Pathways for innovation: influence of industry structures and producer social networks

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Abstract. This paper describes how the innovativeness of producers in primary industry can be affected by individual and social structural factors and how industry and government agencies can encourage conditions conducive to industry innovation. The NZ Ministry of Agriculture and Forestry (MAF) wanted to use the results of a review in industry adoption, adaptation and knowledge transfer, to guide the development of their own role in this area. To provide the Ministry of Agriculture and Forestry with an understanding of the factors influencing farmer behaviour, published research into influences upon innovativeness and its association with fragmented, loosely coupled and highly structured industries was reviewed. The review follows the methodology embedded in the main streams of literature associated with each approach to innovativeness, that is: adoption, adaptation and knowledge transfer. In the discussion and conclusions, these are brought together by reflecting upon the industry structures within which they are each situated. For fragmented industries with individualistic decision makers, their level of innovativeness reflects decision makers' attitudes, norms, confidence, identity and resources. Innovation can be encouraged in fragmented industries by assisting decision makers to identify opportunities for change in their daily experiences. In loosely coupled industries, innovativeness seems to be associated with levels of social capital. Strengthening formal and informal social networks can encourage the innovativeness of loosely coupled industries. The innovativeness of highly structured industry groups is related to the degree of hierarchical and political control that the dominant coalition or core group has within an industry. Innovations by groups aligned with the core group are likely to provide incremental developments consistent with the dominant industry paradigms unless there are disruptive shocks to the industry. The key learnings that the paper highlights, are how industry structures and institutional arrangements can limit or enhance the degree of innovativeness shown by agriculturalists and growers. Innovativeness is only partly influenced by the characteristics of the innovator; it is also the result of linkages between innovators and other parts of their industries and reflects their social experience.

Keywords: innovation, adoption, institutional arrangements, industry structure.

Introduction

This paper describes results from a research project initiated by the New Zealand Ministry of Agriculture and Forestry (MAF) about the processes of adoption, adaptation and knowledge transfer within primary industries. Since 1986, MAF no longer has a role providing extension services for primary industries, but it still has some oversight on behalf of the government to ensure that these industries contribute towards "prosperous, sustainable and innovative agriculture, food and forestry and related sectors" (Ministry of Agriculture and Forestry 2007). Knowledge of the processes of adoption, adaptation and knowledge transfer is considered necessary to understand the potential role for MAF in increasing productivity among farming businesses in New Zealand.

The term 'adoption' is used as a way of describing a conscious decision to implement a new practice or apply a new technology (Fishbein 1980). Adoption is therefore used in this paper to describe the results of processes of decision making and behaviour change. This definition also implies that during the process, a decision maker can reject a change and seek to re-establish their previous practice or technology (Pannell et al. 2006). In this way adoption is considered a process carried out by individual decision makers operating either independently of each other or collectively when shared decisions are required (Rogers 1995).

The term 'adaptation' is used to describe the appropriation, customisation and application of a practice or technology to suit the collective needs of decision makers. It can be described as a process of socialisation of practices or technologies and as a reflection of the social capital within a network or community (Bijker et al. 1987).

The term 'knowledge transfer' is less widely reported in the literature than either adoption or adaptation, but when it is used, it is mainly considered a process operating within formally organised business structures such as commercial companies rather than loosely coupled industries or individualistic decision making (de Canio et al. 2000). Knowledge transfer is examined in this paper as it might operate within primary industries with highly interdependent decision makers.

Innovations are considered to be 'incremental' when producers are able to introduce them to achieve their short-term goals utilising existing skills and knowledge, and with little change to their existing production systems. In contrast, radical innovations require more immediate increases in knowledge in new areas and considerable changes to existing production systems to utilise them fully.

The paper focuses upon the issues underlying innovativeness as distinct from studying the use of specific technologies. It considers the ways that innovativeness can be grown as a capability throughout primary industries with differing degrees of relative connectedness. In particular, the paper examines whether the three different perspectives on processes associated with innovativeness (i.e. adoption, adaptation and knowledge transfer) would provide similar or different insights into the interactions between industry structure and innovativeness.

Some technologies appear to be developed and applied through individual effort influenced by personal social beliefs. The development of other technologies appears to be more reflective of an industry structure that brings together a mix of people with problem-solving and creative abilities. The study for MAF is intended to consider what is known about the influence upon these processes of farmer decision making, community dynamics and industry organisation. In the studies examining innovation some have taken a deterministic approach, regarding the availability and distribution of new technologies as the primary driver of industry growth. These studies describe innovation as a supply-chain like process, starting with idea creation, technology production, marketing and sales activities that need to be managed and coordinated to realise planned targets and goals (Moreau et al. 2001). Other studies consider innovation as a socially constructed activity that is subject to the aspirations that producers might have for exercising control over their natural and social environment to achieve greater self determination (Andrew 2003). This paper takes the latter more instrumentalist approach, in order to assist MAF in its role as a moderator in primary industry innovation rather than a direct participant.

Methods

A literature search was undertaken of published papers and books on adoption, adaptation and knowledge transfer in Pacific Rim countries with strong pastoral economies. The focus was on articles reporting empirical results because that provided information on how the concepts were being applied and what their practical (as well as theoretical) significance might be. The literature search provided the project with over 300 references to draw upon and of these; the 24 most commonly cited by the others were used in this report, along with other sources from allied studies (Parminter and Clouston 2006). This selection focussed the study on the papers considered to be the most reliable in guiding the thinking of other authors.

The literature on each topic of adoption, adaptation and knowledge transfer was initially examined independently and then the results compared across the topics in a deductive thematic approach to identify common and contrasting understanding of how they could be applied in primary industries (Boyatzis 1998; Braun and Clarke 2006).

Adoption and individualistic decision making

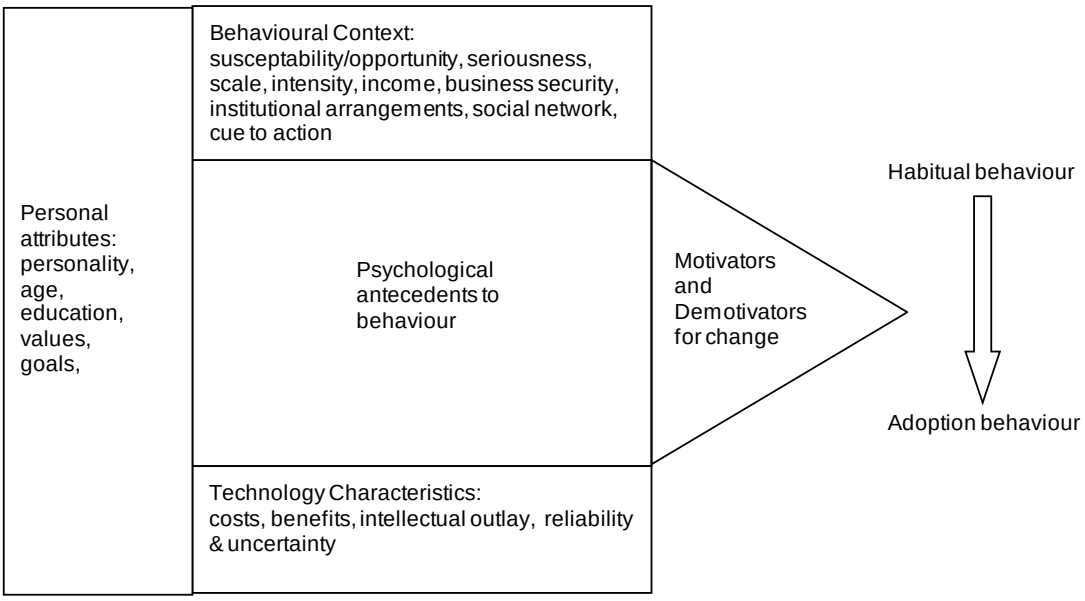
Understanding the processes of adoption and behaviour change by individuals is a different task to predicting the actual changes in people's behaviour. It may be possible to predict the results of behaviour change without any actual understanding of how a behaviour was influenced. However, being able to predict behaviour change provides a way of establishing the level of understanding that has been achieved in any study (Fishbein 1980).

The qualitative studies examined in this study tend to emphasis the contribution of relationships and participatory processes to extension programmes for encouraging adoption behaviour (Guerin and Guerin 1994). In contrast, researchers in quantitative studies more commonly identify key variables associated with technology use and apply them in mathematical models predicting practice change (Flett et al. 2004). These different approaches to examining and improving extension delivery may be a reflection of the results of their respective methodologies (Parminter 2006) rather than mutually exclusive understanding of extension and both are probably important in understanding and evaluating adoption processes and designing extension delivery.

Psychological models of human behaviour describe the immediate antecedents of behaviour through which the influence of more distal and external influences upon adoption and non-adoption may be understood. Models such as the theory of reasoned action (TRA) and its more recent variants (e.g. the theory of planned behaviour; Ajzen 1991) have both used measures of

human beliefs to explain peoples' intentions and so their behaviour (Figure 1; Eagly and Chaiken 1993; Parminter 2009).

Figure 1. Detailed factors influencing the adoption behaviour by individual landowners



Source: loosely based upon Eagly and Chaiken (1993, p 172)

The variables in a psychological model are internal to decision makers and therefore difficult for decision makers to observe. More distant from actual adoption decisions are variables that can be generalised across a number of behaviours and that may be more easily identified by external observers (Frank 1995; Pannell et al. 2006). In a number of studies, these distant variables have included factors associated with the personal attributes of individual decision makers (Frank 1997; Guerin and Guerin 1994) such as age and education. Some studies have identified specific characteristics associated with a technology or practice that influence adoption (Flett et al. 2004; Frank 1997; Guerin and Guerin 1994). These can be costs, benefits, intellectual outlay and reliability of a technology. The behavioural context has also been shown to be important, especially in the health belief model (Strecher and Rosenstock 1996) and other more agricultural studies (Frank 1997; Kaine and Bewsell 2002).

Individualistic decision-making approaches for innovation have been associated with new production techniques such as cryptorcid lambs (Tarbotton et al. 2002) and high dry matter kiwi fruit (Parminter and Max 2004), and environmental practices such as remnant bush preservation and riparian management (Parminter 2009).

Many researchers have described the process of development and adoption of agricultural technologies as if it has been a one-step process from non-adoption to adoption or rejection. However, we know from human behaviour studies that changing previously established ways of doing things is more likely to involve several steps in a multi-stage process. Some studies have identified three stages (Frank 1995) and others six or more (Prochaska et al. 1994). A multi-stage process based upon the work of Prochaska et al, would consist of:

1. *Precontemplation*. A growing recognition that a problem or opportunity exists and needs to be taken notice of.
2. *Contemplation*. The problem is recognised and any difficulties with understanding how it might be addressed are dealt with.
3. *Preparation*. A private commitment to change has been made and this is increasingly strengthened and made public.
4. *Action*. Time, energy and resources are applied to make the required changes.
5. *Maintenance.* Performing the new behaviour becomes less of an effort and more automatic.

In practice, not every stage will be recognisable for any particular individual or technology. Incremental technologies may be developed and adopted more quickly when the thinking contained in many of the stages has been established by being associated with other previous behaviours. The development and adoption of radical technologies may be more problematic if the thinking and decision making for many stages contains a high number of challenging or novel elements (Kaine and Bewsell 2002). Sometimes people recycle through the stages, or

they may compress the stages by appearing to conflate a number of stages together. Other people may stop and start again during the different stages over extended time scales. Coercive behaviour change policies may result in people skipping behaviour change stages or reversing the sequence of some stages.

Beliefs about innovation, technology adoption and practice change are going to be influenced through information, inference and experience. In recent years, agricultural organisations have had decreasing farmer membership (Green 2005; Ross White pers. comm.) and farmers have been turning increasingly to individualistic information sources such as the internet (Botha et al. 2004).

The most effective agency interventions supporting individual change processes will address the psychological motivations for change through the different stages of change. Advocacy that presents the strengths and weaknesses as well as the net advantages of an innovation will encourage positive attitudes and strengthen self-efficacy. It will also increase perceived behavioural control and self-identity. Advocacy alone may be enough of an industry intervention for some incremental technologies. Providing a full range of learning processes will be required if support is to be available for people through all stages of behaviour change. Learning support interventions will be required in addition to advocacy in any industry strategy intended to encourage the use of radical technologies (Parminter 2009).

Adaptation in loosely coupled industries

Innovation in loosely coupled networks of decision makers is influenced by the strength and type of connections existing between decision makers. In loosely coupled networks, decision makers however are still able to choose for themselves the networks that they wish to participate in, the amount of time that they might be involved and the group activities with which they might wish to be involved.

One example of this type of innovation in New Zealand is community-based pest control found in some rural areas, organised by groups of landowners within rural communities. For effective possum control, these groups require the cooperation and participation of all the landowners in their area to be successful. Group members may need to approach their neighbours and ask them to "do their bit" and "not let the side down" (Parminter and Wilson 2003).

The position of producers in a number of social networks has been shown to be associated with positive attitudes towards innovativeness, increased levels of adoption and greater confidence in the value of on-going practice changes to their industry (Cook et al. 2000; Frank 1997). Additional studies (e.g. Guerin and Guerin 1994) have suggested that if technologies were outside the social norms of their social group then producers have resisted the efforts of extensionists to encourage changes. The Parliamentary Commissioner's report (2004) on learning and education, indicated that both science and policy in New Zealand lacked connectivity with rural networks. This lack of connectivity was believed to have limited the changes required in agricultural industries to address serious natural resource issues facing the country.

The effect of social networks upon the innovative behaviour of decision makers has been related to the level of social capital that the network contained (Fleming et al. 2005). Social capital is built up by relationships of shared identity, reciprocity and trustworthiness and eroded by relationships of demand, extraction and suspicion or simple neglect. Social capital encompasses the norms and mutual responsibilities that a network has available for facilitating collective action (Falk and Kilpatrick 2000).

The power of social capital is indicated in the common expression when applying for a job that "it is not a matter of what you know but who you know" (Putnam 2000 p 20). Social capital can be strengthened through activities and interventions that increase peoples' feelings of connectedness. This requires creating opportunities for people to spend unstructured time together, as well as time to problem-solve together. Social capital can be weakened by activities and processes that break down links between industry participants and encourage individualistic or highly coupled decision making (Putnam 200).

Social capital can have positive externalities. For example, in some rural areas residents can benefit from the activities of a Landcare group protecting an area of the local stream where there might be a swimming hole. In such examples, all the families using the swimming hole benefit, whether or not they might be contributing as active members of the Landcare group. Positive externalities from networks with high social capital include greater mutual support when members are in difficulty, cooperation to undertake joint activities, high levels of internal trust reducing transactional costs, and greater effectiveness at realising shared objectives. There can

also be negative externalities from social capital, such as sectarianism when group members hold unswervingly to particular attitudes, ethnocentrism, believing the group to be superior to others, and corruption when the dishonesty of group members has been condoned by others (Putnam 2000).

Two types of social capital identified in the literature are described as bridging and bonding. Bridging social capital is inclusive of others, it occurs when a network consists of people dissimilar to each other, it reinforces social identity and assists a group to access external capability and resources and increases radical innovativeness (Lockie et al. 1995 provides a crop example). Bonding social capital is exclusive, it mobilises solidarity and creates strong in-group loyalty, but also develops out-group antagonisms. Bonding social capital tends to be associated with incremental innovativeness (for a landcare example, Cook et al., 2000). Bonding and bridging social capital have different effects upon innovativeness and are most supportive of innovativeness when they exist in balance (Table 1).

In Table 1 if decision makers have limited social contacts into their industry, then both bridging social capital and bonding social capital will be low. In that case, decision makers are isolated from each other and their innovativeness is dependent upon their individual circumstances and is highly idiosyncratic. One example of this might be the practice by landowners providing public access across private land. It is not a practice that has wide-spread farming support (bonding capital) although there can be a desire by some landowners to meet the expectations of Fish and Game and environmental groups which have valued access across private land for their members (i.e., there is some bridging social capital).

Table 1. Influence of social capital upon innovativeness

		Bridging Social Capital	
		Low	High
Bonding Social Capital	Low	idiosyncratic change *(land access)*	radical innovation *(herd homes)*
	High	incremental innovation *(calicivirus)*	isomorphic change *(zinc drenching)*

Source: Putnam 2000; with examples

If bonding social capital is low but bridging networks are strong, decision makers in the social network will tend to be outwardly focussed and more open to new ideas and radical innovations. For example early investments by dairy farmers into 'herd homes' often tended to reflect unique sets of values about the balance between production and the environment (they have low bonding social capital). Their ideas were often acquired from cosmopolitan linkages with other social groups (high bridging social capital). For example an industry article about herd homes described their originators as "innovation and problem solving seems to be in the Pows' blood. Agriculture wasn't. Kathy Pow was a nurse, Tom was a city boy raised in Auckland but decided on a farm cadetship after holidaying on a farm" (Fox 2005).

If decision makers are in a network with strong bonding relationships but have weak bridging relationships they will tend towards innovations that maintain their existing ways of doing things. An example of this might be the acquisition, multiplication and release of rabbit calicivirus by South Island farmers. This act was strongly sanctioned by a widespread group of farmers (with high bonding social capital), but resisted by farming leaders who were negotiating a formal release with policy agencies - they had some bridging social capital (Parliamentary Commissioner for the Environment 1998).

Decision makers in networks combining high bonding and bridging social capital will be innovative in ways that aligns them with changes that are going on in the overall industry, both radical and incremental. Gladys Reid has now been widely recognised within the New Zealand agricultural industry for developing a practical solution to facial eczema and in 1983 she was awarded an OBE for her contribution to agriculture. Gladys's early revelations about the preventative properties of zinc oxide were associated with non-traditional approaches to farming and were widely criticised by animal scientists and research institutes alike. Despite that, her ideas were initially taken up and used by unconventional farmers operating outside existing social norms (high bridging social capital) and eventually the practice became quite widespread

after the benefits of drenching with zinc oxide was substantiated by agricultural industry leaders (Rennie 2006).

Knowledge transfer in highly coupled industries

Highly coupled industries link decision makers together in organisational structures that have strongly connected internalised relationships e.g. within a company arrangement, or have linked their external relationships formally e.g. by contracts. Vertical networks within an industry are usually established and maintained to reinforce established power relationships and decision-making routines (Le Heron et al. 2001).

The structure of relationships in a highly coupled industry has a greater influence upon productivity and profitability than the structure of loosely coupled industries (de Canio et al. 2000). An industry structure loosely coupled for encouraging innovation generally increases industry performance, increases resilience to external pressures and improves producer morale but it also may have higher overhead costs than a cost-minimisation highly coupled industry (de Canio et al. 2000). When an industry which is highly coupled does not take into account the need to reorganise industry structures as part of the introduction of radical innovations, there is likely to be an underestimate of the innovation's contribution to reduced costs for the industry and an over-estimation of the effect of exogenous cost-shocks in the process of change for producers in the industry (de Canio et al. 2000).

Innovation decision making in highly coupled industries may vary in the amount of participation involved (Zaltman et al. 1973). Authoritative innovation decisions are usually made by a small group of people privileged with leading their industry, sometimes described in the literature as the 'dominant coalition'. The dominant coalition may consult with others in their industry but they are still the ones that will initiate and direct the adoption process. Introducing new technologies into a highly coupled industry with authoritative decision making requires the dominant coalition to:

1. Develop an understanding of the technology
2. Be persuaded in the value of making a change towards using the technology
3. Make a decision to encourage the introduction of the technology
4. Communicate the results of the decision to others in the industry
5. Implement the decision in an industry strategy.

If a highly coupled industry wants to be more participative in encouraging innovation and change it is likely that the decisions will still be initiated by the dominant coalition but they will then involve a much larger proportion of the industry before implementation. Special interest coalitions may form during consultation to promote their ideas to others involved in the process. This means that that there can be much more political conflict and bargaining going on throughout the decision-making process itself in a highly coupled industry (Zaltman et al. 1973).

People developing incremental innovations in highly coupled industries are likely to be aligned with the "establishment" or core group in any industry. They will usually share the paradigms, beliefs and rationalities of the core group and assist their industry by helping to explain those to the wider industry (Kirton 2003; Table 2). They try and develop innovations that are 'better' rather than 'different' and so the innovations that are developed by them are likely to meet the needs of the core group and readily accepted by them. Innovations from people outside this group are more likely to viewed suspiciously. This group will feel uncomfortable with "thinking outside the square" unless there are sufficient shocks to the industry to cause the existing paradigms to be disrupted e.g. the removal of farming subsidies in the mid 1980s (Parminter et al. 2000). They may then develop more radical innovations in an effort to try and restore stability to the industry (Table 2). Outside the core group of the industry there will be a group of innovators that tend towards radical innovations (Table 2; Parminter, 2007, Kirton 2003). If constrained to work within existing industry structures and paradigms they will adopt various coping strategies to maintain their involvement in the industry. If provided with the opportunities and resources to tackle critical industry issues, possibly deep seated and probably more process than product orientated, this group will provide radical innovative solutions.

An industry has only so much capacity to innovate and change (Hammer 2001). Therefore, committing more of its resources to incremental innovation will directly restrict an industry's ability to radically innovate and make significant changes if these should be necessary. Incremental innovations can block radical innovations by dealing with the same issues as radical innovations but without addressing its more critical elements. The resultant industry changes from a high level of investment in incremental innovation may be satisfactory in the short term, but over time those industries will find the original issues resurfacing (Hammer 2001).

Table 2. Innovative behaviour of highly coupled decision making industries

		Social Group Within the Industry	
		Core group	Outer circle
Problem Solving Situation	Incremental	incremental innovations to fit existing internal paradigms	coping behaviour
	Radical	external shocks required to change structural stability of the industry	radical innovations requiring interdisciplinary collaboration and external paradigms

Source: Parminter 2007

To encourage people within a highly coupled industry to become more innovative the industry can provide:

- Role models from outside the industry
- Identification and communication of critical industry constraints
- A mechanism for converting a novelty into the industry norm
- A rethink about the critical dimensions of the core business
- A focus upon successful implementation
- Opportunities to continue involvement with innovations as they develop.

Discussion and Conclusions

In this paper it was found that industries encouraging individualistic innovativeness will be highly aware of the operating environment of producers and the context creating opportunities for developing new technologies and the adoption of new practices.

The behaviour of decision makers in individualistic parts of an industry will be associated with their beliefs about technology characteristics, the personality of the decision makers and their behavioural context. Individuals appear to have a number of adoption stages when they are adopting a technology and each of these stages has different requirements for industry support to encourage successful behaviour change.

Industry and government agencies can encourage innovation through an individualistic pathway by segmenting producers into groups with similar behavioural "drivers" and providing them with opportunities and information to reflect upon their own production systems and their decision making and learning processes (Argyris 2003).

Loosely coupled decision makers are found in those communities and industries responsive to the collective goals of the individuals within them and where the shared net benefits have been greater than the summed individual net advantages. New Zealand and Australian producers in primary industries have typically been loosely coupled decision makers and this has suited their mainly farmer-to-farmer processes of innovation (Guerin and Guerin 1994; Le Heron et al. 2001).

Loosely coupled industry groups are dependent upon the levels of social capital to drive innovativeness. Low levels of social capital lead to increased individualistic decision making and idiosyncratic practice changes through an industry. High levels of bonding social capital encourage incremental innovations that support the status quo. High levels of bridging social capital encourage radical innovations that provide step changes that may be disruptive to established industry practices. A high level of both bonding and bridging capital leads to a balanced mix of incremental and radical innovations able to be aligned to industry priorities. The loosely coupled industry pathway for innovation can be encouraged by building upon the stimulation of the individualistic pathway with opportunities to learn from the examples of other innovative thinkers operating outside their own industry and existing realm of experience.

The innovativeness of highly coupled industry groups is dependent upon the degree of hierarchical and political control that the dominant coalition or core group has within the industry. Innovations by groups aligned with the core group are likely to provide incremental developments consistent with the dominant industry paradigms unless there are disruptive shocks to the industry. Innovation by more marginal groups in a highly coupled industry are likely to tend towards more radical innovations unless they are constrained to work within an existing industry paradigm. A highly coupled industry can encourage greater radical innovation

by establishing multidisciplinary project teams but they have to be prepared to find such groups more difficult to manage and fund.

Highly coupled decision makers in primary industries are usually found in formally organised structures such the poultry-meat industry where the production, processing and servicing of the sector is controlled through vertical integration and contracted agreements (Cooper-Blanks 1999). Organisations in those industries have established objective decision making processes using separate internal structures for governance, management and operations. With highly coupled decision makers, producer behaviour is constrained by the policies and strategies of other parts of their organisation (Parminter et al. 2000).

The pathway for innovation in highly coupled industries can be stimulated by providing a transparent process of investment into innovations and their development. The innovation process can be used to support the generation of ideas from groups outside existing production structures and any decisions about which ideas to proceed further with or restrict left until well into their development and made by a group that includes people from outside the existing industry paradigm.

Product and service innovations have generally tended to be diffused at greater speed through an industry than process innovations. This has been due to products and services being relatively market focussed whereas process innovations have been internally focussed, especially if they were dealing with matters of efficiency. Products have been more observable and product champions have tended to be more centrally situated in an industry, therefore products have tended to be developed faster with less political interference. Products have lent themselves to being standardised for use across an industry whereas process innovations have been much more likely to be idiosyncratic and so their diffusion slower. Process innovations have usually been more disruptive, and they have been likely to affect a wider cross-section of an industry (Damanpour and Gopalakrishnan 2001).

Rather than an industry being entirely one structure or another, different parts of any industry could reflect any of the three different structures described in this paper. Different innovations will be more likely to arise and be diffused through those parts of the industry depending upon the nature of the innovation and how that relates to the connectedness of that group of producers. Considering the way that different industry structures affect innovation can assist the design of policy interventions to encourage innovation.

The challenge for primary industries and government agencies is whether to encourage innovation by supporting individualistic decision-making strategies through direct channels of communication, or to strengthen social capital by assisting networks to develop with similar producer groups and with groups that may be taking quite different approaches to industry development; or to support marginalised groups within an industry capable of radical but maybe disruptive innovations. Depending upon the industry-agency relationship a combination of these three may be possible.

Three Key Lessons:

1. Innovation is produced by social experience.
2. Industry structures and institutional arrangements can limit or enhance the degree of innovativeness shown by agriculturalists and growers.
3. Innovativeness is only partly influenced by the characteristics of the innovator, it is also the result of linkages between innovators and other parts of their industries.

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