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Towards predicting rates of adoption and compliance in farming: motivation, complexity and stickiness

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Towards predicting rates of adoption and compliance in farming: motivation, complexity and stickiness

Introduction

Predicting the extent and rate of adoption by farmers of agricultural innovations is central to assessing the benefits to be had from research, marketing and extension programmes. It is also crucial to assessing if farmers may resist policies compelling the adoption, or abandonment, of particular agricultural technologies and practices.

Predicting rates of adoption, or compliance, and how they might be influenced, requires an in-depth, detailed understanding of the adoption process. After reviewing the literatures on consumer and organisational purchasing, Wright (2011) argued that a prudent approach to modelling adoption decisions by farmers would be to assume the full operation of the most extensive of consumer decision-making models and, therefore, the dual-process model of consumer decision making proposed by Bagozzi (2006a, b) would be most suitable.

Wright (2011) also observed that the adoption of more complex innovations might be expected to involve greater effort and risk. Therefore the factors that might influence the motivation to consider adopting agricultural innovations might vary depending on the complexity of the innovation. The same could be said in regard to changing farm practices and technologies generally. This observation, then, suggested that a classification of agricultural innovations, or changes in farm practices and technologies, into types ranging from simple through complex would be useful to the extent that these types influence the intensity of motivation required to take action.

In this paper we describe an approach to predicting rates of adoption and compliance with respect to the agricultural technologies and practices. The approach draws on the dual-process model of consumer decision-making and a method for classifying innovations in farm systems.

In the next section the dual-process model of consumer decision-making proposed by Bagozzi (2006a) is described. This is followed by a description of the classification of innovations proposed by Henderson and Clark (1990). More detailed descriptions may be found in Wright (2011) and Kaine et al. (2008), respectively. The adaptation of the Henderson and Clark (1990) classification to changing farm practices and technologies is then explained. The way in which the types of innovations that these changes represent influence farmers' motivation to change practices and technologies is then considered. A small, pilot application of the approach is briefly reported.

The implications of the approach for predicting rates of adoption of innovations, and the role of incentives and extension in influencing those rates, are discussed using the economic concept of stickiness (Ball and Mankiw 1994; Szulanski 1996; Ogawa 1998; Sims 1998; Bils and Klenow 2004; Mankiw and Reis 2006). The implications of the approach for predicting rates of compliance with policies compelling the use, or abandonment, of farm practices and technologies are also considered. Particular attention is paid to the implications with respect to the intensity of opposition to such policies and the role of incentives and extension in influencing that opposition, again using the economic concept of stickiness.

In the following the term 'adoption' may be taken to include commencing the use of any practice or technology (innovative or otherwise) and, implicitly, the abandonment of a practice or technology.

The Dual-Process model of adoption[1]

Adoption involves both a decision to adopt, which is intention, and the translation of that intention into behaviour, which may not occur (Bagozzi and Lee 1999). The concept of 'goal striving' was developed to link intention with behaviour (Bagozzi 2007; Bagozzi and Dholakia 1999; Bagozzi and Lee 1999). Consequently, the dual-process model of consumer response to innovations proposed by Bagozzi (2006a) has two components: goal setting and goal striving. Goal setting describes the process of deciding to adopt; goal striving describes the process of adopting.

The goal setting process provides a foundation for identifying when motivation, and the factors that influence motivation, delay adoption. This process clarifies the potential for the adoption of apparently beneficial innovations to be delayed by a lack of motivation. The goal striving process provides a foundation for identifying when it is implementation of the decision to adopt that delays adoption.

Goal setting

The dual-process model is shown in idealised form in Figure 1. In the model the first process triggered by awareness of an opportunity to achieve a goal is a sequence of reflective, deliberative processes: consider-imagine-appraise-decide (Bagozzi 2006a). This process determines the degree of interest the decision-maker has in achieving a goal, that is, goal desire. Insufficient interest halts any move to the conscious formation and use of attitudes and norms. The greater the time and effort envisaged in adopting an innovation, the greater goal desire must be to provoke movement beyond goal desire to goal intention. Goal desire determines whether a goal accepted as worthy of possible pursuit.

[1] The material in this section is drawn from Wright (2011), Kaine et al. (2012).

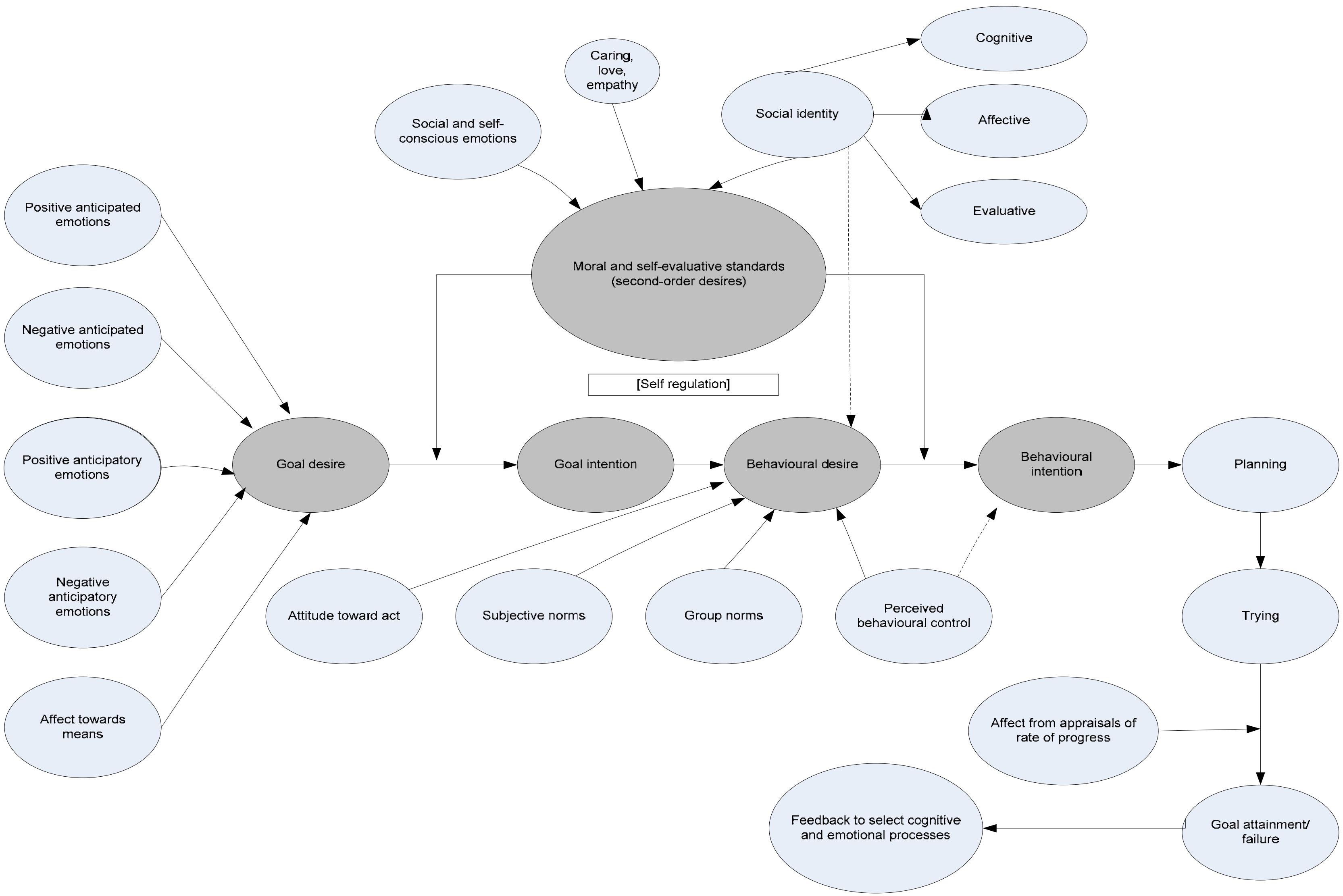

Figure One: Key variables and processes in Consumer Action

Source: Bagozzi (2006a: 15)

Bagozzi (2006a) proposes five elements in the consider-imagine-appraise-decide process. Two of these elements are the emotions that result from imagining success and failure and the associated personal emotional consequences in achieving the relevant goal. These are termed positive and negative anticipated emotions, respectively. These emotions could include happiness, excitement and pride or disappointment, anger and sadness. So, for example, successful adoption of a new technology may be associated with happiness and excitement. Conversely, the forced abandonment of a valued farm practice may be associated with frustration and anger. The likelihood of success or failure is not considered with anticipated emotions.

Another two elements in the consider-imagine-appraise-decide process are termed anticipatory emotions. These emotions can also be positive or negative and are emotional responses to the prospect of a future event. The emotions involved are hope and fear and depend in part on the perceived probability of an event, that is, success or failure, occurring (Wright 2011). In our context anticipated emotions concern feelings about the consequences that would flow from successfully changing farm technology or practice (or failing to), anticipatory emotions concern feelings about the chances of success (or failure).

The final element in the consider-imagine-appraise-decide process is affect towards the means of striving for the goal. This is the personal emotional appeal of the methods, processes, actions and so on required to pursue the goal (Bagozzi 2006a). These may be favourable, or unfavourable, depending on circumstances.

The consider-imagine-appraise-decide process leads to acceptance or rejection of the goal as a basis for acting or not.

A number of personality traits may influence goal desire including: self-efficacy, response efficacy, and causal and responsibility attribution processes (Bandura 1997). Self-efficacy and response efficacy will impact on anticipatory emotions while responsibility attribution will impact on anticipated emotions (Wright 2011).

Moving though the model, goal desire must be converted into some goal intention, a commitment to act to achieve the goal. This happens through the interaction of goal desire with self-regulatory processes, that is, the interaction of goal desire with the decision-makers evaluative and moral standards that govern who they are or want to be (Bagozzi 2006a). The interaction of these standards with goal desires can lead to an intention to pursue the goal, cancellation of the goal, or postponement of goal implementation (Wright 2011).

This commitment or intention must then be translated into a set of specific behaviours or actions to be implemented. This is termed behavioural desire. The factors that moderate the translation of goal intention into a set of actions the decision-maker is motivated to perform are attitude towards the act, social and subjective norms and perceived behavioural control (Fishbein and Ajzen 1975; Ajzen 2001; 2002).

Just as goal desire must be translated into a goal intention, behavioural desire must be translated into specific behavioural intentions. As was the case with the translation of goal desire into goal intention, the transformation of behavioural desire into behavioural intention is moderated by self-regulation, that is, the decision-maker's evaluative and moral standards that govern who they are or want to be (Bagozzi 2006a). The translation of behavioural desire into behavioural intention may also be moderated by perceptions of behavioural control such as self-efficacy.

Finally, the process of goal setting has the potential to be complex and iterative, which means the process can take some time. Action will not proceed until the process of deciding has run its course (Wright 2011).

Goal striving

Typically, the predictions from models of consumer behaviour have been limited to predicting behavioural intention. This limitation is based on the expectation that actual and intended behaviour are highly correlated (Bagozzi and Lee 1999).

Unfortunately, this is not always the case. In the dual-process model the factors that influence the link between intended and actual behaviour are considered explicitly in the goal striving component of the model. Explicit consideration of these factors is particularly important, not only in forecasting rates of adoption but also in highlighting what opportunities, if any, there may be to influence this rate.

The first stage in goal striving is the choice of how the behavioural intention will be fulfilled. Alternative means by which this may be done are evaluated in terms of self-efficacy, outcome expectancy and affect, which is like or dislike of a means (Wright 2011).

The second stage is action planning. This 'involves decisions as to when, where, how and how long to act. In this stage situational cues for the timing of specific actions are contemplated' (Wright 2011: 18). The third stage in goal striving is trying, that is, the implementation of the plan, which is the commencement of action in pursuit of the goal.

The fourth stage consists of the control processes exercised over the planned actions such as tracking progress, identifying opportunities and hindrances and revising plans accordingly, maintaining commitment and reconsidering goals, means, plans and actions in the light of experience. Appraisals of progress will lead to affective responses. For example, positive affect will evoke an intention to stay the course. A negative affect may evoke greater effort. Alternatively, it may result in changes in goals, a redefinition of success or failure or abandonment of goal striving (Bagozzi 2006b).

The final stage is the outcome: adoption, trial or failure to adopt, which will generate emotions. As they are experienced, outcomes will feed back to influence goal setting for subsequent innovations.

Types of agricultural innovations[2]

The effort and time involved in adopting complex agricultural innovations will be greater than for less complex innovations. Consequently, the intensity of the motivation needed to adopt complex innovations can be expected to be greater than that needed for simpler innovations. An important step, then, in using the dual-process model to predict the rate of adoption of agricultural innovations or non-compliance, would be to link differences in the strength of anticipated emotions, anticipatory emotions and affect towards means with the complexity of agricultural innovations. Such a link requires a rigorous method for characterizing the complexity of innovations. There are a variety of methods for doing so.

Wright (2011) suggested Henderson and Clark's (1990) framework for classifying product changes into types of innovations, which was adapted for innovations to agricultural systems by Kaine et al. (2008), was the most suitable in this context. The usefulness of the classification developed by Henderson and Clark (1990) is what it reveals about the magnitude of the impact of adoption (or abandonment) of a technology or practice in terms of disruption to system activity, the destruction of competencies, and the need for new skills and knowledge. See Kaine et al. (2008) for more detail.

In this section we briefly describe the framework for classifying innovations into four generic types and summarise the adaptation of the framework to classifying innovations in agricultural systems.

Classification of innovations

Henderson and Clark (1990) proposed that a product could be conceived of as a system – a collection of components that are linked together. They defined the components of a product as the physically distinct parts of a product. How the components are linked together to enable the product to function is the architecture of the product. Consequently, product innovation can be

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[2] The material in this section is drawn from Kaine et al. (2008; 2012).

conceptualised as changes to components, the linkages between them, or both. They then suggested that innovations could be categorised into four types of increasing complexity: incremental, modular, architectural or radical, depending on the degree of change introduced into the components and the linkages between them (see Figure 2).

Incremental innovations introduce relatively modest changes to the components of a product leaving the links between components, that is, the product architecture, largely unchanged (Henderson and Clark 1990). Incremental innovations exploit the potential of an established design and tend to build on existing skills and knowledge.

Modular innovations introduce relatively substantial changes to the components of a product in that at least some existing components become obsolete because the new components are based on new design concepts (Henderson and Clark 1990). Generally speaking, the architecture linking the components together remains largely unchanged with modular innovation.

New skills, competencies, and processes may be required to manufacture and install the new components. Consequently modular innovations may enhance or destroy competence depending on the history of the specific organisation (Gatignon et al. 2002).

Henderson and Clark (1990) define an architectural innovation as changing the way the components in a system link together. Generally speaking, architectural innovations entail relatively minor changes in the components. Knowledge about the way components link together becomes embedded in the organisational procedures, processes and structures over time (Henderson and Clark 1990). Consequently, architectural innovations have been shown to create serious disruptions to organisations because they require changes in the operating procedures, processes and structures of the organisations, as well as the acquisition of new skills and competencies.

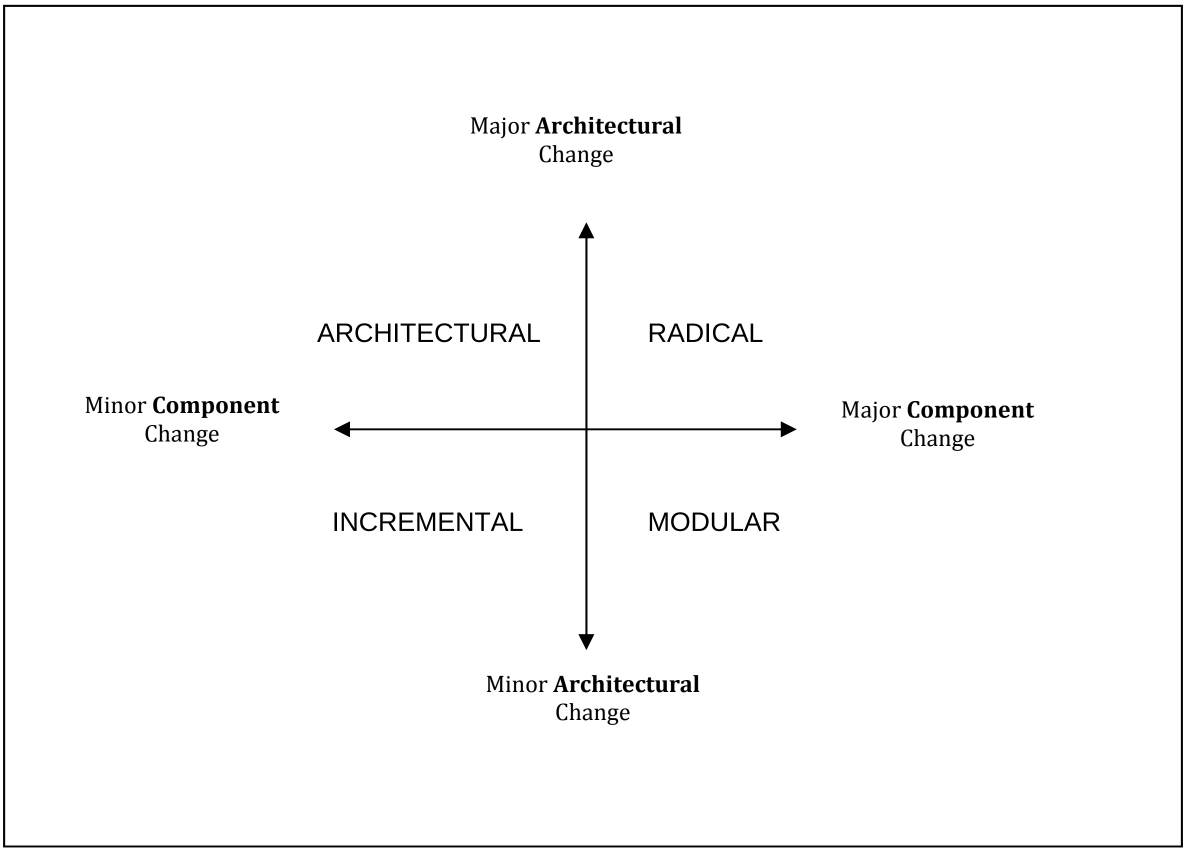

Figure Two: Idealised map of the four types of innovations

Source: Henderson and Clark (1990)

Finally, radical innovations involve a new set of design concepts that are embodied in new components that are linked together using a new architecture (Henderson and Clark 1990). Radical innovations are based on completely different scientific and engineering principles to the principles that were used in the products they supersede. With radical innovations many areas of organisational knowledge and competence are rendered irrelevant, consequently an organisation may have to consider new ways of thinking to adopt a radical product innovation (Smith 2000).

Classification of agricultural innovations

Kaine et al. (2008) adapted the systems approach of Henderson and Clark (1990) to classify different kinds of innovations in agricultural systems. They chose innovations to a farm sub-system as the unit of analysis. A farm sub-system is a set of components that link together in a specific way to perform a function (Kaine et al. 2008). The components of a farm sub-system are the physically distinct elements of the sub-system. The components of a farm sub-system may include technology, techniques and practices. The architecture of the sub-system describes how the components are arranged or linked together to enable the sub-system to function.

Different farm sub-systems are designed to perform fundamentally different functions. For example, a pressure irrigation system is a generic description of a sub-system that distributes water to plants using mechanical energy. Integrated pest management is a generic description of a sub-system for managing pests and diseases based on the use of beneficial insects and species-specific chemicals. Other sub-systems include animal health, feed management and breeding management.

Different sub-system concepts have different architectures and so are underpinned by different architectural principles. For example, the principle that water moves downhill under the influence of gravity underpins the arrangement of components in a flood irrigation sub-system. In contrast, the principle that water moves from an area of high to low pressure underpins the arrangement of the components in a sprinkler irrigation sub-system.

The extent of change to the components and architecture of a farm sub-system provide a basis for classifying innovations in farm sub-system into the four types of innovation: incremental, modular, architectural and radical.

Crouch (1981) observed that farms consist of hierarchies of inter-related sub-systems. The different types of innovation can be expected to have different effects on the interactions between sub-systems, with architectural and radical innovations having greater effects than incremental or modular. Consequently, depending on the type of innovation, incorporating new technologies or practices into a farm sub-system will require knowledge about the sub-system to be changed, and knowledge about how to realign other sub-systems to accommodate that change.

Kaine et al. (2008) proposed that the adoption of each type of innovation could be expected to mean that different skills and competencies will be needed with respect to (i) the sub-system itself, (ii) the interactions between sub-systems and, (iii) planning the implementation of the innovation. This means that qualitative differences can be expected in the time and effort involved in implementing the four different types of innovations, and that there will be differences in the rate of adoption (or abandonment) of the different types as a result.

At this point it is worth noting there is likely to be symmetry in the complexity of practices and technologies when it comes to compulsorily abandoning them. A technology or practice that was, for example, an incremental innovation in a farm sub-system when adopted will most likely be an incremental innovation when abandoned, provided the farmer returns to the technologies or practices that were superseded. The farmer's familiarity with the technology or practice may mean they can abandon it rather more quickly than they adopted it. The potential for this effect increases with the complexity of the technology or practice. If, however, the farmer adopts some other technology or practice in preference to those that were superseded then the type of innovation to the farm sub-system that abandonment entails may quite different to that entailed in adoption.

Returning to the dual-process model, anticipated emotions were identified as potentially important determinants of goal desire. It may be the case that there is limited emotional content associated with incremental and modular innovations. If so, goal desire in relation to incremental and modular innovations would depend mainly on the farmers' perceptions of the time path and reliability of the costs and benefits of changing farm practice or technology (Wright 2011).

In contrast, it may be the case that imagined goal achievement and goal failure have significant emotional content with architectural and radical innovations. If this is the case, then the relative strength of positive and negative anticipated emotions will strongly influence goal desire. The anticipatory emotions of hope and fear, and related factors such as perceived behavioural control and anticipated difficulties in striving are also likely to strongly affect goal desire with architectural and radical innovations.

In short, both anticipated and anticipatory emotions may play a substantial role in changing farm practices and technologies when these changes can be characterised as architectural and radical because of their complexity; not least because of the challenges they may pose to farmer competence. The same may be said for affect towards the means. This suggests that the division of changes in farming sub-systems into incremental, modular, architectural and radical innovations could be most informative about rates of adoption and compliance.

An application

Kaine et al. (2012) conducted a small pilot study into the dual-process model and the classification of innovations to cropping sub-systems in northern Victoria. Kaine et al. (2012) found that anticipated emotions, anticipatory emotions and affect towards means were present in the adoption process for both simple innovations such as changing wheat variety and more complex innovations such as stubble retention and direct drilling. They also found the relative strength of these emotional factors increase with the complexity of innovations. This is consistent with the proposition that the adoption of more complex innovations requires correspondingly greater levels of motivation than less complex innovations.

They also found relationships between the type of innovation and the need for new skills and decision effort. They also found that more complex innovations were evaluated for a significantly longer period than simpler innovations prior to adoption. All of these results were consistent with the literature and highlight that the rate of adoption of complex innovations will be inherently slower, on average, than the rate of adoption of simpler innovations (Kaine et al. 2012).

Kaine et al. (2012) found that current skills, knowledge and experience were useful in the adoption of complex as well as simple innovations in farming. Significant positive correlations were found between the impact of the innovation on the architecture of the farm system, the usefulness of current skills, current knowledge and experience, and decision effort. This suggests that current knowledge and experience is vital in the task of realigning farm sub-systems when integrating more complex innovations into a farm system.

Though not the focus of their study, Kaine et al. (2012) classified a variety of innovations that farmers characterised as simple or complex into incremental, modular, architectural and radical categories based on farmers' assessments of the novelty of the practice or technology, and their impact on system architecture (see Figure 3)[3]. With one exception, there is a positive association between farmer's ratings of the novelty of innovations and their characterisation of innovations as simple or complex. However, the association between their ratings of the degree of change in the relationships between components and their characterisation of innovations as simple or complex was weak.

[3] The angle of the axes is an artifact of the programme used to map the innovations, in principle the map can be rotated to align with the idealised map in figure 2.

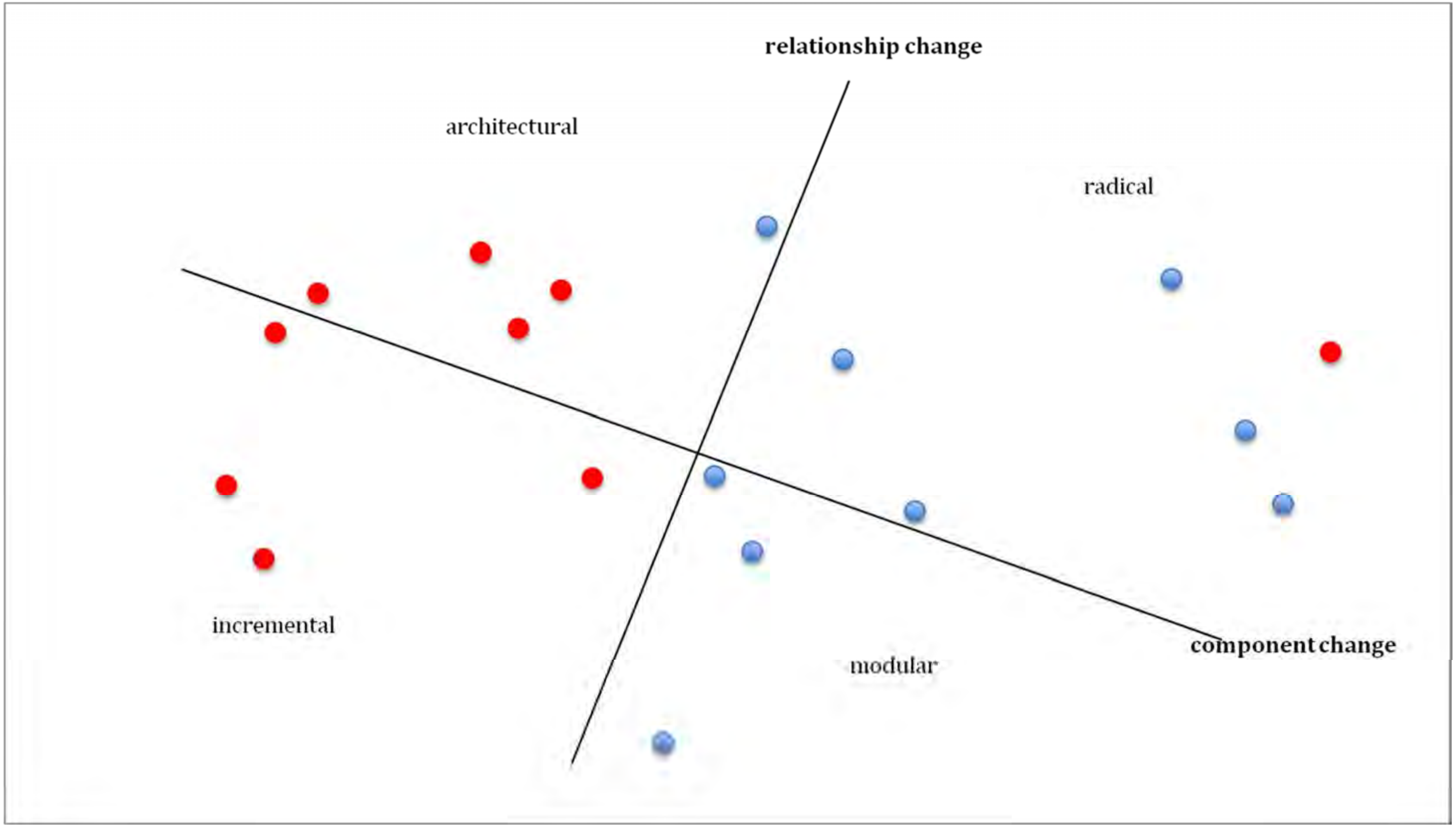

Figure Three: Classification of cropping innovations (red simple, blue complex)

Source: Kaine et al. (2012)

The correspondence between the types of innovation as measured by Kaine et al. (2012) and farmers' characterisations was promising enough to suggest that there is merit in developing scales to measure component and relationship change in farm sub-systems.

Overall, Kaine et al. (2012) concluded that the dual-process model of Bagozzi (2006a), in conjunction with the innovation classification of Henderson and Clark (1990), showed promise as a means for predicting the rate of adoption of agricultural innovations and for providing guidance as to how rates may best be influenced.

Discussion

The findings of Kaine et al. (2012) support the proposition that the adoption of more complex innovations requires greater decision-maker motivation, time and effort than simple innovations. The adoption of more complex innovations takes longer simply because they are inherently more difficult to understand and to integrate into the farm system. The greater time and effort involved in adopting more complex innovations means their adoption is also more susceptible to delay because of insufficient motivation. In other words, complex innovations are intrinsically 'stickier' (Ball and Mankiw 1994; Szulanski 1996; Ogawa 1998; Sims 1998; Bils and Klenow 2004; Mankiw and Reis 2006) than simple innovations; farmers will be more resistant to adopting (or being compelled to abandon) complex innovations than simpler innovations.

These findings have important implications for policies intended to promote change in farming technologies and practices. From the perspective of *voluntary* change, differences in the 'stickiness' of innovations translates into differences in the rate of their adoption, and the potential for incentives and extension to influence that rate (see Figure 4).

For example, simple innovations require very little learning to implement. By definition, the farm system is virtually unchanged by simple innovations and the farmer already possesses the knowledge and skills needed to implement them.

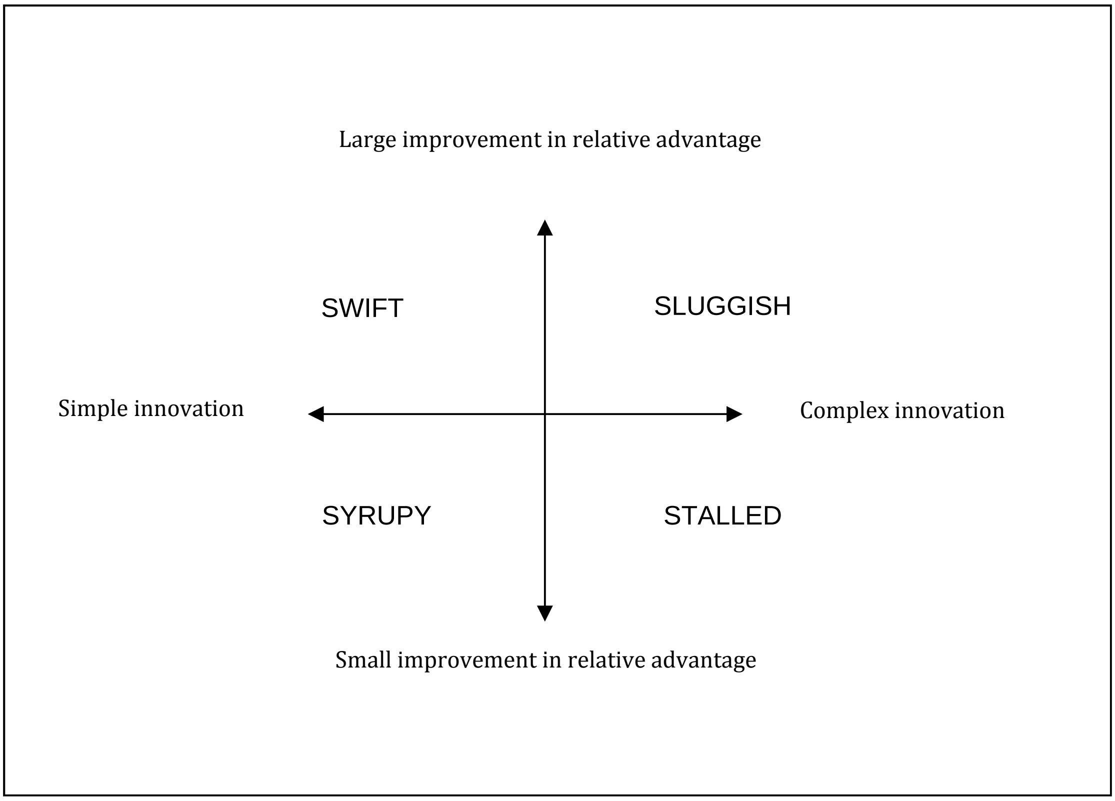

Figure Four: Stickiness in the rate of adoption of innovations

Differences in the rate of adoption of simple innovations will most likely reflect differences in the relative advantage they offer: that is, their superiority over current technology or practice. In these circumstances the role for extension is limited to raising awareness of the practice. The rate of adoption of simple innovations is likely to be quite sensitive to the provision of incentives because simple innovations are relatively inexpensive and low risk. The rate of adoption of simple innovations with a large relative advantage will be 'swift'. The rate of adoption of simple innovations with a small relative advantage will be slower; they are 'syrupy'.

The adoption of complex innovations requires the acquisition of new knowledge and skills by the farmer and entails planning and making substantial changes to the farm system. Differences in the rate of adoption of complex innovations will reflect differences in the time and effort involved, as well as differences in the relative advantage they offer. Complex innovations with a large relative advantage are 'sluggish': their rate of adoption will be slow. The rate of adoption of complex innovations with a small relative advantage will be even slower; they may even be 'stalled' permanently.

There may be an important role for extension in reducing the effort farmers must devote to searching for information on, and to learning about, complex innovations, and acquiring the knowledge and skills needed to implement them. Extension may also increase the rate of adoption if it is possible to increase the motivation of farmers to consider adopting the innovation. This would require knowledge of the root cause of the lack of motivation. The rate of adoption of complex innovations is likely to be quite insensitive to the provision of incentives, unless those incentives cover a major proportion of the cost of adopting the innovation.

From the perspective of *compulsory* change variations in the 'stickiness' of practices and technologies translate into differences in the rate of compliance, differences in the likelihood and intensity of opposition to the policy, differences in apparent compliance, and differences in the potential for incentives and extension to influence compliance (see Figure 5).

With regard to simple practices and technologies, the rate of compliance with a policy compelling their use (or their abandonment) is likely to be high while the likelihood and intensity of opposition to the policy is likely to be low. This will be especially so if the relative advantage of the change in practice or technology is small. In these circumstances the role for extension is likely to be limited largely to raising awareness of the policy.

Compliance with respect to changing simple practices and technologies with a small loss in relative advantage is likely to be high and 'swift'. Compliance with respect to changing simple practices and technologies with a larger loss in relative advantage may be high, eventually, but could happen more slowly, to be more 'syrupy'. The greater the loss in relative advantage the greater the motivation to delay compliance. The rate of compliance and degree of opposition to the policy is likely to be quite sensitive to the provision of incentives, particularly where the change in practice or technology entails a substantial loss in relative advantage.

With regard to changing complex practices and technologies the rate of compliance with a policy compelling their use (or their abandonment) is likely to be lower than with simple practices and technologies. Furthermore, the likelihood and intensity of opposition to the policy is likely to be high. This will be especially so if the loss in relative advantage of the change in practice or technology is large.

Compliance with respect to changing complex practices and technologies with a small loss in relative advantage is likely to be moderate but 'sluggish'. Compliance with respect to changing complex practices and technologies with a large loss in relative advantage will be low and 'stalled'.

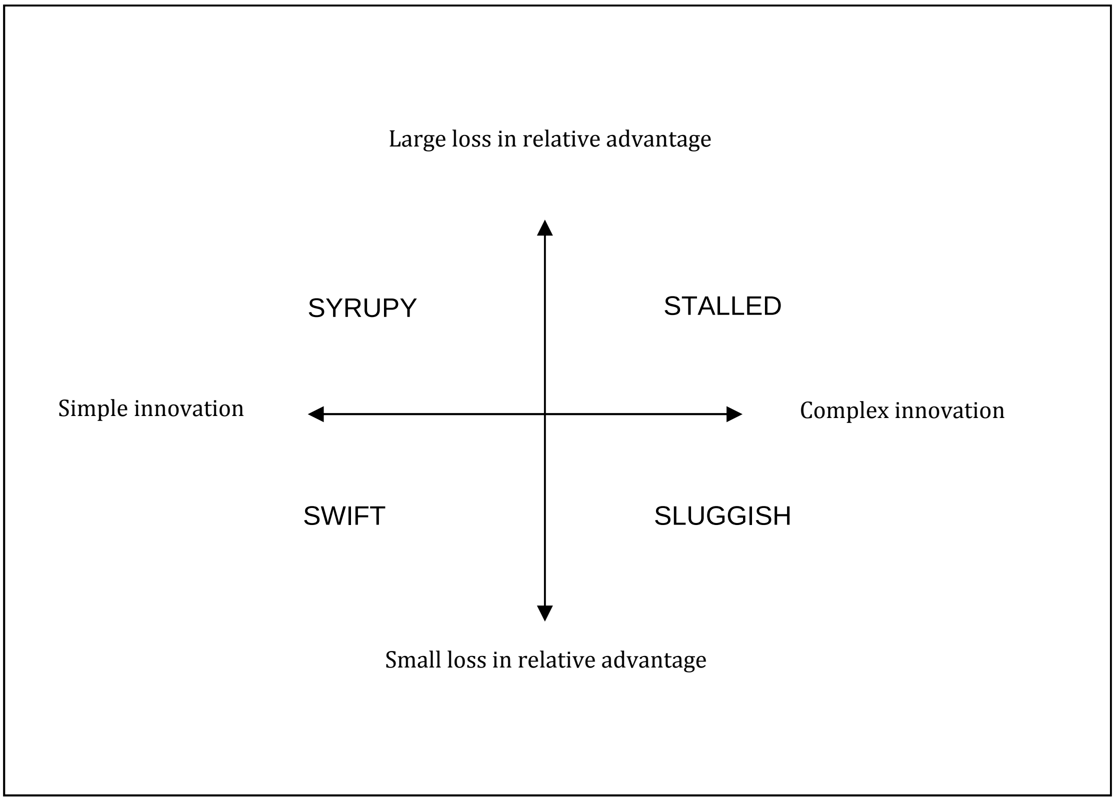

Figure Five: Stickiness and compliance in the use or abandonment of practices and technologies

In these circumstances the role for extension appears problematic. Where the change in practice or technology entails a substantial change in relative advantage the rate of non-compliance and degree of opposition to the policy is likely to be quite insensitive to the provision of incentives. This may be the case even where incentives represent a substantial proportion of the cost of changing practice or technology. The reason is that, returning to the dual-process model, changing complex technologies or practices requires a high degree of motivation; this entails a substantial emotional investment in terms of anticipatory and anticipated emotions, and affect towards means.

The greater the emotional investment in adopting a complex innovation, and the relative advantage it offered, the correspondingly stronger the resistance to abandoning the innovation will be, and the greater the likelihood of outrage. Relatedly, where a policy compels adoption of a complex practice or technology, the greater the emotional investment in adopting that innovation, and the smaller the relative advantage it offers, the correspondingly stronger the resistance to using the innovation will be, and the greater the likelihood of outrage.

In these circumstances farmers will seek to block or modify the policy, or delay its implementation. They will seek ways of complying with the letter of the policy while avoiding complying with its intent (Kaine and Higson 2006). Rigorous enforcement, including punitive sanctions, may be the only means of substantially improving compliance in this situation.

Conclusion

In this paper an approach to predicting the rate of adoption of agricultural innovations has been described. The approach applies equally to predicting rates of non-compliance with policies prescribing the use, or abandonment, of particular agricultural practices and technologies. The approach draws on the dual-process model of consumer decision-making and a method for classifying innovations in farm systems. A pilot application has shown that the approach has merit.

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