

SYSTEMS APPROACHES TOWARDS UNDERSTANDING THE BARRIERS TO INNOVATION ADOPTION IN THE AUSTRALIAN BEEF INDUSTRY

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ABSTRACT

The slow and low level of innovation adoption in the Australian beef industry was explored by using a systems approach. A causal loop model of innovation adoption system in the Australian beef industry was built based on various sources of literature and fieldwork findings in Queensland Australia. Further analysis of the systems model and fieldwork findings revealed the systemic structures of innovation adoption system in the Australian beef industry which underlie the complexity and dynamics of innovation adoption behaviour. To the utmost importance is this research also externalized key mental models of different actors within in the beef production system.

Key conclusions drawn from the systems analysis were (1) the barriers to innovation adoption are business situation specific, barriers shifting along with the changing of business situation; (2) a lack of fully understanding the systemic structure of innovation adoption system in the Australian beef industry is common; (3) a lack of shared mental model among different key actors in the beef production system was also clearly shown which inhibits effective cooperation among them for various innovation activities; (4) using systems approaches to understand barriers to the innovation adoption in the Australian beef industry can add valuable insights to this complex issue which traditional non-system based methods are not able to achieve.

Keywords: Systems approach, systemic analysis, innovation adoption, Australian beef industry

INTRODUCTION

The Australian beef production is the country's second largest agricultural industry which extends over almost half of the Australia's land mass and across all climate zones. The beef industry not only adds AU\$ 8.1 billion gross production value to the economy but also contributes 15% of the total farm export value between years 2011-12 (Thompson & Martin, 2012). Over the last decade the domestic market consumed an average of 35% of annual beef and veal production, while 65% was exported which makes the Australia is the second largest beef exporter after Brazil (MLA, 2012b; NLWRA, 2008; PWC, 2011). Internationally, Australia is a highly effective beef exporter in that it only has around 3% of the world's cattle inventory and produces 4% of the world's beef supply (MLA, 2012b). A recent statistics also shows that more than 220,000 people were employed in the beef industry at the farm, processing and retail levels (PISC, 2010). Among them there were 47,086 people were directly employed in the beef cattle farming industry which equals more than one fifth of the total agricultural employment at the time (NLWRA, 2008). Bearing in mind that the main cattle growing areas in Australia are in

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the rangelands and semi-arid areas which cover three quarters of Australia's land mass, the successful management of the beef industry is significant in terms of environmental protection (MLA, 2008). Furthermore, due to many natural environmental factors such as geological, topographic and climatic factors, these regions are not suitable for any high volume food production other than grazing (MLA, 2008).

A healthy beef industry is therefore essential to Australian economy, society and environment. However, a further sustainable development of beef industry is facing several key challenges which include international competition, increasing cost of production, water scarcity, climate change, fluctuation of beef price and world economy downturn (PWC, 2011). Both Australian Government and beef businesses realized a continued productivity growth in the beef industry is therefore required for offsetting the declining trade and to maintain and improve profitability (Nossal & Gooday, 2009). The adoption of various innovations in beef businesses throughout the industry are thought to underlie the productivity growth in the Australian beef industry during the last three decades (Nossal & Gooday, 2009; Nossal, Zhao, Sheng, & Gunasekera, 2009; Sheng, Mullen, & Zhao, 2010). Further productivity growth in the Australian beef industry has to rely on innovation adoption (Nossal & Gooday, 2009; Sheng et al., 2010). However, many research showed that innovation adoption in the whole agricultural industry is very slow and the adoption of innovations in the Australian beef industry are widely reported as around 25%, and lags in the order of five years and longer (Griffith et al., 2008).

There is urgent need to examine what are the barriers to the innovation adoption in the Australian beef industry in order to achieve further productivity growth. However, there were many research on the slow innovation adoption in broad agriculture as well as specifically in beef industry (Burrow, 2010; Frank, 1995a, 1995b; Pannell et al., 2006). Extensive literature review revealed two common weaknesses of previous research on the slow innovation adoption which are the lack of holistic views and adopted methodologies were unable to cope with the complexity and dynamics of the innovation adoption process (Sun, 2012). For this reason a new approach which can overcome these two identified weaknesses is required in this case. The systems thinking approach is widely acknowledged in dealing with real-world issues characterized with complexity and dynamics in a holistic way (Jackson, 2000; Maani & Cavana, 2007). Therefore, this research employed a systems thinking approach to examine barriers to innovation adoption in the Australian beef industry.

METHODS AND PROCEDURE

Systems thinking

Systems thinking is regarded as a discipline for seeing the "whole", interrelationships and patterns (Senge, 2006). Systems thinking incorporates a set of modelling tools which can be used to understand the structure of a system, the interconnection between its components and how changes in any area will affect the whole system and its constituent parts over time (Bosch, Maani, & Smith, 2007; Goodman, 1991). It also emphasizes

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circular interdependencies between cause and effect, understanding concerned issues from the deepest level - mental model level (Maani & Cavana, 2007).

Causal loop modelling techniques were mainly employed in this research (Sherwood, 2002). Various successful cases show that many complex issues can be successfully addressed by using only causal loop modelling in that causal loop models reflect the systemic structure of studied issues. It can also be used to externalize mental models of key stakeholders within systems under studying (Maani & Cavana, 2007; Sherwood, 2002; Sterman, 2000).

Research procedure

A research procedure had been designed to facilitate the research process (see Figure 1).

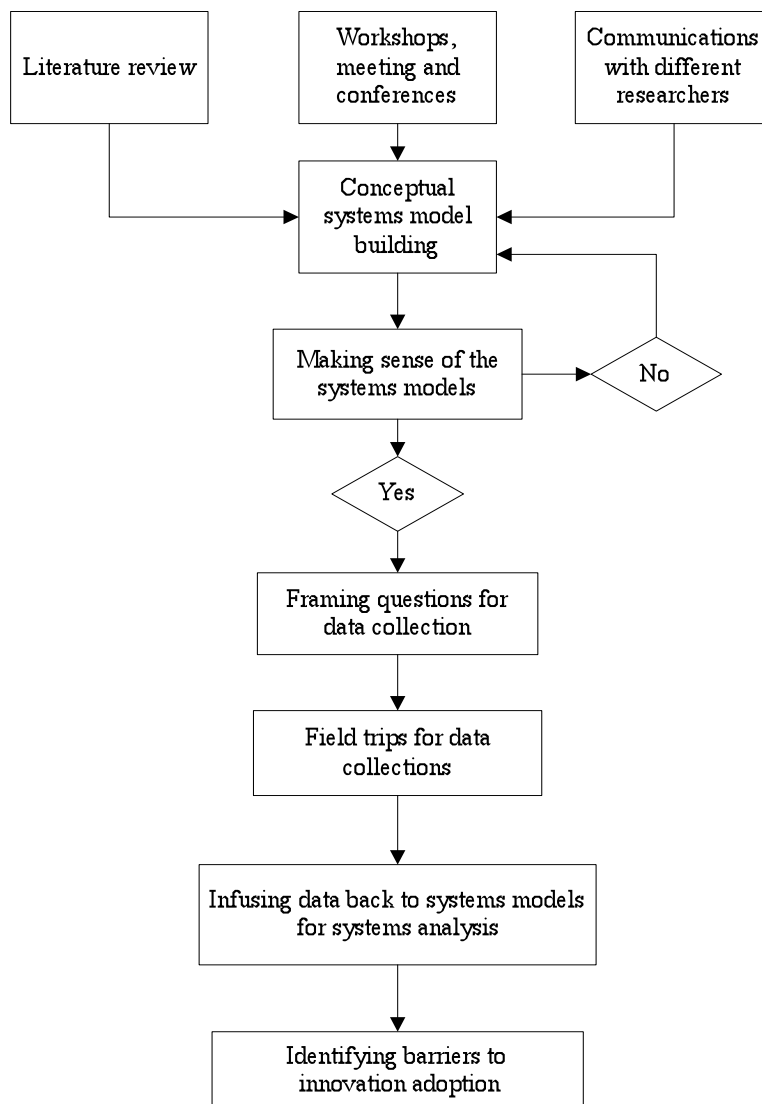


Figure 1 The research procedure

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The procedure starts with building a conceptual systems model which rested its solid foundation on an extensive review of relevant literature, the researcher's experiences of direct involvement in the beef industry and personal discussions with various researchers from different research organisations. The conceptual systems model consists a business situation subsystem, an innovation adoption process sub-system, a continuous improvement and innovation sub-system, a social network sub-system and a innovation culture sub-system. The conceptual model was also verified and improved by incorporating feedback from different researchers before using it as fieldwork framework. The key issues related to the conceptual model were then framed into questions which target the collection of data and information during fieldwork. By doing so, a holistic view is guaranteed; this also facilitates a smoother systemic examination of innovation adoption system in the Australian beef industry.

Field trips for data collection have been another important stage in this research. In order to address another common weakness in most former research studies, the lack of variation of samples (Doss, 2006), this research design managed to cover as large as possible a research area to ensure enough variations in data sources. Efforts were also made to obtain an even larger sample size for data collection. As a result 34 beef businesses across Queensland State were visited and 51 people were successfully interviewed on their beef properties. These on-site interviewing experiences and informal discussions before and after interviews not only enriched the data but also helped significantly to contextualize and interpret the collected data and information. The data collected were processed and used to refine and improve the conceptual model in order to closely reflect the real situation. The improved systems model was used for further systems analysis. Figure 1 demonstrates the key stages of the research procedure.

Queensland was selected as the research area because it has Australia's largest beef cattle numbers and is the nation's largest producer and exporter of beef (DEEDI, 2010). During the last decade beef production in Queensland accounted for more than 40% of all beef production in Australia (MLA, 2012a). Queensland also covers an area of 1.85 million km² which is big enough to overcome the "lack of variation" weakness. Beef cattle production provides about 83% of the total gross value of production of all Queensland's livestock industries and over one-third of the total gross value of all Queensland's agricultural industries (DEEDI, 2010).

By infusing fieldwork findings back into the conceptual systems model an improved systems model on innovation adoption (see Figure 2) was obtained which closely reflects the situation of the beef industry at business level within the researched area. The improved systems model then was used to understand barriers to the innovation adoption.

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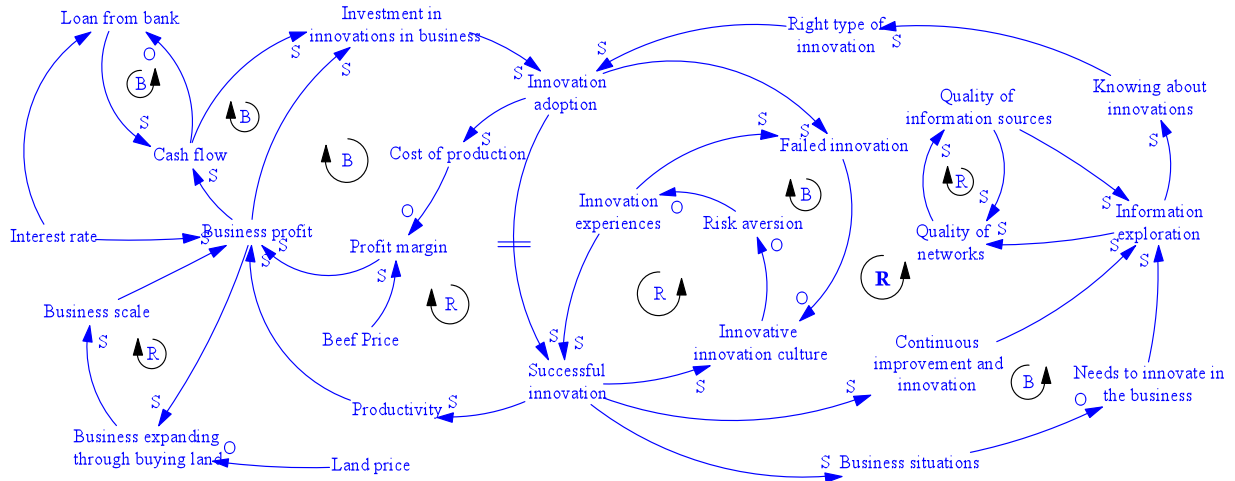


Figure 2 The innovation adoption model

RESULTS

The understanding of barriers to innovation adoption in the Australian beef industry focused both systemic structure and mental models levels. A series of systems archetypes were identified from the innovation adoption systems model (Figure 2) and fieldwork findings. Systems archetypes are generic systems models or the templates that represent a wide range of situations. Systems archetypes provide a high-level map of dynamic processes. Mental models behind the systemic structure were also externalized.

Identified systemic structures

Innovation adoption limited by the innovation adoption process - limits to growth

A “limits to growth” archetype relates to innovation adoption loop (in blue) and the innovation adoption process loop (in red) which shows in Figure 3.

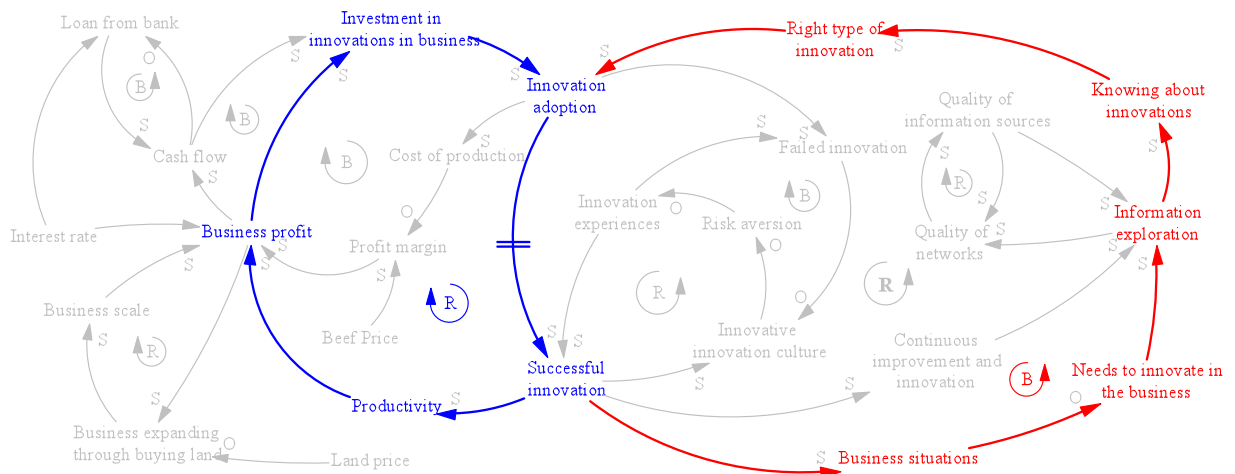


Figure 3 Limits to growth by the innovation adoption process

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Innovation adoption loop is a reinforcing loop which can generally serve as an engine of growth or decline. This loop forms a virtuous reinforcing cycle which tells the story of beef producers investing in business innovation which brings business profit through increasing productivity and production efficiency. Thus, the more investment in innovation the higher the productivity – signifying that innovation has been successfully adopted. Thus more business profit can be achieved which in turn will enable businesses to invest even more in future innovations.

In connection with this innovation adoption loop is the innovation adoption process loop which is a balancing loop. The combination of these two loops through common variables forms an archetype named “limits to growth”. Any actions aimed to make changes in the system will be counterbalanced by this balancing loop (in red).

The limits to growth archetype formed by the innovation adoption loop and the innovation adoption process loop reflects the reality that while beef producers are encouraged to adopt innovation in their business for better business performance, the success of their adoption effort is ultimately limited by the innovation adoption process. Further investigation of the model shows that in order to achieve more innovations a producer has to go through different stages of the process. Hence in order to successfully accomplish all the stages in the process, substantial effort and perseverance will be required.

Innovation adoption limited by cost of production – limits to growth

Another “limits to growth” archetype was also identified which is highlighted in the model below (Figure 4).

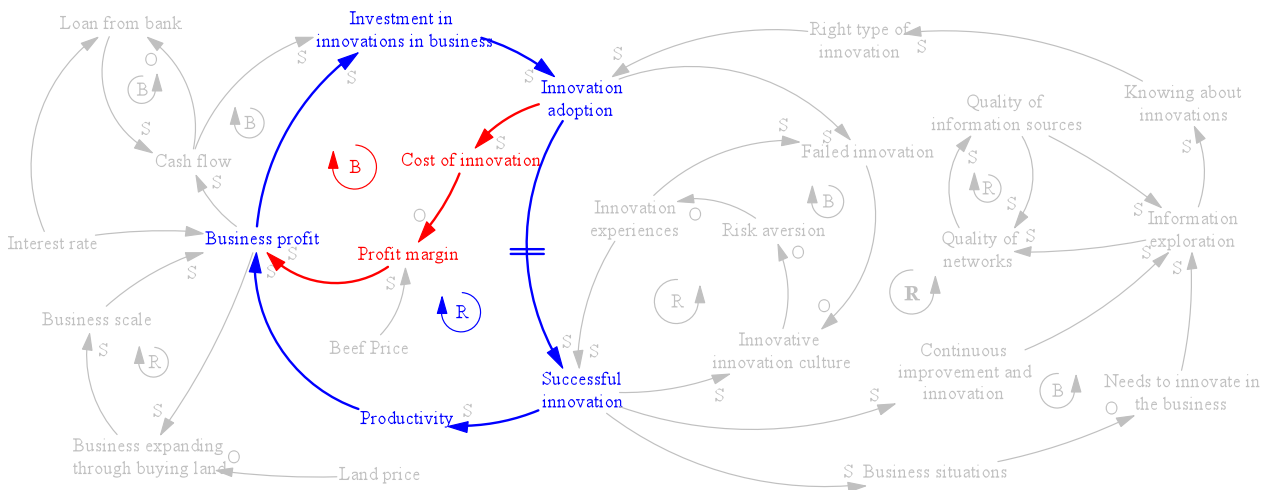


Figure 4 Limits to growth by cost of innovation

As shown above, another balancing loop, named the “cost of innovation” loop (in red). This balancing loop connects with the innovation adoption loop through their common variables. These two loops form another “limits to the growth” archetype where the

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innovation adoption is limited by the cost of innovation. This model reflects the current situation in that many producers complain that the cost of production is too high, preventing them to do any innovation in their business.

Continuous improvement and innovation process limited by the innovation adoption process – limits to growth

The continuous improvement and innovation process loop (in blue) and the innovation adoption process loop (in red) also forms a “limits to growth” archetype which is highlighted in Figure 5.

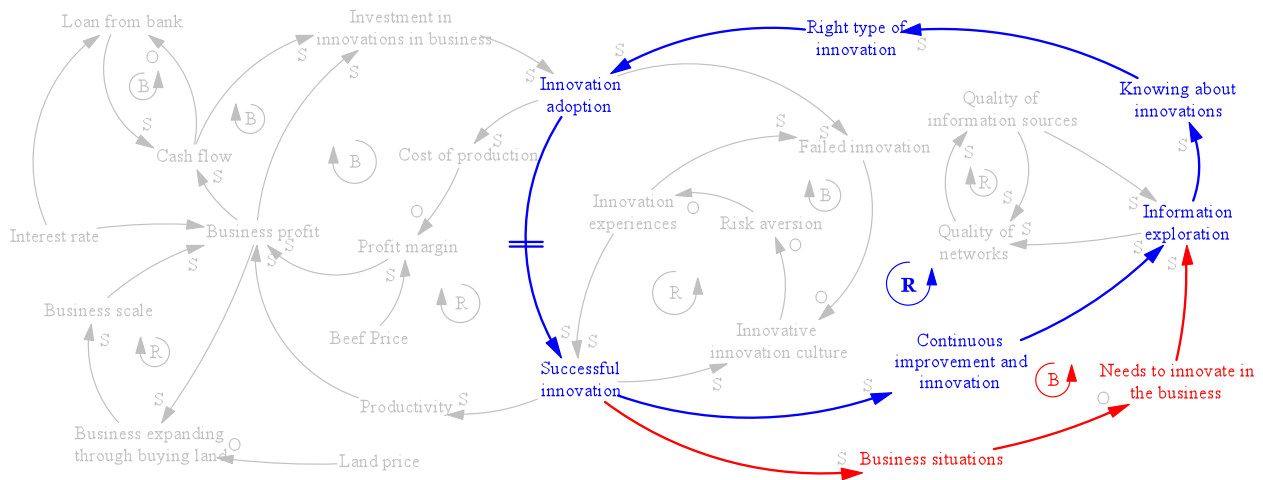


Figure 5 Continuous improvement and innovation adoption process limited by the innovation adoption process

The reinforcing loop of continuous improvement and innovation process implies that the more a beef business engages in innovations or improvements, the more likely it is that the business will continue to follow the process. The overlap between the continuous improvement and innovation loop and the innovation adoption loop indicates that these two processes have a lot in common. In fact, any innovation adoption is an integral part of the continuous improvement and innovation process. Therefore, the balancing nature of the innovation adoption process would limit the growth (development) of the continuous improvement and innovation process.

Continuous improvement and innovation limited by failed innovation experiences – limits to growth

A balancing loop is formed as a result of failed innovations, risk aversion and other common variables (in red). The two loops highlighted in Figure 6 form another limits to growth archetype.

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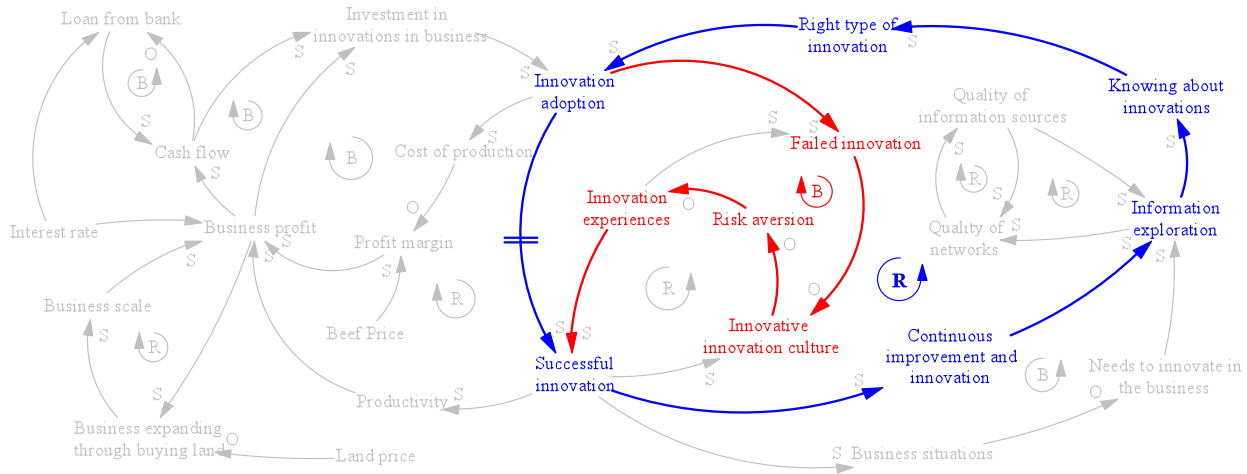


Figure 6 Continuous improvement and innovation limited by failed innovation and risk aversion

This archetype indicates that the continuous improvement and innovation process (reinforcing loop) is embedded in an even a larger loop that is formed by the continuous improvement and innovation loop plus part of the loop formed by the variables in red in the model. The key insight from this archetype is that continuous improvement and innovation are limited by failed innovation and risk aversion outcomes.

Business development relying on buying land – path dependency

A path dependency archetype was identified in the model which is shown in Figure 7. This reflects a scenario which came about during a period of rapid land value appreciation.

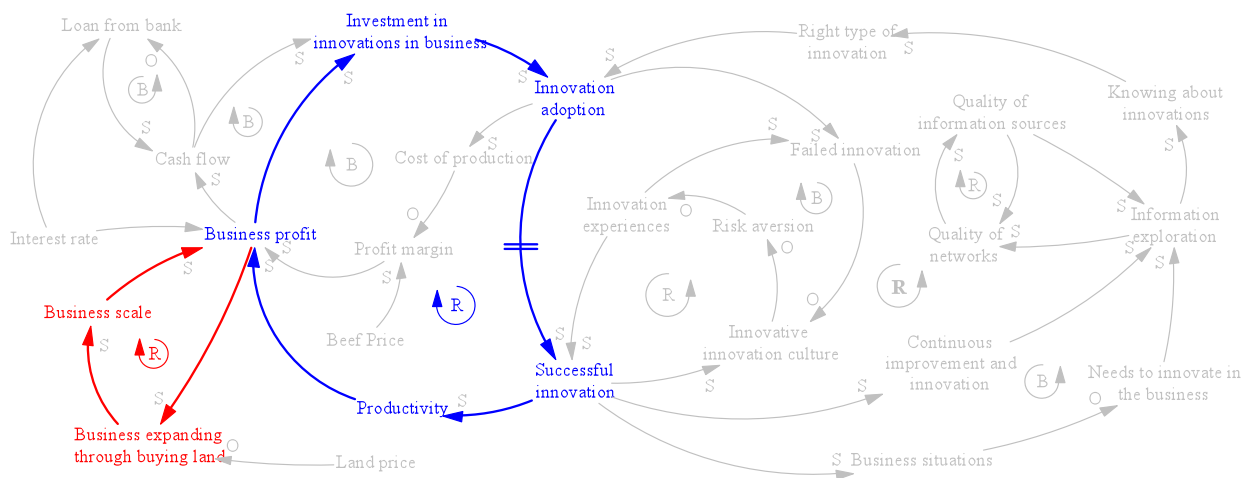


Figure 7 Business expansion relies on buying more land

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As it can be seen from the model there are two reinforcing loops within this archetype. Besides the “innovation adoption loop”, another “business expansion” reinforcing loop is formed. Beef businesses can choose either of the paths to achieve better profits. However, in contrast to investing in land, the innovation adoption path is a lot harder and slower. Many of the businesses interviewed claimed that their business development benefited tremendously due to buying more land in the past but complained that this was not an option anymore due to high land prices as well as land value depreciation. This scenario lasted more than a decade until around 2007 when land values started to depreciate.

Innovative culture limited by failed experiences – limits to growth

A “limits to growth” archetype was identified in the area of innovation culture Figure 8.

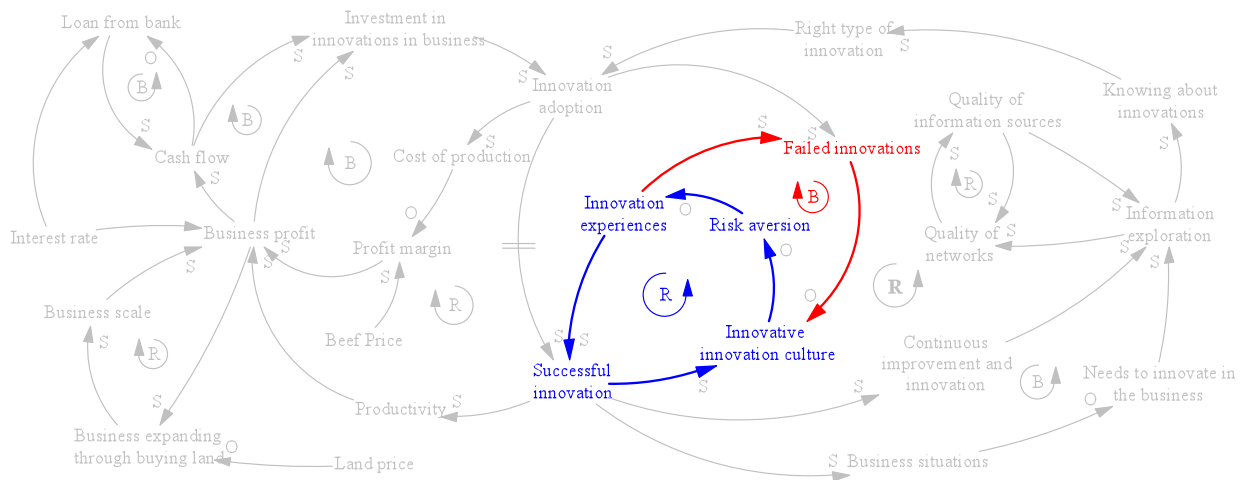


Figure 8 Innovative culture building limited by failed innovation experiences

An innovation culture is built through innovation experiences. Successful innovations positively contribute to an innovative culture while it is negatively affected by unsuccessful innovations. The model indicates that innovative culture is not only built on the number of overall innovation experiences, but on how successful they were. The failed innovations experiences act as a barrier to building an innovation culture.

Innovation culture limited by the innovation adoption process – limits to growth

This archetype illustrates how an innovative culture is being built by successful innovation adoption experiences. This is shown by the reinforcing loop indicated in Figure 9. However, the combination of this loop with the innovation adoption process loop, through common variables of successful innovations, formed the limits to growth archetype. Being a balancing loop it poses limitations directly to successful innovations. In the end, the innovative culture building will be limited due to the fact that successful innovation is being limited.

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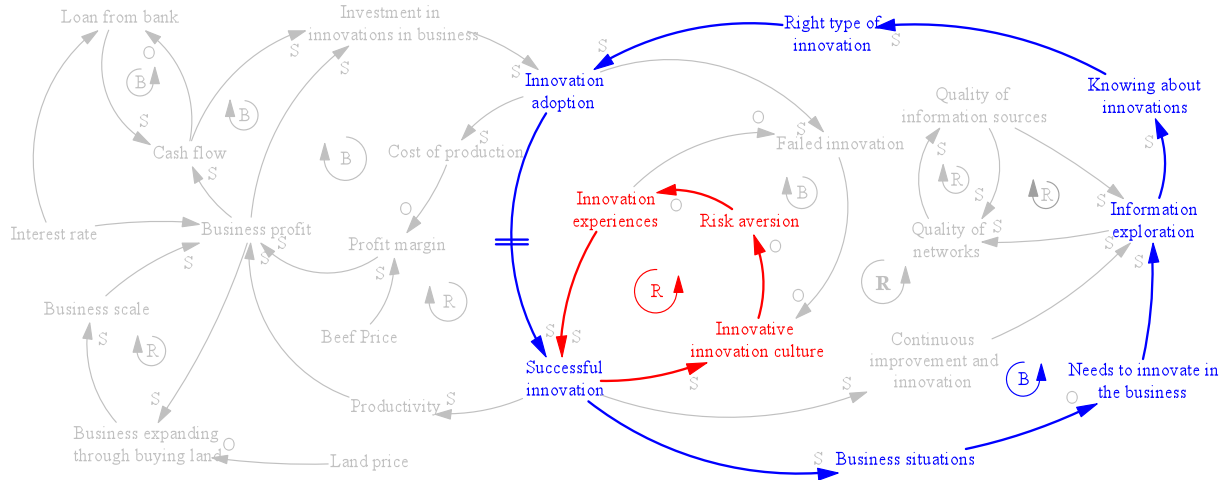


Figure 9 Innovative culture building limited by the innovation adoption process

Loan for cash flow – shifting the burden

When facing tight cash flows, one option for beef businesses is to borrow money from financial institutions. In this case interest rates are the key to the decision to borrow money.

Considering that the low interest loan is a policy intervention used by government, it is important to understand the scenario that low interest loan could bring about. This scenario is highlighted in the model where a “shifting the burden” archetype is formed. To visualize the archetype additional variables and links were added (Figure 10).

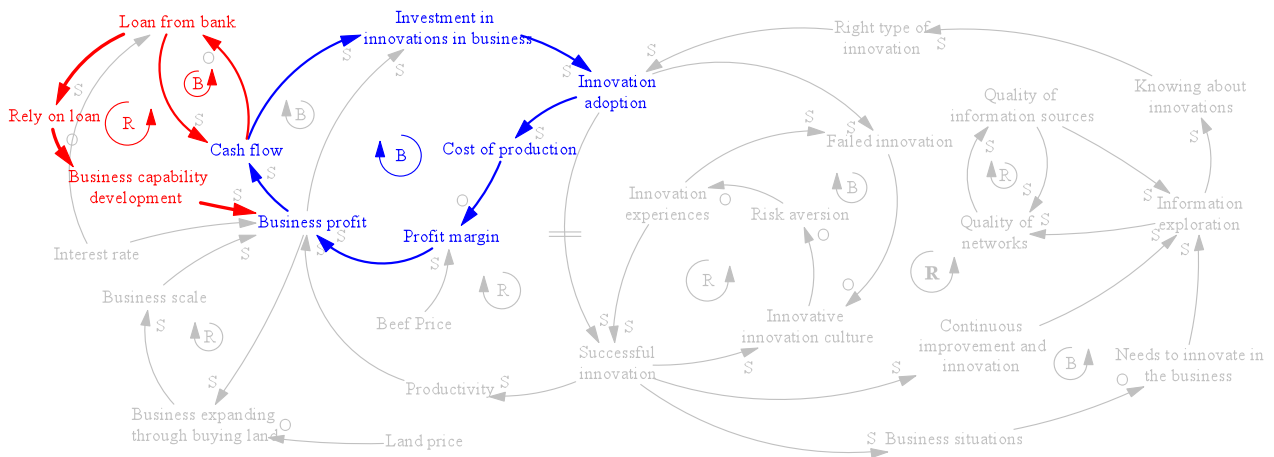


Figure 10 Low interest loans for cash flow – shifting the burden to financial institutions

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The model shows two highlighted balancing loops. These loops indicate that beef businesses can address tight cash flow problems either by loans from the bank or through self-development. When lower interest rate loans are available, beef businesses prefer to increase their cash flow through borrowing, rather than business capability building. Thus, the easier it is to get low interest loans, the more readily beef businesses will opt for the borrowing option. This would lead to shifting the cash flow problem to a short term solution (shifting the burden to financial institutions), delaying or postponing the more fundamental business capability development.

Quality network limited by innovation adoption process - limits to growth

In a similar way to the above, the building of quality networks within the innovation adoption process forms another “limits to growth” archetype which is highlighted in Figure 11.

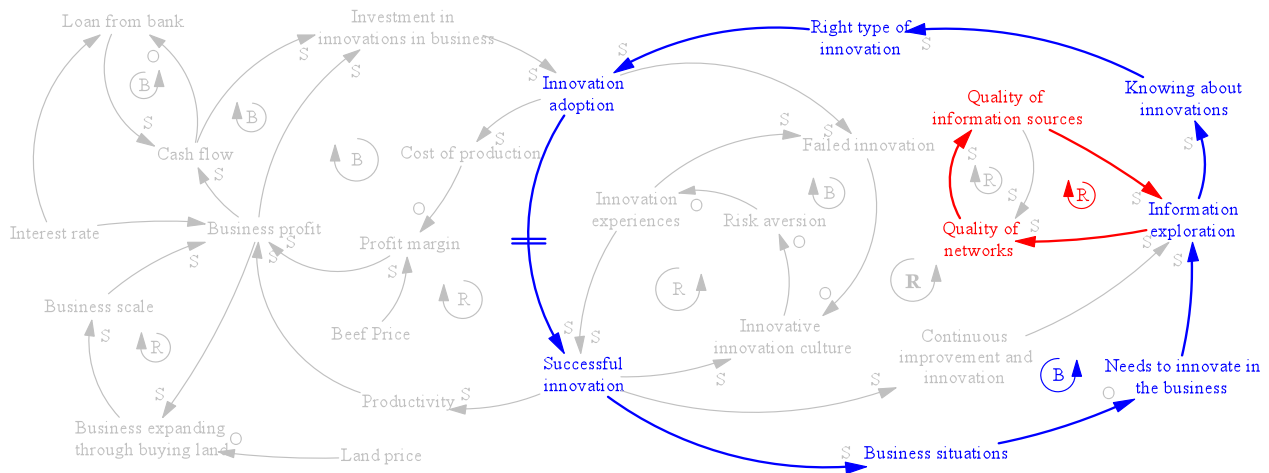


Figure 11 Building quality networks limited by the innovation adoption process – limits to growth

Building quality of networks in relation to the information channels forms a reinforcing loop. In this loop “information exploration” is a common variable with the innovation adoption process loop, which could be limited by the innovation adoption process.

Further study on fieldwork findings also revealed other archetypes which were not shown in the model due to they are embedded either in a higher level or lower level systems. These archetypes include “drifting the goal”, “fixes that fall”, “success to successful” and “tragedy of the commons”.

High business pressures and lowering expectations- drifting the goal

The “gap between the business situation and business target” and “innovation adoption” forms a “drifting the goal” archetype. Beef producers understand that successful innovation adoption is probably the only vehicle which can lead to better business

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performance. The field data have revealed that moderate business pressure is a driver for innovation adoption. However, too much pressure would eventually inhibit innovation that will lead to the formation of a “drifting goal” archetype (Figure 12).

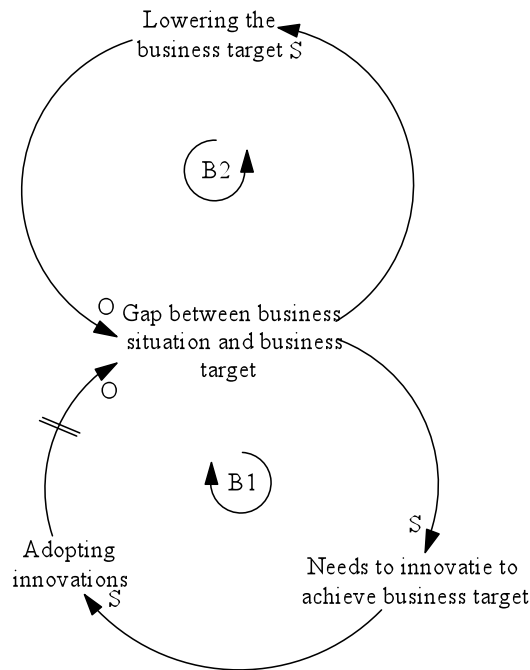


Figure 12 Dealing with business pressures

Figure 12 describes a situation that beef producers should increase innovations to achieve business targets when facing the gap between the business situation and business targets. However, there is an alternative for beef producers to achieve their business targets when they face robust challenges in doing innovation. They could adjust their targets in order to reduce the gap. This is a common scenario as many beef producers admitted in the interviews that they would like to do more innovations, but there are too many limitations that cause them to just give up. The stated barriers to innovation included tight cash flow, cost of doing innovation, time limitation and others.

Farm management practices – fixes that fail archetype

It is common practice for Queensland beef businesses to improve pastures by introducing new species of grass or legumes. This is aimed at better cattle growth by providing better nutrition. However, there are many uncertainties about newly introduced species turning into weeds that could lead to lower quality pastures on the property. Therefore, the scenario can be shown with a “fixes that fail” archetype in Figure 13.

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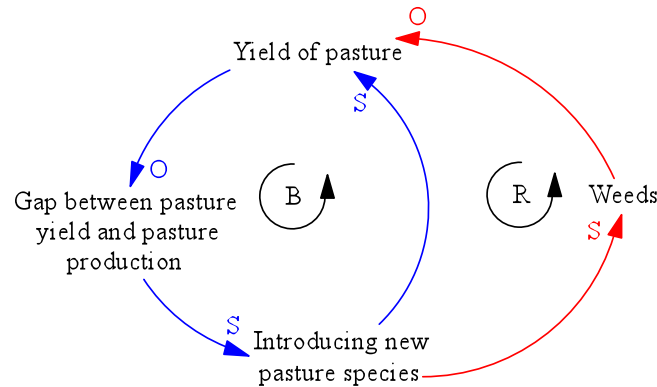


Figure 13 Improved pastures changing into weeds

There were several other issues also fit the fixes that fail archetype which include

- Over stocking to increase productivity can only be achieved in the short term but it causes severe damage to pastures which damages long term business profit.
- Innovations in improving cattle breeds that have a high growth rate and large body size fails, because these breeds cannot adapt to the environment.
- Producers are successful in their crossbreeding efforts, but fail to sell the breed to the market.
- Addressing tight cash flow by borrowing money from banks incurs high interests which further burdens the business.

Available funding for innovation adoption – “success to successful”

As the fieldwork findings have shown, beef business were generally limited by available sources for doing innovation in terms of lack of profit, tight cash flow or lack of time to do innovation due to cost cutting and hiring less labour. Business profit is enhanced largely by innovation adoption through the boosting of production efficiency and increasing productivity. Businesses in different financial situations will have different capabilities for innovation. The better the overall profits are for a business, the more likely that it will have the necessary funding for further innovation and it will continue to improve. The relationship between those that continuously improve and those that cannot innovate because of poor performance and profits influences the industry as a whole. The businesses that cannot improve disappear out of the industry, while those that continuously improve become bigger. These dynamics forms a “success to successful” archetype which is modelled in Figure 14.

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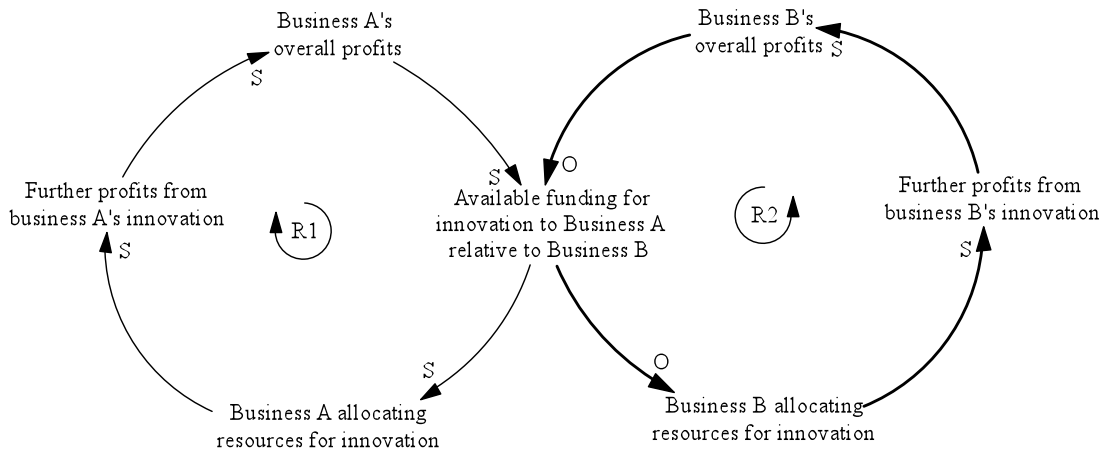


Figure 14 “Success to successful” in terms of available funding for further innovations

The implication of this model is that for any business to succeed it needs to innovate continuously. Without sustained innovations the business will experience a downward spiral of poor profits and will eventually disappear. This is shown by the reinforcing loops R1 and R2 in the model. This archetype explains the increase of bigger businesses and a decrease in the total number of businesses in the industry as a whole.

Beef business profits – “tragedy of the commons”

Examining the business profits of the overall market size and competition among beef businesses, another systems archetype, namely “tragedy of the commons” was identified (Figure 15).

It was shown by the fieldwork results across Queensland, all the interviewed beef producers agreed that increasing productivity and improving production efficiency are their common business targets. In this regard innovation can either increase the overall production or lower the cost of production, which will contribute to the net profit of businesses. This virtuous scenario is illustrated by using two reinforcing loops R1 and R1 (or R3 and R4) in the systems model.

When all businesses strive to do innovation for the sake of their own business profits, an unintended consequence follows due to the competition between businesses. This unintended consequence is an increase in overall production in each of the individual businesses, which will inevitably lead to a lower price for beef products (surplus on the markets). Such a lower price will reduce the average business profits of the industry as a whole, as shown by the two balancing loops B1 and B2 in the model.

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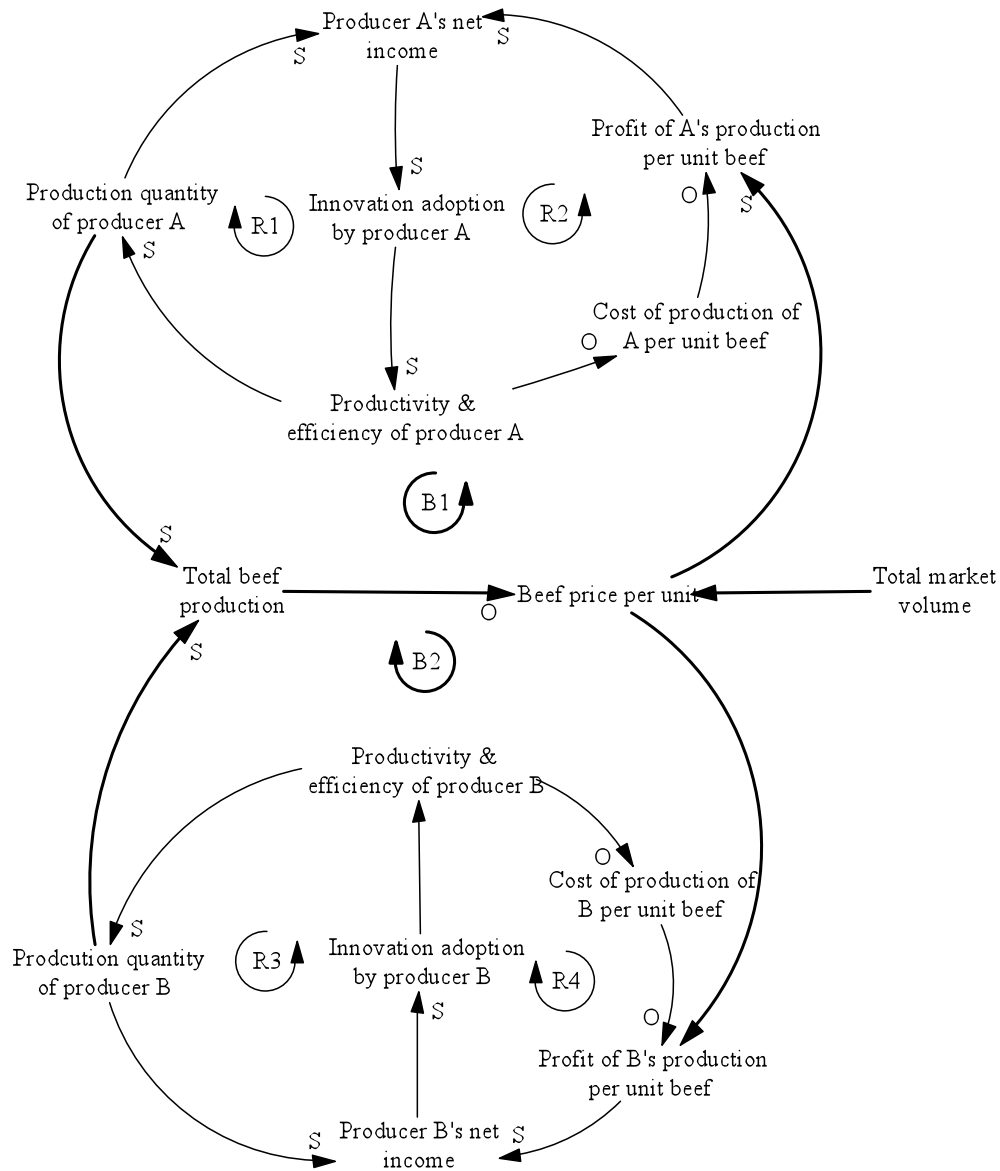


Figure 15 Beef business profits - “tragedy of the commons”

The model implies that innovation at the single business level will boost business profit through increased productivity, However, at the industry level innovation adoption may not guarantee an enhanced business profit because of the negative effects on the markets due to a surplus in supply. This implies that the “early adopters” who adopt innovations before the price of beef is affected by a surplus, can disproportionately benefit from the innovation.

Mental models of different actors in the beef industry

The methods used to externalize the mental models of different key actors within beef industry included the interviewing and categorization of key findings (Abel et al., 1998; Jonassen & Cho, 2008; Young, 2008).

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Beef producers' mental model on available innovations

Mental model: There is a lack of suitable innovations available to fit business operations.

The adoption of innovation is not simply a question of telling and listening, rather the acceptability of the information for the beef producers (Abel et al., 1998), as well as the assessment of available innovation. The fieldwork of this study provided a striking disparity between beef producers and scientists engaged in innovation adoption research. In this thesis the research questions were based on the findings of the Beef CRC that innovation adoption rates are too low compared to the number of available innovations and that there are long time delays before innovations are adopted. However, the fieldwork in this study revealed that most of the interviewed beef producers claimed that there are not many innovations available which could fit their business operations. This points to a serious mismatch between science R&D and end user needs. This disparity of opinions on available innovations underlies the discrepancy of mental models between researchers and beef producers. Frank (1995a) attributes this to the difference of learning experiences between researchers and beef producers. Most researchers, extension experts and R&D administrators have been trained formally to work as scientists in relatively constrained 'lab' environments; whereas the beef producers have learnt to manage beef production systems of varying complexity, through their experience in a risky and ever changing environment.

Public mental model on environmental impacts of beef businesses

Mental model: Beef businesses are only profit seekers.

This is a mental model that is held by the general public, or at least of some influential green groups, who keep posing pressures on Government which led to even stricter regulations on environmental protection. Interviewed beef businesses, especially those located along the east coast of Queensland, complained about overly strict Government regulations on natural resource utilization and environmental protection. Imposed restrictions on water use, tree clearance and feral animal control have shown signs of possible damage to businesses.

Beef producers' mental model to environmental sustainability

Mental model: Environment sustainability is essential to sustainable business profits.

It is understandable that the general public would think that beef businesses only care about profit and forget about the protection of the environment. It is true that beef businesses need to clear some tree cover for better grass production or to withdraw water from rivers or from under the ground, especially when a new beef property is established. However, interviewed beef producers maintain that they do care even more about the environment and sustainability than business profit, because they fully understand that a sustainable environment is essential for sustainable business profit. Decades of experience enable them to balance environmental protection and business profit.

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Government's mental model on regulations

Mental model: Beef businesses need to be strictly regulated for sustainable resources utilization.

To some extent the Government shares the same mental model that the general public has on environmental protection. Government continues to impose more strict regulations on beef businesses in terms of environmental protection, which indicates a distrust of the management abilities of beef producers. The point is not that government regulations are not necessary, but the producers feel that the regulations should be flexible and practical. An example provided by beef producers is the quota system on underground water extraction, where the entitlement of the next year's quota is based on the current year's usage. In order to secure next year's quota beef producers are forced to extract underground water mainly to keep the water meter running.

Mental models regarding private agricultural consultants

Mental model: Many current consultants are failures in their own beef businesses.

As a consequence of the withdrawal of public funded beef extension officers, there was a rapid growth in the private consultancy service sector. In our sample, some beef producers appreciated the service they receive from consultancy companies. However, at least an equal number, if not more, showed a strong distrust in consultants. Beef producers are well aware that many of these consultants used to be beef producers themselves who failed in their own beef business. Hence the general view was that consultants know less than themselves. In some cases, producers regarded the suggestions provided by consultants were impractical for business improvements. In contrast beef producers' attitudes to the creditability of government funded extension officers were on average much higher than that of private consultants.

Beef producers' self-awareness of their capability

Mental model: Beef producers believe that they are capable to adopt most of innovations.

All the interviewed producers claimed that their capability to adopt innovation was not an issue. However, in interviews producers experienced inconsistent results in the adoption of the National Livestock Identification System (NLIS). For example, one beef producer claimed success using the NLIS system to increase the efficiency of herd management, while another was very disappointed about the usefulness of it. Considering that the same system was adopted by different beef producers in similar business situations for the same management purpose, such inconsistent outcomes of innovation adoption could possibly be attributed to the capabilities of beef producers themselves. This points to beef producers' misperceptions of their own capability for doing innovation in their businesses. This view is supported in the literature. Klein & Sorra (1996) mention that technologies often yield little or no benefit to adopting organizations, not because of their ineffectiveness, but because of their implementation .

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Mental model on enhancing innovation adoption in beef business

Mental model: Dominant linear and static thinking on enhancing innovation adoption which simply includes two steps: identifying barriers and getting rid of the barriers.

Too many persons including many scientists work in the beef industry expect that research on enhancing innovation adoption in the beef industry should come up with only two answers, namely what factors inhibit innovation adoption; and how can we get rid of the inhibitive factors. These two questions can not be answered in a simple way, because the process of innovation adoption is much more complex. The systems analysis has already shown that barriers to innovation adoption are business situation specific. While business situations are changing all the time, the barriers are also changing. Addressing identified barriers to innovation adoption often leads to “fixes that fail”. This will require systemic interventions in other parts of the system. It is understandable that so many people have the above mental model, because the majority of people are still trained following a reductionist paradigm (Frank, 1995a).

Researchers’ mental model on innovation adoption

Mental model: Profit oriented innovation with scientific basis should be adopted widely and easily.

Scientific research is generally aimed at adding scientific value as well as to contribute to the financial situation of end users. However, “lifestyle” is implicit in beef producers’ business goals. In stable economic conditions lifestyle may easily overshadow the profit target. In this regard, Frank (1995a) asserts that agricultural research and extension policy have been based on implicit assumptions, “These assumptions imply that research is based on values which are scientific and oriented towards profit; and that consequent innovations are desirable and suitable for adoption, independent of a person’s self image, personality or social environment”. In contrast, beef producer’s choice to adopt or not adopt relevant technology depends on the perceived value it offers as a means of achieving personal satisfaction which is beyond pure economic reasons (Frank, 1995a).

Beef producers’ mental model on government regulation

Mental model: Current state government doesn’t really care about beef businesses. No one in the government is really understanding beef business.

Several beef producers believed that the current government does not really care about beef businesses because they account for only a very small proportion of voters.

Field interviews revealed that beef producers, especially those businesses located along the coast of Queensland were highly dissatisfied with government regulations in relation to water use and tree clearance. Beef producers actually appreciate the tree clearance regulation as it aims to protect the environment. However, they regard some of the regulations as too restrictive, for example the blocking of entire forests on the property and not allowing beef producers to utilize them and make it impossible to manage weed

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invasions and feral animal numbers. As a result the locked up area becomes infested with feral animals and weeds, which becomes a threat to other parts of the property.

Some producers complained about the restrictions on extracting underground water for irrigation. A large amount of money has been invested on bore drilling before these regulations were introduced. Even worse were the wild river regulations that put restrictions on water use and producers needed to continue paying for permission to extract water during the continuous drought period when there was no water in the river.

CONCLUSIONS

The systems analysis on the Australian beef industry innovation adoption has identified some key systemic structures and externalized mental models of key actors. The key implications from this systems analysis are:

- (1) It is fair to say that humans are inclined to think in a systemic way, but when faced with high levels of complexity and dynamics, it is often beyond the cognitive capability of humans to deal with it. This is exactly the case with the innovation adoption system in the beef industry. Beef producers have consistently agreed that the beef production system is actually a system formed by many factors that are interconnected and continuously interacting with each other. However, it is also true that beef producers seldom have an understanding of how these factors are interacting and how this determines the behaviour of the system as a whole. Adding to the complexity of interpreting systems behaviour are the systems archetypes. Understanding the complexity of the beef production system and identifying the systems archetypes within the beef production systems require specialized skills and tools which are beyond the capabilities of beef producers.
- (2) The mental models presented above reveal deep seated values and beliefs held by different actors in the Australian beef industry in relation innovation adoption. There is a clear lack of shared mental models. Shared mental models provide frameworks of value and belief systems which act as the basis for any successful teamwork and cooperation in that they affect activities such as the analysis of any new ideas, concepts and policies, and also promote cultural developments (Graydon & Deborah, 2005). In order to achieve a common target either for an organization or for a team it is essential to have a shared mental model. As research shows “currently, the agricultural sector is moving into an era of rapidly changing markets, technological, social and environmental circumstances that are evolving in often unpredictable ways. This is an era where collective intelligences need to be relied on in response to changing circumstances” (Hall, 2007). In this setting , to be successful in agricultural industry different actors including business managers, scientists, policymakers, consumers and entrepreneurs need to seamlessly organize their interactions in order to mobilize knowledge and continuously innovate in the face of change (Hall, 2007). This means that the degrees of successful innovations in the beef industry are dependent on how well stakeholders can collectively work towards a common innovation adoption target. Abel et al (1998) support the point that non-adoption of technologies and

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management recommendations from research and extension agencies can be attributed to divergent mental models between individuals and groups.

If answers to the question “what are the barriers to the innovation adoption in the Australian beef industry” have to be provided based on such a systems analysis. Then the short answers would be:

- (3) A lack of understanding of the systemic structures (including the archetypes) of the Australian beef production systems is believed to be the key barrier at the systemic structure level.
- (4) The lack of understanding each other’s mental models and failing to form a shared mental model among the key actors of beef industry is believed to be the key barrier to innovation adoption at mental model level.

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