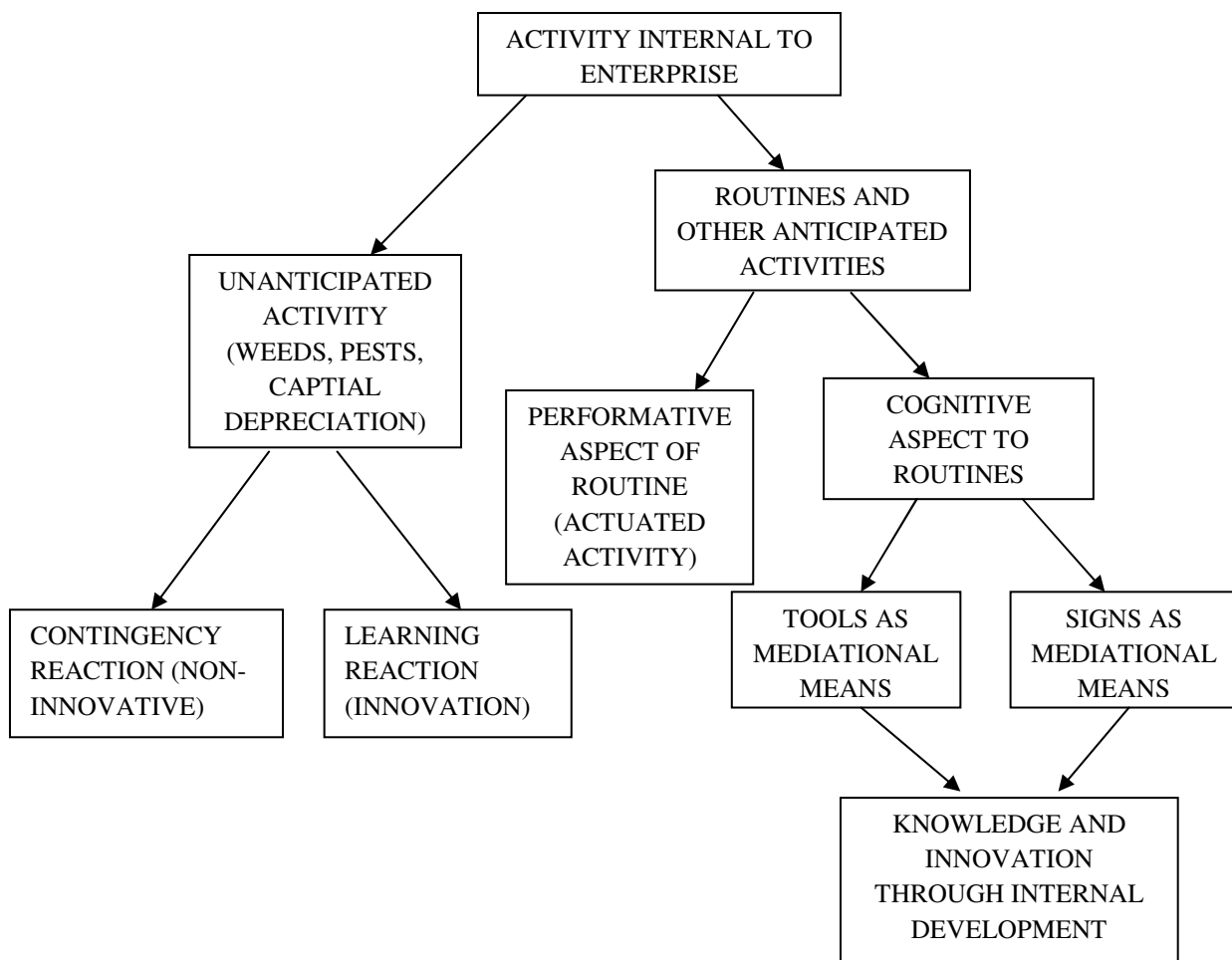


Figure 2 - Categorisation of Activity Internal to Beef Cattle Farm Enterprises. Internal activity of beef cattle production aspects are categorised showing a distinction between activities producers contribute purposefully toward (anticipated activities) and those where unpredicted elements arise (unanticipated activities). Cognitive aspects of solicited activities are broken into the Neo-Vygotskian framework which allows producers the ability to carry out their routines and provides the capabilities for dealing with unsolicited activities. Unexpected behaviour may lead to producers reacting by either employing contingency or attempting to learn and fix the problem through innovative means.

Activity can be divided into two categories depending on the actions and knowledge of producers:

- routines where the producer is carrying out anticipated acts they previously intended to undertake and;
- unintended activities where producers react in order to maintain routines.

If the system moves away from order, producers will have to unpredictably devote resources to rectify such events. Unpredicted events include damage to physical capital, weeds, pests, parasites, erosion and stock behaviours. Such occurrences may motivate producers to innovate because producers have to act to restore their productive order. Innovation is the result if during the cause of restoring productive order producers gain new knowledge and then act on this knowledge to implement it into production. Feldman (2000, p. 620) refers to this as *repairing* the routine. This represents an encounter with either a novel state of affairs or being presented with a routine failure (Gersick & Hackman, 1990) but *repairing* the routine relies on producers being able to use their *tools* and *signs* as their capabilities.

Methodology

Empirical data was gathered using semi-structured in-depth interviews (Minichiello, Aroni, & Hays, 2008) and focus groups (Stewart, Shamdasani, & Rook, 2007) of beef cattle producers from the New England area of New South Wales as well as related people or organisations that were nominated as important information sources by these cattle producers. Producer participants who were involved in small and medium enterprises were targeted to be involved in this study although some others who had slightly larger herds were also interviewed. ABARE defines small enterprises holding herd size of 100 to 200 head of stock and medium enterprises 200-400 head of stock (Hooper, 2010). A total of 32 beef cattle producers and 8 information sources were interviewed.

In-depth interviews with producers were designed so that responses illuminated the processes of innovation that had taken place. Participants were asked to tell their ‘story’ so that a historical account of how producers both acted and thought about innovations they had implemented could be constructed. They were asked about knowledge they held previously to undertaking innovative activities and their reasoning for the decisions they had made. This included not only successful elements of implementation but also failures that had occurred in order to gain richer information about the innovation process. Responses allowed insight into the build up of knowledge that producers achieved at the same time as related activities were performed.

Discussion of Results

Discussion with producers suggests that continuous innovation, as opposed to radical change, is the preferred mode of introducing novelty. Change is highly path dependent not only in deployment of physical capital but also in terms of the knowledge used to organise resources and decision making for innovation. Producers generate much of their knowledge internally suggesting “we work a fair bit out for ourselves”. Factors other than information and knowledge are prominent in the minds of producers when planning production, such as availability of labour and general levels of cost of production, which unanimously is seen as an increasing barrier to innovation implementation.

It is well recognised by producers that they are heterogeneous in almost all areas of production. Local conditions and markets accentuate this as well as differences in the knowledge capabilities and goals of enterprises. This diversity means that producers are using different knowledge and that adopting the exact same innovations across most enterprises is not a feasible notion. Instead producers have suggested that they modify ideas to their own particular needs. Producers generate concepts internally, or if they received them from external sources, they change and develop concepts to suit their production. Producers have also suggested that they often do not just rely on one *tool* but use as many as they can bring to bear on their decision making.

It is a consequence of the uncertainty of production that producers recognise risk in their decision making about whether to implement or not. 'Mistakes' is a widely recognised concept and accepted amongst producers as an outcome. The 'level' of uncertainty present is high, making good decisions that lead to intended outcomes on a frequent basis difficult. Uncertainty clouds much of the decision making on processes of production. As one producer stated:

"they are not black and white decisions. Outcomes may be unknown even afterwards whether they were good. No basis for making the next decision. Even then there is a slightly different decision next because of changing circumstances. Outcomes may only be known over long lengths of time. Even then if you know the outcome, you mightn't know your alternatives."

Producers, under these conditions will move towards knowledge they are satisfied is reliable when implementing novel concepts. Narduzzo, Rocco and Warglien (2000) suggests that under uncertainty, time constraints and novelty, people who can not verify outcomes immediately use their previous experiences instead to undertake tasks and rely on the processes that are familiar. They use their routines, which through their iterative nature allow producers to use their previously constructed knowledge repetitiously.

Much productive knowledge is experiential and internal to the enterprise; producers spend time on location at their enterprise managing its resources. Experience is derived from observations as primary sources of information that are reconciled with the producer's existing knowledge. Occurrences are observed and commuted into knowledge through the use of *tools* (in the Neo-Vygotskian sense) at their disposal to interact with the situation; this participation generates knowledge. For example, producers look at their stock, their colour and appearance to compare the animals. Colour is a cognitive *tool* that they employ toward their decisions. Other *tools* are mechanical such as cattle crushes that allow producers to investigate and manipulate animals. In general, although some producers may have access to more sophisticated *tools*, producers can interact with problems on the scale that corresponds to human senses such as what is visible to people ordinarily, or hear, smell, or feel in similar fashion.

Where *signs* (and *tools*) are not evident or not recognised, knowledge is not produced. For example, producers need to have an understanding of stock weight and the introduction of weighing scales into their enterprises has changed their ability to make decisions. Producers have frequently used physical appearance to appraise the weight of stock because an animal's physical appearance is readily apparent to them. However, weight of stock depends on many factors other than the outward physical appearance such as hydration and metabolism. These other dimensions are not visually apparent to producers so the knowledge on these factors affecting weight is not developed. Producers suggested that before the use of weighing scales,

they were only guessing at the weight of stock as they had no way to measure the concept that they required. A further illustration of this dimension can be observed with feed efficiency. The lack of *signs* to measure gain in stock weight from feed consumption is still a significant barrier to producers. They can observe the variables of interest such as livestock, pasture intake, and pasture depletion, but cannot gain a useful understanding of feed efficiency because the necessary *signs* are not present. The physical capital used in weighing stock allows them to understand some situations if they can employ it as a *tool* and *signs* are received as feedback from this; they can weigh stock but feed efficiency is significantly more difficult.³

Many of the factors influencing cattle production cannot be resolved at the human sense level, i.e. using information directly from senses. For example, the micro-biological occurrences that are always present in what is essentially a biologically driven pursuit are not directly observable. Producers cannot see enzymes and plant cells breaking down various chemical compounds in the soil, or sometimes failing to do so. What producers can see are effects within a situation; they can see that certain types of grasses grow in patterns such as several years of growth before ‘dying’ out. Thus the knowledge produced is that this type of pasture dominates in a cyclical fashion from year to year. In other cases the knowledge can be of the characteristics animals display when they are sick. The knowledge produced is on the human observable level. The knowledge does not deal with the source of the occurrence and instead notices the correlation between the effects and the outcome. Producers often form hypotheses to suggest why these occurrences could happen, aware that they do not really know for sure what the situation is. This provides an avenue where information could be received from an external source.

This also suggests that for most producers there are many factors that simply cannot be learnt about with the available means, internal to the enterprise, but they do affect production. The knowledge produced will be able to be used as long as conditions and unobserved variables do not change. When they do change significantly, the previous knowledge is rendered ineffective. This could be considered as a mistake by producers (mistakes are seen as a normal part of production), as the knowledge they believed to be appropriate did not provide the expected results. More knowledge is required to maintain the productive outcomes desired by producers. This could be sourced through either internal or external means. Internal means will rely on further observation and prior knowledge of the producer and requires the producer to find a suitable *sign*. External means include finding information elsewhere to understand the new situation, e.g. an agronomist, veterinarian, dietician or colleague, and then reconciling it with existing internal means.

Where producers have additional physical capital, gaining knowledge in addition to the human scale, producers have expanded their knowledge and changed production accordingly. An example is utilising a microscope to analyse faecal matter for parasites. The producer was able to modify their management of parasites accordingly in terms of drenching and rotational grazing systems. This represents the use of a *tool* to expand the experience providing the possibility of gaining knowledge with differing characteristics. In terms of information, physical capital represents a *tool* and a capability to the development of knowledge; innovation from an internal perspective will not, in general, develop beyond the human sensory scale unless there are certain forms physical capital present. It can also be

³ Methods for estimating feed efficiency are available but they are costly, time consuming and disrupt production significantly. It involves controlled feeding and measuring of weight gain. This has the disadvantage of removing the animal from the productive context to undertake a controlled experiment.

seen from the comparison of the use of capital such as a microscope and the other *tools* such as cattle yards and hand implements, that some capital is designed specifically to provide information to producers, the microscope, and that other forms of capital are primarily suited for carrying out set tasks, such as hand implements, but these also convey information to the user (Polanyi, 1967). Physical capital that focuses on providing information may be able to facilitate more innovation than capital which provides information more secondarily. Some producers have expressed interest in the notion of *tools* that are specially designed to provide information internally to their production.

Historical knowledge

Results from empirical enquiry suggest producers have substantial historical knowledge of past events involving their enterprise. Producers frequently refer to past events as sources of knowledge, in some cases they refer to events as historically distant as the 1950s to base an understanding of current events. In a system where the exact causes of current situations may be difficult to see and to predict outcomes instantly, producers can use history to gain understanding: “the further you look back the further forward you see”. They are using experience based knowledge to understand time dependent events as they occur. They refer to an occurrence that happened previously and try to base their decisions on sequences of occurrences that are happening in the present. This is a consequence of complexity, unobserved variables and that many of the processes in beef cattle production take place on long time scales.

Being experience-based knowledge, referring to historical occurrences is an ‘imperfect’ mechanism to seek guidance. It is beneficial because it allows producers to consider past decisions and errors they made and what they could have done i.e. hindsight. Routine organisation helps this by providing timing and a comparison with alternative events. Extensive knowledge of the historical kind is derived from outcomes linked to the processes and occurrences that lead to those outcomes. An extensive knowledge of situations allows producers to act when the type of uncertainty present may not provide a clear course to do so. However, producers’ use of historically-based knowledge assumes that the current situation they are applying their knowledge toward is practically the same. The overall circumstances of the enterprise are always changing but not in consistent fashion which means some parts are changing while others can remain relatively unchanged. Producers, in the face of uncertainty and employing this technique to overcome it, may not be able to deduce the effects of the changes since they are using a different history to apprehend the future. Using techniques from prior understanding, means that change induced by the producer is not innovation; instead they are using contingencies. There might be other options available to use since they gained this knowledge, particularly if there has been several decades since its construction. Producers may have a method of acting in mind for a situation but this may in fact act as a barrier to innovation. They “lack the tools and the language for getting free of their contexts and implementing change” (Hedberg, 2003/1981, p. 563). In knowing how to act to their satisfaction, they are implicitly not asking the question about alternative methods. For innovation to take place there has to be recognition that the situation needs changing or that a better outcome might be available.

The time element is present in almost all producer knowledge because production is time based. Participants discussed changes to their practice over a series of years and decades and often discussion implicitly refers to time elements. From their speech it can be inferred that time is a concept within their perspective (Geertz, 1995). This was the case with either *simple*

or *complex* innovations such as fencing, drenching or cattle crushes and genetic technology-assisted breeding or estimated breeding value technologies. “I think it’s a long path... ...we’re all on a long path, and you know, it’s not the sort of thing you can jump off and say ‘I’m a bit sick of this, this week’ and then... ...get back on again you know. It’s a matter of whatever you’re doing, it’s a matter of just slogging along where you think you want to go and using tools that are appropriate to do it...”. This could refer to material barriers to development such as cost, but the reference to ‘tools’ provides a direct path to the cognitive problem within the time dimension context. The producers are taking a different stance to researchers and others developing innovations externally to the beef enterprise. Producers indicate innovation is a long term agenda rather than adding in new things as they are developed. As a result they look to produce consistently using similar technologies over the long term rather than changing their enterprises frequently.

Internal innovation often follows where producers experiencing a novel state of affairs are acting out of ‘necessity’ to correct unpredicted changes. Some producers have said that ‘necessity’ is a mechanism that they use towards innovation. Necessity represents an attempt to *repair* routines from an unpredicted change in the performative aspect. Maintenance of routines may occur with no innovation or, alternatively, innovation may occur and the routine will be changed. Internally producers problem solve using the means they have available such as building new fencing and gates to handle stock movement or water troughs for reducing stock water consumption.

‘Failure’ of a process to deliver the desired result will also prompt producers to change routines (Gersick & Hackman, 1990). For example, a producer being committed to a productive line of steers, and using surgical techniques (blade) for castration, saw the loss of production in using surgical methods because the condition of animals post treatment was unsatisfactory. The producer made the change to using ‘rings’ for castration, which they had preferences against prior to this failure. Again the *signs* correlating to the problem, animal condition, are on the human sense scale and with appropriate knowledge can be recognised.

Three examples of widely used innovation types, rotational grazing systems, high performance and improved pastures, and estimated breeding value (EBV) and genetic breeding technologies have been presented to provide understanding of the necessity of internal knowledge for innovation.

Rotational Grazing Systems

Rotational grazing systems are management systems timetabling the movement of stock between areas of grazing pasture. The idea is that stock will move between smaller areas of pasture for shorter periods of time depending on the designs of the producer. It is contrasted by ‘open’ or ‘set’ grazing systems where stock feed on large paddocks where pastures regrow at a sufficient rate that stock can remain in the same location for long periods of time. Most producers in the New England area follow a rotational grazing system although there is great diversity between various systems.

Producers all have different views about what is rotational grazing which range from close to open grazing where paddocks are approximately a hundred hectares to cell grazing where individual cells or ‘strips’ are twenty metres across. Each system is unique to the individual enterprise in the programming and timing of rotations, the size of areas per paddock, the fodder used, stocking rate, fencing type, watering methods or method of transiting stock.

These individualistic systems are based on the enterprise specific knowledge producers generate.

The routines involved range from daily (sometimes less than a day in high intensity production) to annual frames and often longer. For example, a producer might set the time frame for grazing a paddock to three to five days before they move the stock to a different paddock. This cycle is part of a larger cycle where the producer attempts to have pastures in paddocks regenerated over two or three months before restocking the paddock. These rotations in stocking are further varied according to the longer term goals of production. Producing breeding stock requires joining, gestation and growth of animal to desired age which could take two and a half years. Each of activity in these routines to produce yearlings affects the other shorter routines. During later stages of gestation and calving, the rate of pasture consumption by stock increases significantly, requiring change to paddock rotations. Subroutine behaviour appears to be built within the larger routines.

These systems often show development of enterprises as they are formed over a lengthy period of time. Participants required a matter of years to introduce and may require up to a decade to streamline the system. The amount of capital resources and finance required to make the change is a substantial barrier which frequently leads producers to build the system in affordable stages. Complexity is another apparent barrier for such a system which leads to the complete system being broken down into manageable stages so that resources can be manipulated without incurring substantial loss. Thus some implementations of systems are built piecemeal; developments of routine change through the 'milestone' path (Gersick & Hackman, 1990) as producers complete one area of rotational development, they move on to the next phase in their development.

Knowledge usually evolves over time leading to changes to the system rather than being implemented according to initial plans, so factors that were not known initially are incorporated. For example, one participant suggested changes occur in the manner of fencing where stock behaviour combined with planned rotations dictated a change so that herds remained separate. Allocation of water resources for stock needs to be modified according to paddock arrangement. The quantity and method of delivery were changed as needed, some producers used a system of pumps to reticulate water, others after initial plans moved away from reticulation, instead opting for placement of dams. Initial planning (which is necessary) was discarded in the light of their experiences and need to make decisions towards the development of a long term productive routine. Regular feedback allowed the innovation to change in accordance with the routines. It appears initially that rotational grazing is one radical innovation but the reality for the producers implementing it is that it is not one change but a collection of small related incremental changes over a period of time.

Rotational grazing involves tangible capital that producers, under different systems of grazing, had knowledge through experience to use. The knowledge required to implement this system is intangible (although complementary) and its development requires the coordination of resources into a process; it is difficult for producers to apply tools and signs prior to using a proposed innovation to gain working knowledge; it does not exist. Producers have nearly failed to implement after significant attempts. Others have made unintended discoveries that have been beneficial through the development process. People employing their understanding from previous systems will gain some understanding, but the rotational grazing system and open grazing system seem to be distinct substitutes that do not afford one another adequate complementary knowledge. Some of the understanding of previous systems had to be changed in the process. The intangibility of much of the knowledge in the process is

such a substantial barrier to using tools and recognising signs that quick implementation is not possible. Producers' historically gained knowledge did not necessarily work when they implemented the new system.

Improved and Performance Pastures

Improved and performance pastures are initially tangible seed products that are usually obtained through external retailers. A significant level of information comes from external commercial channels in codified form, such as the sowing rate and method, compatibility with other species, soil preferences, climate preferences, research trial results and comparisons to alternative and previous pasture varieties. Retailers and agronomists are often sources of information complementary to those accompanying marketing and sale of the product and are often recognised as influential in decisions to implement. Pastures are often recommended to and implemented by producers because they hold a particular desirable trait such as the rate of plant growth, water and drought tolerance, climate tolerance, seasonality, protein content, disease and pest resistance, foliage size, or soil suitability; these should complement the specific enterprise's requirements.

From the internal perspective a significant understanding is required to run the pasture successfully. Improved and performance pastures have moved increasingly away from natural pastures by their design; producers have recognised this and produced accordingly. Many performance pastures have a limited lifespan as a useful pasture through built in obsolescence. This reinforces the fixed timing of routines as producers have to re-sow paddocks depending on the predictable useful lifespan of the product. For example, participants have looked at 'Italian Rye' which, depending on the variety, may be biannual.

Participants were using improved and performance pastures as fodder, although some suggested they would make crops into hay. Participants have reported mixed results with performance pastures as a concept and on individual species, often reporting pastures did not satisfy expectations in performance. While agronomists readily advise producers, producers are using their expectations and acquiring their own knowledge while making decisions and implementing them. Reasons suggested why producers did not wish to integrate performance pastures included they required too much labour, reduced flexibility and contingency, or exposed them to greater risk. They may or may not have implemented highly improved pastures but their organisational knowledge from their own production indicated to them whether they wish to have these components in their production. Frequently, producers' expectations performance pastures were that the innovation did not meet their preferences for producing and made the decision not to implement it.

Knowledge developed is on the human scale with understanding of crops based on observable variables rather than on actual underlying causes. The use of highly improved pasture draws on some knowledge similar to natural pastures, but a significant amount of different knowledge is also needed. Biological needs differ between pasture species and, as a performance plant, they are more useful with different grazing patterns such as rotational grazing systems (short periods of intensive use and being let recover). Signs used by producers to manage pasture use include visual elements such as heights of the pasture sward, which are interpreted as the amount of grazing suitable for an area. Overgrazing and adverse climate will destroy pastures. These signs are considered relevant by historically developed knowledge but they are limited in effectiveness. With experience through use new knowledge was developed by and producers were surprised at how quickly 'Italian Rye' regenerated. This new understanding led to changes in timetabling of stock rotations. Other newly

recognised signs included the pastures species presenting with yearly dominance patterns when it had been expected that pastures would regrow each year. These features lead to incorporation of additional species in pasture development.

Several internal sources of failure were reported by producers in terms of information or knowledge. Unobserved variables relating to climate and plant biology were problematic as neither allow development of the necessary tools or signs. The need for additional information from outside the enterprise can be seen when tools and signs are not available. Climatic conditions, which are difficult to predict sufficiently far ahead of time, caused problems for performance pastures in comparison to natural pastures because many required more hydration. Producers did not get the rainfall they required to establish their pastures. A lack of water destroyed these pastures sooner and they exhibited reduced ability for regrowth. Reflection by producers suggests they may have changed their timing or withheld planting altogether if they could have foreseen this. Plant biology presents unobserved variables where species of pasture were planted by producers which did not perform well despite prior beliefs that they should be reliable. Producers could not provide an unequivocal reason for the failure, and instead provided guesses as to why the plants did not perform. The tools needed to interact with the cause of failure were not present.

In some cases it was a lack of historical knowledge initially that caused failure and tools and signs were available during or after implementation. For example, on advice of an agronomist, a participant included Chicory (a herb) into their pastures because it is regarded as high quality fodder. When the Chicory went to flower the producer did not recognise the plant as they had no prior experience with it. Believing it was a weed, they attempted to remove the plants which they had sown; they had no recognition of the plant's form. Sources of information may have been able to rectify the problem quickly, but internally, the lack of history caused an inability to act satisfactorily. The method of sowing was another shortfall producers had to address when the new pasture did not take as well as expected. They had to modify their approach despite using standard approaches such as direct drilling and low level tillage. Pasture that exhibited low yields from seed lead to different methods or at least reconsideration of method. This may have been a distinct technique change such as from drilling to tillage, but producers also looked at modifying their techniques such as the depth of sowing and method of 'filling in'.

These changes in sowing represent on-going incremental innovative activity brought about by experiencing failure when pastures did not meet expectations. Other incremental actions in improved pasture improvements included improvements to sowing methods, not out of failure for the pasture, but in an effect to improve it according to the producer's preferences. Producers realised that sowing the pasture in the same direction was problematic because of the low density of pasture growth. To rectify the situation, they sowed in two perpendicular directions. The tools used were machinery that they already had knowledge how to use. Thus a novel situation (Gersick & Hackman, 1990) created an innovation and the solution represented a situation consistent with their historical understanding.

Estimated Breeding Value (EBV) and Genetic Breeding Technologies

Much of animal biology is hidden from the observation based analysis producers can bring to bear because genetic features exist at the cellular level. Most producers do not have the ability to analyse genetic material for items of interest. The analysis involves an external laboratory, where producers send samples and measurements according to the lab's requirements. Similar to other areas of production breeding includes the time aspect, but

because the goal of much of the genetic breeding technologies is to join the appropriate sire and dam or find suitable embryos, the time issues become less obvious.

Genetic breeding technologies represent the canonical innovations developed externally to an enterprise. Information in highly codified form is received from outside the enterprise on a commercial basis. Producers as users have to interpret the information for their own purposes. It is a different sort of modification to rotational grazing as the producer is not changing the innovation itself, as it is codified, but instead interpreting it in order to make decisions in the context of their own enterprise.

Different routines feature in the use of Estimated Breeding Values (EBV's) or genetic breeding technologies because it requires the use of resources such as labour and stock to be diverted from other activities. EBV's require timetabled measurements of stock to be taken which requires significant labour and animals have to be diverted from routines they would otherwise partake in. The knowledge required by the producer is monitoring and manipulation of stock and using capital such as scales, callipers and crushes. Most of the involvement of producers in generating data for external organisations providing genetic services is on the human scale. The measurements of stock's physical attributes are taken by producers and testing of genes is achieved by producers sending a hair or blood sample to a laboratory. The new knowledge present is through taking accurate, consistent measurements and changing routines effectively so that production can continue with reasonable labour costs and animal disruption.

In some cases genetic testing is a simple matter of selection such as testing for sex of embryos, copies of polling genes or muscle genes. Producers have preferences when purchasing a test, usually based on a market outcome, and they will select stock to continue breeding if the test shows a desirable trait. For example, a Limousin bull that has two copies of polling genes is valuable in the market and producers will select that bull to continue breeding programs. This represents a simple decision that the producer already understands the options in advance. The internal innovation is limited because one bull with a positive test can be quickly substituted for another if they are part of the same herd.

New internal knowledge can be formed where the options are not known previously and explanations of genetic tests are informing producers of their options. This knowledge relates to the qualities stock possess and is more tacit because producers can interpret the information, in the context of production, in many different ways. Producers show a variety of attitudes towards various genetic breeding technologies, which can be negative even if they are using the innovation. To make decisions some producers use a combination of EBV's and genetic markers as guides in conjunction with visual and ancestral lines. It has been suggested by some that, ideally, objective measurement through these technologies is the future of the industry and that it is preferable. However the current development of these technologies makes the use of tacit understandings necessary. Producers have indicated these objective measures do not describe all the traits they are interested in.

Producer's tacit knowledge in breeding exhibits in several ways including the physiology and behaviour of animals, use of ancestral lineage for breeding and understanding of compatibility with breeding program. They use visual methods to judge whether an animal has particular traits such as shoulder and pelvic width, phenotype, facial and orthodontic characteristics, feet and ankle structures and genitalia. Interest is frequently generated through past events such as outcomes of breeding, for example, where large shouldered animals can cause calving problems or animals with structural problems are more likely to

breakdown with injury. Other forms include looking at the ancestral line to understand the possible performance of future progeny of an animal. Good temperament of animals is highly valued by producers because it makes animals easier to work with, animals are less likely to get injured and meat is often of superior quality. Temperament traits can be present as dormant genetic characteristics and appear in later progeny affecting their value. Producers can look at this trait and others if they can obtain the information on ancestral lineage to make decisions. Further depth in knowledge can be seen where producers can see how animals will breed with others for certain outcomes. This can be individual traits of animals such as the phenotype and families within breeds. This tacit knowledge takes time to build and in the process producers gain extensive and in-depth knowledge of the behaviour, personality and breeding value of their stock.

Conclusion

Analysis shows there are internal motivations for innovation directly attributable to the internal productive nature of beef cattle farm enterprises. Producers frequently have to acquire new knowledge in order to deal with the changes in preferences for production, unanticipated changes that affect the internal workings of the enterprise or to modify a new idea that have originated from outside the enterprise. This new knowledge enables producers to change their routines as they acquire the capabilities to innovate and improve their production.

Routines are a useful way to describe the capabilities of producers and to show the processes of implementation of innovation. Routines describe the organisation of *tools* and *signs* that compose producers' abilities to act. Producers also use routines as a cognitive means to deal with the complexity inherent in beef cattle production by allowing them to use their previously constructed knowledge. The ability to act in a confident and knowledgeable manner is important for producers because it allows them to carry out production. In addition, routines are a cognitive method for interacting with production that complements the cyclical natures of aspects in beef cattle production. Being able to describe production from both a performative and cognitive perspective is useful in linking the knowledge producers possess to the source of its development.

It can be seen from the use of routines that producers will undertake innovation in an incremental and continuous manner rather than radical approaches. The complexity present in beef cattle production fixes the timing and composition of routines. Producers have to work within this rigidity to find complementarities between resources. Each aspect has to complement others or production will be significantly reduced. This restricts the possible combinations and organisations that will be effective for production. Because of the complementarities and interdependence between different aspects, a change in one aspect will affect another. This leads producers to make incremental changes that they believe will not destroy the productive order of the enterprise.

Different innovations that producers implement show producers have significant ability develop innovations from internal resources. Many innovations involve spatial, mechanical or animal health and behaviour ideas. These innovations are conceptually apparent to the human senses and producers show in-depth knowledge of these concepts within their enterprise relating to production. It can be expected that producers will develop innovations in these areas. When concepts are not apparent to the human senses knowledge will not be developed. Producers are frequently left 'guessing' at causes of failures and are unable to act using internal means.

Conceptually rotational grazing and its variants seems to have been developed externally, with producers acquiring a broad general notion of its concept from external information sources, much of their knowledge seems to be constructed internally. Producers tailor their system to their preferences over a significant period of time while concurrently producing. Innovation takes place through change in the organisation of resources and routines, i.e. through anticipated activity generated using endogenous knowledge. Rotational grazing is an example where the complexity of production leads to incremental innovation as development may take up to ten years to occur. During this period, producers modify many aspects of production from fencing, weaning, water provisions, timing of rotations, timing of turnoff and stocking rates among others. Although rotational grazing systems could present as a radical innovation, producers take extended periods of time to perfect their production and break it down into a collection of refinements instead. It represents not only development of knowledge about use of tangible resources but also development of knowledge about processes that can be developed internally if given sufficient time.

High performance pastures exemplifies an innovation that is brought into an enterprise from an external source. Producers then deploy it to their needs. However, frequently the use of high performance pastures changes over time as producers try to improve its value to the enterprise. Frequently producers have an idea of what they wish the improved pasture to achieve such as a finishing crop, fast recovering pasture for rotations or a high value pasture for the entire year. They modify the method of establishing the pasture, the pattern in which it is sown, the composition, the watering, the stocking rate and the resting period in an effort to use the pasture more effectively. Most of the modifications attributable to internal knowledge are at the human scale. However, not all producers who tried to use high performance pastures implemented it successfully. Some producers said that it did not live up to their expectations but when questioned about the reason this had happened, they said that they did not know why. This suggested that they did not interact with the concepts, such as the soil or plant biology, that could explain the failure.

EBV and genetic breeding technologies are generally informational goods rather than a tangible good such high performance pastures. Even though they are brought into the enterprise from external sources, this information is used in conjunction with the knowledge producers have accumulated over time to make their decisions. Producers suggest that it takes significant experience to breed cattle with the desired traits and that the information gained from these technologies augment their understandings rather than replace them. Producers suggest that there is other information available from eyeballing cattle that test results and computation do not provide. As a result producers modify the use of figures according to their understanding. It shows that enterprise specific knowledge is always present in activities relating to the enterprise.

The approach taken gives legitimacy to producer's knowledge by recognising the important efforts producers make towards innovation implementation and provides an outline of the activities that are taking place within an enterprise. Innovation is not viewed as a process that is extraordinary and instead mundane activities and maintenance of productive orders provide motivation and scope for innovation to occur. The innovation that is occurring is diverse but unique to each enterprise which means it is not immediately apparent to outside on-lookers. From a policy-makers point of view, understanding the complexity and the decision-making situation of producers will allow policy to be made to better complement production. Although researchers and other people who design potential innovations listen and are informed about developments in farm enterprise production, the current the situation seems

somewhat hit and miss, with many good ideas not being readily taken up. Researchers can consider the processes that producers may go through to innovate or introduce new understanding into their enterprises in order to understand the take-up of newly devised external innovations.

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