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Rates of Adoption: The Diffusion of Agricultural Innovations

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Victoria
The Place To Be

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Foreword

Estimating the extent and rate of adoption is essential to assessing the benefits to be had from research into agricultural innovations and evaluating the success of marketing and extension programs. While advances have been made in regard to methods for predicting the likely extent of adoption of agricultural innovations, the same cannot be said in regard to methods for predicting the rate of adoption of agricultural innovations.

Predicting rates of adoption, and how they might be influenced, requires an in-depth, detailed understanding of the adoption process; more so than is the case in regard to predicting the extent of adoption. The question arises as to how to characterise the adoption process of farmers. Should the adoption of agricultural innovations be treated as adoption by an individual, and so models of consumer purchasing are relevant; or should the adoption of agricultural innovations be treated as adoption by an organisations, and so models of organisational purchasing are relevant?

In this paper, the economic literature on consumer adoption and organisational adoption are reviewed to identify how decisions by farmers about the adoption of agricultural innovations might best be described and modelled. The results should provide a foundation for developing better methods for predicting the rate of adoption of agricultural innovations.

This paper was commissioned by the Service Design Branch in Farm Services Victoria as part of a program of research on methods for estimating the extent and rate of adoption. We have made the paper available to others to contribute to the continuing debate in extension on the issues of estimating and interpreting rates of adoption in agriculture, and how the design of extension services might influence them.

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Table of Contents

Executive Summary

Predicting and estimating the extent and rate of adoption is central to assessing the benefits to be had from research into agricultural innovations and evaluating the success of marketing and extension programs. Predicting rates of adoption, and how they might be influenced, requires an in-depth, detailed understanding of the adoption process.

The bulk of research into the adoption of innovations by farmers treats the process as a black box, seldom even recognising Rogers' suggested stages of the innovation-decision process. The mainstream diffusion models maintain this black box approach; reflecting little of the findings from research into adoption processes. Much more is known about purchase decision making than the black box approach to adoption and diffusion reflects and this report accesses this knowledge.

The question arises then, as to how to best characterise the adoption process of farmers. Like consumers, but unlike larger organisations, farmers are unlikely to possess professional purchasing skills. They are likely to be influenced by salient personality traits in their adoption decision-making. Like organisations, but unlike consumers, farmers consider innovations in the context of clear production systems, with well-defined costs, and well-specified output objectives. Meaningful models of diffusion, that is, rates of adoption, seem likely to need to draw on both consumer and organisational adoption theories.

Upon reviewing the literatures on consumer and organisational purchasing it seems that a prudent approach to modeling adoption decisions by farmers would be to assume the full operation of the most extensive of decision making models. Farmers may act like consumers; the structures and roles that impede this in larger organisations are simply absent in micro-organisations like farms. Consequently, the models of consumer decision making proposed by Bagozzi and colleagues would be most suitable for modelling adoption decisions by farmers, and subsequently rates of adoption, as these are the most comprehensive.

In the models proposed by Bagozzi and colleagues goal desire plays the key role in determining the urgency that is attached to an adoption possibility, both in terms both of promptness and persistence of attention. In these models goal desire is, to a greater or lesser degree, influenced by anticipated emotions, anticipatory emotions, and affect towards the means of achieving goals, that is, preferences for action. These factors may be relatively trivial in the case of incremental and modular innovations; hence goal desire would depend primarily on farmers' evaluations of the time paths, and reliability, of the costs and benefits of adoption.

On the other hand, these factors may be critically important in the case of architectural and radical innovations; hence goal desire would depend on variables such as social values, social norms, dispositional resistance to change, perceptions of outcome

control and self-efficacy, as well as farmers' evaluations of the time paths, and reliability, of the costs and benefits of adoption.

This suggests that a classification of innovations into types of innovations such as incremental, modular, architectural and radical will be most informative about the rate of adoption to the extent that they condition intensities of motivation to adopt: that is, goal desire.

In principle, models such as those proposed by Bagozzi and colleagues may be operationalised using agent-based modelling to estimate rates of adoption.

1. Introduction

The extent and speed of adoption of innovations contain important feedback for those guiding and promulgating innovations. Extent of adoption indicates the value of net benefits attributed to an innovation by those to whom it is targeted. Speed of adoption indicates the promptness with which those benefits, and the derived benefits for the sponsoring organisations, are achieved.

Because it may be possible to avoid poor choices of innovations to launch, modify innovations to advantage or modify the rate of adoption, reliable projections of the extent and rate of adoption may have considerable value. This reliability depends, however, on the absence of conflation of extent and rate of adoption. This is because, at any point in time during the adoption process for a given innovation, the number of adopters only indicates rate (the proportion that has adopted) when extent (all adopters) is known. Without a denominator of eventual total expected uptake, it is not possible to know how near or far one is from the end of the process, nor what percentage has adopted.

A great deal of adoption research in the farming context has conflated extent and rate. This is partly a result of an assumption of common causality, namely: the diffusion of an innovation is often assumed to involve a firming up over time of confidence in the relative advantage of an innovation (e.g., Lindner 1987: 145-146, Rogers 2003: 232-3). Likewise, so-called 'barriers' to adoption are commonly much more obviously determinants of extent of adoption than rate of adoption (e.g., Schneeberger et al. 2002).

This conflating has fed into a long-standing concern, in the adoption literature, that diffusion research has a 'pro-innovation bias': 'that an innovation should be diffused and adopted by all members of a social system… rapidly and… should be neither re-invented nor rejected' (Rogers 2003: 106). As vigorously critical as this allegation of bias may seem, it is in fact a gentle way of pointing out that the conflation forces any implicit model of the *process of adoption* to be trivial and deterministic; a point discussed below.

The absence in most adoption research of explicit attention to the likely final extent of adoption is consistent with the usual absence of any classificatory schema for innovations, in detailed or aggregate terms. Without a schema it is difficult to move towards any absolute or conditional valuation of innovations, and thus likely market uptake. Even with a schema, it would be necessary to be able to capture adoption contexts in such ways that conditional innovation value can be projected.

Similarly, the absence of such classing of innovations means that the subjectivity attending notions thought to influence rates of adoption, such as complexity and observability (Rogers 2003), is left total and undefined *a priori*.

In this report the objective is to draw together relevant literature that seeks to categorise farming contexts and agricultural innovations with the purposes of avoiding the conflation identified above, and thus move towards better accuracy in projecting total uptake, and analysis of real rates of adoption.

2. Australian Farmers as Adopters

Technically, Australian farms could be defined as profit-seeking organisations and their adoption behaviour viewed as part of their organisational purchasing activity. As a result, decision-making about the adoption of agricultural innovations would be expected to tend to objectively rational approaches in contrast to the more subtle and complex motivations normally guiding consumer decision-making (Bagozzi 2000). Such an inference may be too glib.

All but six percent of Australian farms are family farms (Pritchard 2007). Two thirds of Australian farms are broadacre or dairy farms, 99 per cent of which are operated by owner-managers. On average, about half of farm income for these farms is from off-farm sources. The average number of full-time farm employees is 1.8 per farm, approximately (Fragar et al. 2008). The characteristic Australian farm then is a family operated business with few permanent employees. On such farms the authority for all significant decisions typically rests with the owner-manager and family.

There are farms that do not resemble this characteristic type. They include large 'corporate agriculture', most notably in cotton, viticulture, hogs and poultry, where managers have little or no equity, and 'farm family entrepreneurs' (Pritchard 2007). Due to scale and workforce size, each of these is more likely to resemble organisational purchasers and their decision style. The numerically predominant context for adoption of farm-related innovations, however, is plainly family farms with a single manager. Compounding this exceptional character of Australian farms is the intensity of competition, as distinct from rivalry, and resulting lack of financial control that is typical.

As with many small private businesses the locus of decision-making authority in a single farm manager makes decision-making subject to that manager's idiosyncrasies, perceptions and analytical skills. In larger enterprises this is mitigated by the common involvement of multiple, salaried stakeholders in major decisions and their ruminations as to what appropriate decision criteria should be, given the organisation's objectives.

An implication of the nature of Australian farms as businesses is that the major existing theoretical frameworks of diffusion do not fit very well. The explicit farm production process is very different to the typical consumer context, so consumer-focused models of diffusion are likely to be insufficient. However, the small size and low financial control of farms makes it unlikely that models focused on organisation diffusion will apply well. There are no distinctive models constructed for small and medium enterprises as such. This is because small and medium enterprises, being considerably larger in workforce number terms than farms, replicate the key distinction between farms and large organisations: a professional, structured approach to purchase decision making. In contrast farms are predominantly either micro-businesses or non-employing businesses, defined in Australia as having zero to four employees (ABS 2002).

Like consumers, but unlike larger organisations, farmers are unlikely to possess professional purchasing skills and are likely to be influenced by salient personality traits in their adoption decision-making. Like organisations, but unlike consumers, farmers consider innovations in the context of clear production systems, with well-defined costs, and well-specified output objectives. Meaningful models of diffusion seem likely to need to draw on both consumer and organisational adoption theories.

3. Theories of Adoption and Diffusion of Innovations

Bagozzi (2007: 245) has asserted that 'the study of technology adoption/acceptance/rejection is reaching a stage of chaos, and knowledge is becoming increasingly fragmented with little coherent integration'. A decade earlier, Ruttan (1996: 66-67) argued that the:

> *'failure to maintain the momentum of the convergence of research traditions which seemed so promising in the early 1960s clearly remains an obstacle to a richer understanding of the diffusion of technology. Advancement of understanding of knowledge about the sources, processes and consequences of the diffusion of technology is inherently an interdisciplinary project. It will be necessary to draw on psychology, sociology, economics, geography, technology and history in order to advance the project. It is important that sociologists who value the research tradition that established the adoption-diffusion paradigm as a field of research contribute to this broader research agenda'.*

A starting point for putting some structure to research and theorising in this domain is explicit consideration of adoption, diffusion and the relationship between them. An innovation that is new to the world, and its creator, impacts on societies mainly through the extent to which it modifies behaviour. This can be analysed at both a micro and macro level. At the level of the individual adopter of the innovation the process of adoption can be analysed. At the level of the aggregation of adopters, the diffusion of the innovation among them over time, can be analysed. With either framework the focus is the first adoption of the innovation (Mahajan and Wind 1986).

Adoption has a clear meaning, although in practice adoption may involve some degree of adaptation of an innovation and the persistence of the adoption may vary across adopters. Rogers (2003: 11) defines diffusion as 'the process by which (1) an *innovation* (2) is *communicated* through certain *channels* (3) *over time* (4) among the members of a *social system*.' Colyvas and Jonsson (2011: 30) observe that 'diffusion reflects the spread of a practice or organizational structure within a social system and can be understood as both process and outcome'. The latter is what we are calling 'uptake'. 'Practice' 'might be a behaviour, strategy, belief, technology, or structure' and 'diffusion' 'the most general and abstract term we have for this sort of process, embracing contagion, mimicry, social learning, organized dissemination, and other family members' (Strang and Soule 1998: 266). Diffusion, as defined, is thus viewed intrinsically through a societal prism and adoption, following communication, is implicit. Each of these aspects places a good deal of pressure on the definition of 'social system'.

In turn, this flags the fact that 'innovation' is a broad church. Colyvas and Jonsson (2011: 31) conclude that 'contemporary studies treat diffusion indiscriminately, as the spread of all manner of social practices, from the use of a technology to specific beliefs to forms of organizing'. The diversity of innovations is arguably a factor in the conflation pointed to earlier in the case of the adoption of farm technologies. For many innovations, such as positive attitudes to gay marriage or negative attitudes to capital punishment, it is neither possible nor meaningful to project aggregate adoption: total uptake. This is because the appeal of adopting such innovations is unknowable, and quite possibly shifting through time.

With more prosaic innovations, in the context of profit-seeking organisations, the appeal can be deduced with some confidence. Desired consequences of adoption are relatively clear, the consistency of the innovation, or some adaptation of it, with its usage context is clear and relevant uncertainty tends to be specific.

The diversity of innovations affects other dimensions of diffusion and adoption, as well, such as duration of adoption, extent of imitation of other adopters and source of influence (Colyvas and Jonsson 2011: 31).

'Most diffusion studies draw on imagery of social influence and contagion' (Colyvas and Jonsson 2011: 31), 'a heterogeneous process that entails both internal and external sources of influence - i.e., distinguishing between the population through which something travels as well as the social setting that encompasses this process' (Colyvas and Jonsson 2011: 32). A difficulty with contagion models is that they focus on 'infectious' populations (or social systems). Such are not always readily defined. In the case of farms, however, the prosaic nature of the innovations means, arguably, that the 'infectious' population can actually be defined.

The way an innovation diffuses through a social system would seem very likely to be related to the way adoption decisions are made. 'Communication', 'influence' and 'contagion and infectiousness' all imply that needs and predispositions within each adopter will condition the relevance of a 'message', 'persuasive observation' or 'character of the viral innovation', respectively. Therefore, diversity in innovations will impact, potentially, on both adoption and diffusion, and reliable analysis of either process will need to recognise salient variety in innovations.

Colyvas and Jonsson (2011: 32) observe that:

> *'Collectively, the subjects who adopt, whether individuals or organizations, have exhibited remarkably similar patterns, although through varying mechanisms and theoretical assumptions. Traditional diffusion models are often represented as S-curves'.*

The nature of the innovation will determine whether diffusion analysis can or cannot be used in a predictive way, or whether the diffusion, post hoc, is of no interest due to the arbitrary incidence of the innovation and the lack of an identifiable path of contagion or communication (cf Strang and Soule 1998: 266).

3.1 Modeling adoption

As noted above, meaningful analysis of diffusion processes is more plausible when the adoption processes that are served by the information flow that diffusion amounts to, are understood. As Rogers (2003: 116) cautioned, 'diffusion scholars would do well to remember that individuals' own perceptions count in determining their innovation behavior'. Which perceptions count depend on the needs and preferences of the individual and the decision-making process they bring to the adoption decision.

Extant economic research into the adoption of innovations by farmers involves a process whereby 'researchers typically select a number of potential independent variables for inclusion in their analysis based on prior theorizing and test, usually via logistic or probit regression, to determine which variables correlate with adoption in some statistically significant sense' (Knowler and Bradshaw 2007: 29). As indicated here, there is no comprehensive model underlying this mainstream economic approach beyond adoption being assumed to involve choice under uncertainty. Rather, farmer, farm, farm household, and farm financial and management characteristics, together with exogenous factors (especially innovation characteristics and information) are surveyed econometrically to find likely correlation suspects.

This is a theoretically ad hoc approach and does not even usually incorporate the specific version of a hierarchy of effects model (Gatignon and Robertson 1985), the five stages of the innovation-decision process that Rogers (2003) proposed. Thus, there is no explicit decision-making process embedded in farm-related adoption decision research. It is a black box. This is very common across all research into the adoption of innovations (Bagozzi and Lee 1999: 218). So far as farmers as adopters are concerned this may not matter much: 'in its current form, the economic approach [to modeling human behaviour] is too impoverished to account for the rich and varied ways that consumer decision processes operate and that consumption behaviours afford' (Bagozzi 2000: 106).

Notwithstanding the commentary above, as to the uniqueness of most Australian farms as organisations, the model-free specification of independent variables and the absence of decision-making process in much of the extant farm adoption research means that this body of research is much closer to the assumptions of considerable objective rationality associated with organisational adoption than to the subjectivity associated with consumer adoption. The results of this work, to the mid-1980s, were summarised by Lindner (1987: 148) as being richly diverse, due mainly to poor research methods, but that the most clearly emerging core finding is that 'the final

decision to adopt or reject is consistent with the producer's self-interest', where 'self-interest' has more dimensions, potentially, than profitability.

We have noted above that managers of profit-seeking organisations, of any size, are likely to have a relatively clear comprehension of self-interest as an innovation relates to them, once they understand the innovation and its implications. This creates an interesting situation that we might describe as follows. The physical and financial feedback to a farmer following the adoption of an innovation tends to be bleakly objective. Uncertainty about the commercial wisdom of adoption is ultimately resolved clearly. The innovation is used repeatedly because it is a component of a production process which is used repeatedly. Mistakes will lead to modification or disadoption rather than tenacious acceptance of net negative outcomes.

The techniques that a consumer may use to deny, ignore, reconstruct or otherwise modify their *post hoc*, cognitively dissonant (McColl-Kennedy and Kiel 2000) perceptions of the wisdom of adoption, in lieu of disadoption by discarding or non-use, are too expensive for a farmer. So mistakes will tend to be corrected more by farmers than by consumers (or managers of other businesses with greater financial slack than farms) independent of the quality of adoption decision-making. The effect may be to cause self-interest, or relative advantage (Rogers 2003), to emerge in post hoc studies as the principal determinant of adoption.

However, the factors that were argued above to cause farmers to be more similar to consumers than non-micro business managers imply that farmers will approach adoption decision making as consumers do: as nonprofessional purchasing managers. We would therefore expect them to make more errors, take longer to decide and to engage in more disadoption than other managers. Models of consumer adoption are necessary here to indicate what this non-professional, consumer approach might embody.

3.2 Adoption by consumers

With respect to consumers, Bagozzi (2000: 106) asserts that 'economic accounts of consumption are descriptively sterile, not only in terms of the decisions consumers make, but also in terms of the deliberative and dispositional determinants of these decisions and in terms of the post-decision processes underlying decision implementation'. An effect of relying on economic approaches is 'to forego any hope of explaining how and why consumers consume the way they do and providing policy guidelines on how to better adapt to, or change, consumer behaviour' (Bagozzi 2000: 106). Similar observations have been made about the inability of purely economic models to 'capture the full complexity of farmers' behaviour and motivation' (Flett et al. 2004: 200).

Our need is to frame contemporary models of adoption by consumers and deduce the implications of these models for farmer (micro-business) adoption. Bagozzi's work in

this area is very useful to this end because (a) it is the most elaborate and comprehensive extant model of consumer adoption processes and (b) he has applied it himself to modeling organisational (specifically information systems) adoption processes.

Bagozzi and Lee (1999: 218) focus on goals, arguing that decision processes about innovations are decisions about consumer goals 'related to his or her subjective well-being'. They rely on the definition of goals by Austin and Vancouver (1996: 338): 'internal representations of desired states, where states are broadly construed as outcomes, events, or processes'.

In contrast to the neutrality of consumers to innovations that is assumed in most approaches, Bagozzi and Lee (1999) model consumer responses in terms of resistance (see Ram and Sheth 1989) and acceptance, the former being a special case of general resistance to change. This locates their approach within the longstanding, and contemporary, notion that the self has both an evaluative and a regulatory, or 'executive', function. 'An important aspect of the executive function of the self is to regulate goal-directed behavior: to set goals in line with self-relevant standards, to implement strategies designed to accomplish these goals, and to monitor progress toward goals attainment' (Heimpel et al. 2006: 1294).

Resistance to change has long been studied in the context of specific interventions, especially in organisational contexts, and analysed as a situationally-specific response. More recently, however, resistance to change has been studied as a disposition of individuals (Oreg 2003). A scale has been developed and the construct validated across multiple cultures (Oreg et al. 2008). Dispositional resistance to change has also been found to correlate both with likelihood and speed of adoption (Oreg 2003: 688-689).

> *The trait comprises four dimensions: Routine seeking involves the extent to which one enjoys and seeks out stable and routine environments; emotional reaction reflects the extent to which individuals feel stressed and uncomfortable in response to imposed change; short-term focus involves the degree to which individuals are preoccupied with the short-term inconveniences versus the potential long-term benefits of the change; finally, cognitive rigidity represents a form of stubbornness and an unwillingness to consider alternative ideas and perspectives. Although different dimensions become salient in different contexts, the composite RTC score has been shown to predict individuals' reactions to change in a variety of contexts under both voluntary and imposed conditions*
>
> Oreg et al. (2008: 936)

Resistance to innovation is the obverse of 'innovativeness', a personality characteristic that has long been employed in adoption and diffusion research (Rogers 2003). The

notion in economics that differences in speed of adoption of ultimately gratifying innovations, are due to differences in the adequacy of uncertainty reduction is simply a very general version of this model. Its generality causes sources of, and responses to, uncertainty to be unspecified, leading to econometric hunting for them.

Since much of the interest in adoption is with its dynamics, the explicit focus on resistance as the key determinant of adoption delay following launch of an innovation would seem to go to the core of the issue. But another element is involved. Bagozzi and Lee (1999) argue that adoption involves both a decision to adopt and a translation of this into behaviour. The latter may not occur.

This approach has its origins in an enduring effort by Bagozzi to develop a model of attitude-behaviour linkages that makes explicit the link between decisions to act (behavioural intention) and behaviour. The most prominent models that make use of the link between behavioural intention and behaviour are the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) (see Bagozzi 1992; Bagozzi and Warshaw 1990). Bagozzi (2007: 245) has suggested that 'the intention-behavior linkage is probably the most uncritically accepted assumption in social science research'.

Following introduction of a 'theory of trying' (Bagozzi and Warshaw 1990), Bagozzi and colleagues have developed the model to one labelled 'goal striving' (see Bagozzi 2007; Bagozzi and Dholakia 1999; Bagozzi and Lee 1999). The overall model of consumer response to innovations thus has two components: goal setting and goal striving.

Beyond the explicit modeling of the intention-behaviour linkage, and attending its development, Bagozzi (1992, 2006a) has expanded the determinants of attitude-behaviour linkages to add cognitive and emotional self-regulatory mechanisms to the attitudes and social norms that populate TRA and TPB. This follows from Bagozzi's proposition that mainstream consumer behaviour theory is inadequately served by its main paradigm, cognitive response (or 'information processing') theory, and other main research tradition, attitude theory. 'The two traditions complement each other: attitude theory emphasizes primarily the explanation of what consumers decide or do, whereas the cognitive response paradigm is marked largely by what consumers think and how they make evaluations' (Bagozzi 2006b: 114). The two traditions are separate and each has been elaborated upon through time while neither, alone, provides a coherent model of consumer behaviour. There is still a black box at the heart of conceptual models.

In seeking a general model that does not itself seek to capture the heterogeneity of manifestations of consumer behaviour (i.e., psychological processes) but to identify a unified, common core model, Bagozzi (2006b) has worked from a depiction of consumers:

> *…as being in a tension or dialectic between selfhood and sociality, and where consumer agency complements more deterministic aspects of consumer behavior … . Consumer agency is manifest in purposive action and self-regulation, whereas selfhood rests in personal identity, and sociality plays out through social identity, group norms, and interpersonal dynamics. The consumer can be thought to navigate his/her life with regard to consumption by resolving the tensions that occur between selfhood and sociality, as he/she purposively self-regulates his/her desires, decisions, and actions. By looking above the fray, I refer to a specification providing guiding, abstract scientific principles; by looking below the surface of seemingly chaotic consumer behavior, I call for identification of basic, universal concepts and processes underlying consumer behavior.*
>
> (Bagozzi 2006b: 120)

The parallels between mainstream economic and marketing approaches to explaining behaviour, where neither has a core model that guides model specification in specific contexts, are clear. In both disciplines the standard approach, to analysing buyer behaviour and the adoption of innovations, relies on the artful application of typically parsimonious and partial sub-models.

One response that Bagozzi (2006b: 118-119) notes is a suite of attempts to use deductive, grounded approaches to better describe consumer behaviour. This approach is content rich but explanation and prediction poor. It has not contributed to greater unity in consumer behaviour research.

Reflecting his interest in goal striving, as well as goal setting, Bagozzi (2006a:7-8) advocates distinguishing between 'consumer behaviour', the psychological processes undertaken to make choices and move to volition, and 'consumer action', 'what one does as an agent either as an end in and of itself or as a means of achieving a goal' Bagozzi 2006a: 8). Purposive action can be summarised as follows:

> *'…reasons for action → desire to act → decision making/choice/intention to act → action (as an end or means to an end) → achievement of an end → collateral outcomes'*
>
> (Bagozzi 2006a: 8)

Bagozzi (2006a) grounds his model of consumer action (Figure 1) in the notion that consumers rely on both automatic and preconscious processes and on deliberative or reflective processes when responding to stimuli that may propel action. Reflective processes include self-regulation.

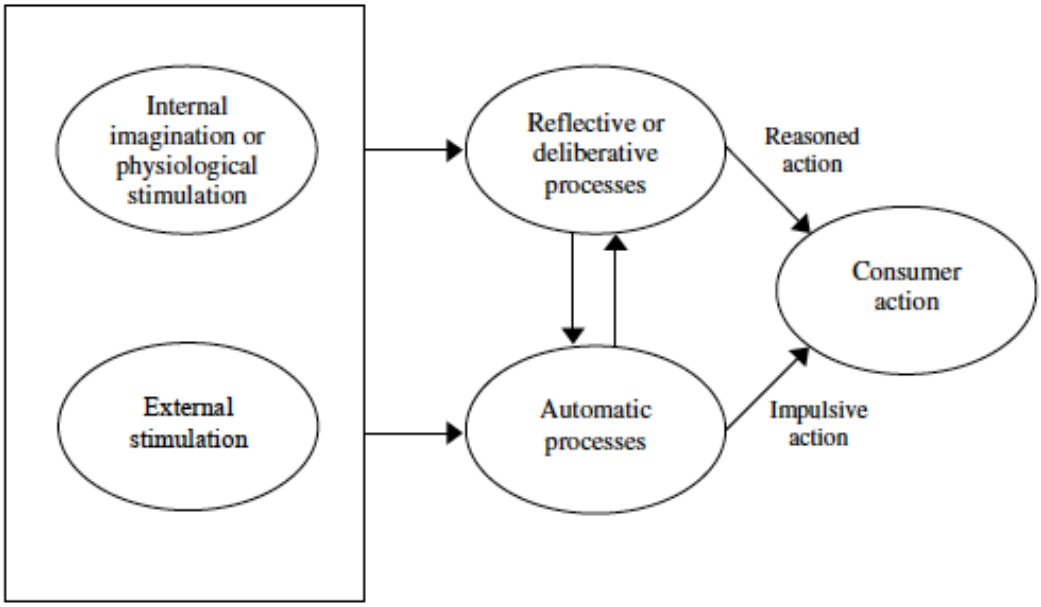

Figure 1: Bagozzi's Dual-Process Model of Consumer Action
Source: Bagozzi (2006a: 4)

The extent to which action can become automatic, and the nature of interactions between automatic processes and deliberative processes, has a great deal of research ahead of them. Automaticity is clearly real (e.g., driving vehicles, habitual purchasing) albeit unlikely to relate commonly to the adoption of innovations, where deliberative processes are likely to be active. However, automatic processes such as learned positive or negative feelings about extension officers as information sources may bias perceptions and judgments in the deliberative processes.

Bagozzi models the sequence of specific processes involved as shown in Figure 2. They should not be expected to follow a tidy linear sequence without feedbacks causing revisits of processes but, for the purposes of explanation, we shall track the sequence from left to right. In reality, movement backwards and forwards through the entire model is possible.

Goal setting

Bagozzi (2006a) argues that the first stage of reflective, deliberative processes leads to a state of goal desire which, if insufficient, aborts any move to cognitive use of attitudes, norms, etc. That goal desire, he argues, results from a sequence of consider-imagine-appraise-decide (CIAD) that leads to a degree of interest in achieving the goal. This is the first process triggered by awareness of an opportunity to achieve a goal. The decision-maker first considers the goal, meaning they attend to and elaborate the opportunity, they imagine the implications of succeeding and failing to achieve the goal, and then appraise the personal relevance of these possible alternative outcomes.

Goal desire determines whether a *goal* will be adopted. It is a critical first stage in Rogers' 'persuasion' phase of the innovation adoption process.

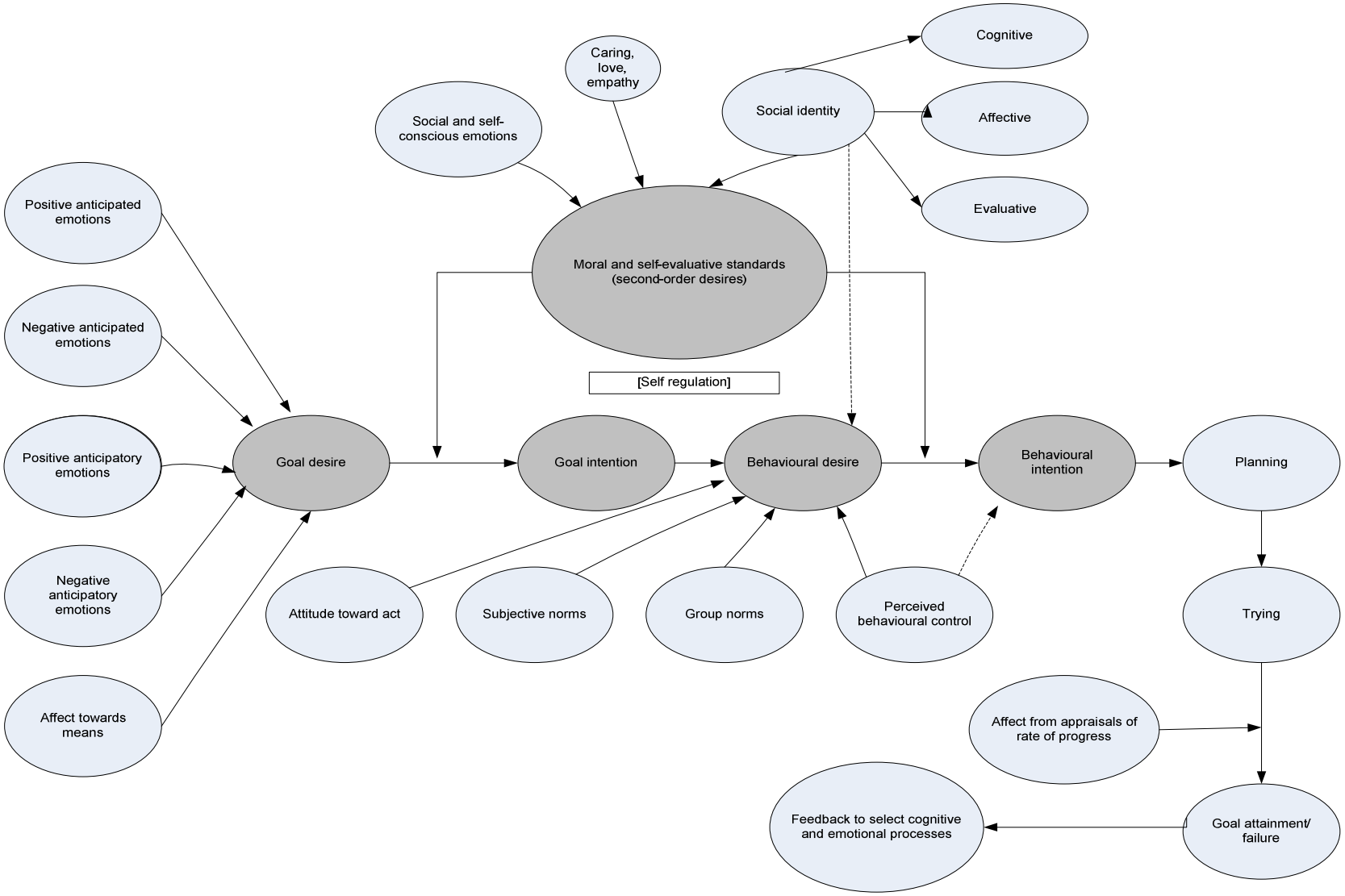

Figure 2: Key Variables and Processes in Consumer Action
Source: Bagozzi (2006a: 15)

In the CIAD process five elements can be identified. Two are alternative *anticipated emotions*. Positive and negative anticipated emotions result from imagining success and failure, respectively, in goal attainment and their personal emotional consequences. Emotions potentially in play include happiness, excitement and pride or disappointment, anger and sadness. The range of possible emotional outcomes is defined. The likelihood of success or failure is not considered. Interestingly, Bagozzi (2006a: 25) argues that 'anticipated emotions apply especially to situations in which consumers already have goal intentions' and, therefore, 'positive and negative [anticipated emotions] capture a decision maker's appraisal of the significance of anticipated goal outcomes for his or her survival or for flourishing in a specific goal situation.'

Two more elements in CIAD are *anticipatory emotions*. These can be positive or negative and are 'presently felt emotional responses to the prospect of a desired/undesired future even' (Bagozzi 2006a: 27). The emotions involved are hope and fear and, unlike anticipated emotions, which are unaffected by probabilities of success or failure, anticipatory emotions depend on the perceived probability of an event occurring.

The final element Bagozzi suggests is *affect towards the means of striving* for the goal; that is the personal emotional appeal of the broad notion of the means required to pursue the goal.

As antecedents to decision making these emotional responses to a novel action, and affect towards the means of striving to achieve the goal, act as a gateway to further consideration of its adoption. The CIAD process leads to acceptance or rejection of the goal as a basis for acting or not. Action is not triggered by reasons to act (e.g., favourable attitudes and norms) unless motivation to act, as goal desires and behavioural desires, is present to transform reasons to intentions. However, goal desire can influence intentions directly, bypassing the need for reasons for action (Bagozzi 2006a: 30).

Feeding into this stage of the process are some personality inputs: self-efficacy which is the degree of confidence in successful adoption, if chosen; outcome expectancies pending adoption which is response efficacy; and causal and responsibility attribution processes, which fine tune emotional responses on the basis of where responsibility for outcomes is judged to rest (e.g., another person, the self or external circumstances). Self-efficacy and response efficacy will impact on anticipatory emotions and responsibility attribution on anticipated emotions.

Another input into emotional responses is goal valence. That is, 'goals can be conceived of in terms of approaching a positive outcome or end state (i.e., approach goals) or in terms of avoiding a negative outcome or end state (i.e., avoidance goals)' (Heimpel et al. 2006: 1295). A goal may, thus, be perceived as a positive aspiration or a negative aspiration. That is, to excel or to avoid failure. The significance of this

distinction is that avoidance goals are inherently inferior regulatory structures relative to approach goals; negative goals imply regulation on the basis of negative possibilities and lead to poorer outcomes (Heimpel et al. 2006: 1295). 'The approach-avoidance distinction is regarded as one of the most fundamental psychological dimensions as illustrated by its prominence in personality, emotion, learning, and social psychology as well as psychobiology' (Schnelle et al. 2010: 226). We return later to this issue as it might impact on farmers.

Relative advantage can also influence goal desire via its impact on anticipated emotions; the magnitude of a successful outcome (Bagozzi 2007: 251).
Some marketing researchers have approached the attachment of emotional responses to innovation, using a single dimension, in terms of 'eagerness' for the innovation (Furukawa et al. 2002).

An overarching approach to modeling the motivational impact of a possible action is to evaluate it using *cognitive schemas*. Schemas are '"learned, internalized patterns of thought-feeling that mediate both the interpretation of on-going experience and the reconstruction of memories" (Strauss 1992: 3) ... [and] ... capture a person's knowledge structure' (Bagozzi et al. 2003: 917). Goal schemas have emerged as a means of identifying context-specific motives to fill the explanatory lacuna between universal, general motives (such as Maslow's, for example) and specific actions. Image theory (Beach and Mitchell 1990) was an early similar attempt.

That is, a decision maker is assumed, potentially, to bring an evaluative frame, composed of goals and linkages between them, derived from experience. Experience reflects prior contemplation of means-ends chains of reasoning from superordinate goals, such as Maslow's, to focal goals in specific contexts. This approach points to the role of memory as context for the evaluation of innovations, for example. It will likely operate as such, for reasons of cognitive efficiency, whenever a stimulus relates to goals previously contemplated. A clear example is stimuli relating to farm production processes. The schemas can also inform self-regulation.

An implication of cognitive schemas is that modeling of reasons for action, such as the TPB, is likely to fail to recognise the interactions among expectancies and valences a decision maker owns, nor the relevance of all outcomes (Bagozzi et al. 2003: 916). That is, the use of TPB with no reference back to the decision maker's relevant cognitive schema would ignore the role of prior cognitive effort by the decision maker.

Decision making and self-regulation

Goal desire, moving through the model, is converted into some goal intention: a commitment to act to achieve the goal. This has to be translated into an action desire: a set of specific behaviours sought to be implemented. The factors that moderate the translation of goal intention into behavioural desire are those identified in TPB: attitude towards the act, social and subjective norms and perceived behavioural control. This is then translated into specific behavioural intentions, possibly moderated by perceived

behavioural control, often measured as self-efficacy.

Operating over this process of goal desire being transformed into behavioural intention is self-regulation. Self-regulatory processes, which are second-order desires relative to the first-order status of goal desire or behavioural desire, involve reflection on goal or behavioural desire that can lead to cancellation, overriding or postponement of implementation, or further consideration of the desire. Likewise, they may involve reflection on the lack of a goal or behavioural desire.

Second-order desires are 'personal self-evaluative or moral standards concerning who a person is or wants to be' (Bagozzi 2006a: 31). The processes may also operate automatically, drawing on 'learned values, dispositions, traits, virtues, and vices' (Bagozzi 2006b: 127). They interact with goal desires to regulate goal intentions and with behavioural desires to regulate behavioural intention. That interaction may lead to the creation of intentions previously absent. That is, self-regulation can install goals that had not been initiated in the goal setting process: goals that the decision maker believes they should have.

Self-regulation operates, reflectively or reflexively (automatically), as if posing questions such as:

> *Am I the kind of person who should have a desire? Am I the kind of person who acts on this kind of desire? Is the desire consistent with the kind of person I wish to be? Will acting on this desire lead to personal flourishing? What effect will acting on this desire have on other people important to me, other people whom I might not even know, or social welfare writ large? In answering the question what to decide or do, the decision maker brings to bear reasons for deciding or for acting or not (e.g., duty, obligations, or other personal standards and social requisites). Such reasons both justify and motivate the decision or action. Thus self-regulatory reasoning comes to interact with our desires to influence our intentions and through intentions action.*
>
> Bagozzi 2007: 251

Goal striving

Mainstream consumer behaviour theory does not model consumer action as defined here. Rather, behavioural intention is viewed as the last relevant outcome of consumer choice, with actual behaviour highly correlated to it (Bagozzi and Lee 1999). Bagozzi (2006a) argued that this is an artificial termination to such models given that our interest is choice and behaviour rather than simply choice. Particularly, feedback effects from realised success in acting on behavioural intentions are bound to inform future decision making and action, and difficulties in striving may be replete with marketing management implications.

The first stage in goal striving is the appraisal and choice of how the decision will be fulfilled. Alternative means by which this may be achieved are evaluated in terms, particularly, of self-efficacy, outcome expectancy and affect, that is, liking or disliking of a means. These elements of appraisal need to be integrated to make a choice.

The second stage is action planning, involving decisions as to when, where, how and how long to act. In this stage situational cues for the timing of specific actions are contemplated. The next stage is the commencement of action in pursuit of the goal: the implementation of the plan.

The fourth stage is the control process exercised over the action. This involves tracking progress, surmounting impediments that arise, maintaining commitment and reconsidering goals, means and actions in the light of the experience being realised.

The outcome is the final stage: adoption, trial or failure to adopt.

This outcome will generate emotions. These feed back to inform goal setting and goal setting processes with respect to subsequent innovations.

On the way from trying to outcome, appraisals of progress will lead to affective responses. Positive affect, from exceeding some reference rate of progress, will evoke an intention to stay the course. A negative affect, from poor progress, will evoke greater effort. 'Of course, when consumers try to achieve a consumption goal, they sometimes alter the target goal or their definition of success or failure; indeed they even might abandon goal striving in certain cases' (Bagozzi 2006b: 136).

Model core

Bagozzi (2006b; 2007) describes the elements that are grey shaded in Figure 2 as the decision making core of the action model. The operation of the core is deterministic, with the exception of self-regulation, with the impact of other variables and processes determining goal and behavioural desire and intention being context specific. Bagozzi (2007) argues that human agency enters the model through self-regulation.

The attractiveness to analysis of adoption of this model is that, while the processes and variables outside the core will take values according to the idiosyncrasies of given contexts, they are defined. The model is presented as a comprehensive one. There is no need for econometric trawling for explanatory variables.

3.3 Adoption by organisations

The Technology Acceptance Model (TAM) has been the dominant model of organisational adoption since its introduction in 1989 (Bagozzi 2007). Davis (1986) first presented the model as an intersection between a number of strands of research into product use, one of which (expectancy theory) has an action orientation as does

Bagozzi and Lee's approach. As a result, the TAM overlaps with TRA and TPB (Bagozzi 2007, Flett et al. 2004).

The model is parsimonious, employing only two beliefs to predict intention to use: perceived usefulness and perceived ease of use (Davis 1989). 'Significantly, TAM has consistently outperformed the TRA and TPB in terms of explained variance across many studies' (Bagozzi 2007: 244). 'After 17 years of research and a large multitude of studies investigating TAM and its many variants, we now know almost to the point of certainty that perceived usefulness (PU) is a very influential belief and that perceived ease of use (PEOU) is an antecedent of PU and an important determinant of use in its own right' (Benbasat and Barki 2007).

Despite this impact, concern has grown that TAM is limited and not readily extended to deal with its limitations. Some limitations are related to its parsimony: antecedents of the beliefs are undefined and not contemplated theoretically; emotions and habits are omitted; intention to use may be a problematic dependent variable as predictor of actual adoption or use; and there are no self-regulation processes in the model (Bagozzi 2007; Benbasat and Barki 2007). Attempts at broadening the model have been weakly grounded theoretically (Bagozzi 2007; Benbasat and Barki 2007; Chuttur 2009).

A TAM study of adoption by New Zealand dairy farmers (Flett et al. 2004) had a prediction accuracy of 71.8 per cent across four different technologies, with PU contributing 50.1% of the factor analytic solution variance, and PEOU 18.6 per cent. The study confirms the usefulness of TAM, and the role of perceived ease of implementation/use even in businesses as intensely profit-sensitive as dairy farming (Flett et al. 2004: 208), but still leaves around 30 per cent of both analysis and prediction unexplained.

Importantly, this application of TAM indicates that, while the domain in which it has been developed and mainly applied is management information systems, there is nothing about the model that limits the 'technology' to which it may relate.

Bagozzi (2007: 252) has proposed that progress beyond TAM requires the use of a general model that 'rests first on specifying fundamental psychological processes of decision making ... and second on providing a basis for delineating contingent, contextual causes and effects of the basic decision making core ... [resulting in a] deepening [of] the theory of technology use acceptance, while suggesting fruitful avenues for better understanding how, when, and why decisions are made in various technology applications.' That is, progress is contingent on explicit exploration of what, even in TAM, has predominantly been treated as the black box of adoption decision-making.

Bagozzi (2007) argues for the application of his model of consumer action, or at least its core, with contributing other variables in the fuller model to be used as appropriate

in the decision-making context. Other, more parsimonious models, such as TAM and Roger's, can be interpreted as heavily trimmed down versions of Bagozzi's model. What may often be absent in such models, however, would be a compelling rationale for the excision of processes, particularly core processes. The optimism underlying typical econometric regression-based approaches is exposed when relevant psychological insight is applied to buyer decision-making.

In the context of non-micro-organisational adoption, where purchase decision making is a specific, dedicated role potentially involving a buying group of managers in the case of major investments, the implications for the operation of Bagozzi's model are rather clear. As suggested earlier, a substantial reduction in emotional inputs would be expected. Likewise, automatic processes are likely to be few and explicit and 'self-regulation' to be limited and driven by organisational policies and corporate identity rather than those of individuals.

In such circumstances, models such as TAM can represent a much less severe distillation from the true complexity of adoption processes than would otherwise be the case. In the case of very small businesses, or less systematic adoption decision processes within large organisations (e.g., desktop computer and software choices by university staff), arguably too much is lost in the distillation. This is as true of goal striving as it is of goal setting.

A prudent approach to modeling adoption decisions by farmers would seem to be to assume the full operation of the most extensive of decision making models. This is because organisational size, and the coincidence of management and ownership, conspires to reduce the likelihood of systematised decision making and of the restriction of decision criteria to explicit, corporate objectives and policies. A priori, farmers may act like consumers; the structures and roles that impede this in larger organisations are simply absent in micro organisations.

Thus, where a large organisation will have formal procedures for the evaluation of 'new buys', being innovations for the organisation, a farmer likely will not. They will have, though, goal schemas that have developed in the context of evaluating production processes and possible new inputs and practices related to them. Only for new enterprises to the farmer will these schemas likely not exist. Schemas will also be in place for reflective self-regulation purposes.

Likewise, where a large organisation may have a corporate identity that it actively manages, it is unlikely to feed directly into adoption behaviour. A farmer, however, may have subjective norms and a social identity that favour conservatism, for example, in the face of innovations. As well, a large organisation will normally be much more adept at modifying skills to capitalise on an innovation than a farmer, and enjoy greater financial flexibility to invest in the adoption of innovations. That is, goal striving may be more challenging for a farmer than for larger organisations.

In the farming context, located somewhere between consumer and organisational adoption, the factors that may lead to the selection of approach or avoidance goals is of interest. Most research conducted to date has been focused on antecedents to choice of approach or avoidance goals that are enduring temperaments or personal predispositions. This has established strong influence by personality dispositions and has been inferred to indicate that the choice is stable: individuals are prone to lean one way or the other (Schnelle et al. 2010: 216).

Another line of enquiry, however, is pursuing the possibility that the choice may vary, changing temporarily in a person as a self-regulatory strategy. One approach is to investigate the impacts of unstable goal-relevant resources on choice of approach of avoidance goals. Here, resources are defined as 'material, social or personal characteristics' perceived to be available by an individual for the pursuit of their goals (Schnelle et al. 2010: 216).

Schnelle et al. (2010: 227) found that there is a positive correlation between the quantity of goal-relevant resources and the tendency to choose approach goals, and that change in the availability of resources shifts goal choice. The underlying mechanism linking resources and goal valence is output expectancy: as resources decline, outcome expectancy declines, triggering the selection of avoidance goals. This work is consistent, as an explanation, with findings in this domain that older people tend to choose more prevention of loss goals than do younger folk, who favour growth goals.

4. Diffusion: Rates of Adoption

4.1 Mainstream models of diffusion

Diffusion research has been extensive over the last half century. As the aggregate consequence of individual adoption decisions, a notable feature of the major, commonly used, diffusion models is their lack of interface with adoption models. Various contagion mechanisms are modelled, sometimes simply referred to as contagion, sometimes as communication. The focus is on the progress of uptake of an innovation in a social system with the assumption that the key to time taken is the flow of relevant information, with explanations of variations in uptake promptness, once information is controlled for, due to adopter personality characteristics such as 'innovativeness'.

The process assumed is well described in the following.

> *The multidisciplinary literature on the diffusion of new products is extensive (for starting points see Mahajan, Muller, and Bass, 1990; Parker, 1994; Rogers, 1995) and shows that many new products follow roughly logistic or S-shaped growth trajectories. Much of the research has focused on identifying the causal relationships that underpin this S-shaped pattern of behavior. For example, prior research shows that an important factor driving the growth phase in new product diffusion is social contagion through word of mouth. Early purchasers tell their friends, work associates, and families about a new product, resulting in some of these potential customers buying it for themselves. Sales to potential customers increase the installed customer base and further reinforce the word-of-mouth effect. Another source of awareness and adoption identified in the literature is the level of marketing spend on advertising, promotion, public relations, and direct sales efforts. The combined effects of word of mouth and marketing spend drive the adoption rate from the pool of potential customers to the installed customer base. However, these growth processes cannot continue forever. Once the population of potential customers depletes, sales fall to the replacement level of purchases driven by the average useful lifetime of the product.*
>
> Gary and Wood (2011: 576)

A striking feature of this description of the diffusion process is its implicit reference to final consumers rather than, for example, businesses. Apart from differences in adoption decision making outlined earlier in this report, there are commonly big differences in scale between consumer and organisational markets. This changes contextual features for promoters of innovations. For example, personal selling (e.g.,

extension) is plausible at the launch of an innovation to organisations but not to consumers. Also, detailed research into characteristics of buyers (e.g. farmers) is much more plausible financially than is true of potentially hundreds of thousands, or more, of consumers.

A consequence of these scale differences is that reliance on simplistic, 'social movement' type reasoning and 'theoretical naivety' (McMaster and Wastell 2005: 387) for the transmission of a new agricultural practice or product across relevant farms is neither necessary, nor likely to have its naivety hidden by the smoothing effects of large numbers.

The appeal of the mainstream diffusion model to marketers rests on the fact that it is the only temporal theory on which management of marketing over the life cycle of a product may be based: the 'moving target market approach' (Wright and Charlett 1995: 3). That is, it enables the projection, on the basis of adopter category characteristics, of valid modifications to the marketing mix (McColl-Kennedy and Kiel 2000). However, this approach is somewhat bedevilled by the fact that the claimed characteristics of different adopter categories (Rogers 2003) are 'questionable' (Gatignon and Robertson 1985: 861).

Particularly, the first category to adopt an innovation, Innovators, 'must be identified and characterized on a product category basis ... and ... there is not a generalized innovator across product category or interest domains' (Gatignon and Robertson 1985: 861). 'It seems that consumers are innovators not because of some underlying general trait of "innovativeness", but merely because they are one of the first 2.5 per cent of first purchasers, regardless of their demographic, socio-economic, or personality characteristics, and regardless of their adoption behaviour in other circumstances' (Wright and Charlett 1995: 3).

Challenging diffusion research generally are some serious methodological issues. These have included: that 'adoption' is usually defined in binary terms thereby ignoring any pre-action stages - only sales are counted; the potential market is defined as fixed over time for lack of any basis on which to contemplate a change in size; marketing effort is ignored; heterogeneity of product perceptions by potential adopters is ignored; the diffusion of each innovation is assumed to be independent of all other innovations; the innovation does not change over time; and just what it is that potential adopters actually observe via communication is assumed to be a constant (Mahajan and Wind 1986; Mahajan et al. 1990; Strang and Soule 1998).

There are also problems resulting from the pro-innovation bias discussed earlier. Few studies have reviewed failed products (c.f., Greve 2011), 'the adoption of non-beneficial innovations, the abandonment of beneficial ones, and the transience of most new practices' enabling a 'pitfall in diffusion research [to tend] to conflate long duration of a practice with resilience and invulnerability to competing alternatives' (Colyvas and Jonsson 2011: 33).

Two prominent diffusion models are Rogers' (2003) Diffusion of Innovation model and the Bass (Mahajan et al. 1990) model. Rogers' model can only be applied after adoption is complete; it has no projective capability. The Bass model can predict, and does so, on the basis of the estimation of the probability that adoption will occur in response to exposure to the innovation (coefficient of external influence) and the social interaction effect (coefficient of internal influence) which is then applied to the total who have adopted by some point in time.

The first term is logically connected to Rogers' Innovator category but differs in that adoption can occur at any time during the diffusion timeframe. The second term is calculated from an estimate of the 'imitation' effect, of interpersonal influence, in effect, divided by the total number of potential adopters.

To be useful in prediction, estimation of these coefficients can be made by market research, use of historical data for similar products or managerial judgment. As diffusion proceeds, prediction of remaining adoption rates can be undertaken. The Bass model has performed well in consumer durable markets, and some organisational contexts (education, hospitals and agriculture), and has been capable of predicting well in advance levels of adoption at the peak of diffusion curves (Wright and Charlett 1995).

In a survey of diffusion research, Wejnert (2002: 297) argued a 'need in diffusion research to incorporate more fully (a) the interactive character of diffusion variables, (b) the gating function of diffusion variables, and (c) effects of an actor's characteristics on the temporal rate of diffusion.' The parsimony and simplicity of dominant models has arguably constrained analysis of diffusion unacceptably for too long. This is particularly so from a marketing perspective, as 'almost 50 per cent of new products introduced into the market are complete failures and more than 70 per cent of them do not reach their goals in terms of sales' (Delre et al 2007: 827). The predominantly descriptive character of diffusion studies, in this context, is unhelpful as it does not see failures nor explain disappointing products.

The main response to weak connection between adoption models and diffusion models has been the application of agent-based models to diffusion. 'In agent-based modeling (ABM), a system is modelled as a collection of autonomous decision-making entities called agents. Each agent individually assesses its situation and makes decisions on the basis of a set of rules' (Bonabeau 2002: 7280). ABM uses simulation modeling and has the following benefits over other modeling techniques: '(i) ABM captures emergent phenomena; (ii) ABM provides a natural description of a system; and (iii) ABM is flexible. It is clear, however, that the ability of ABM to deal with emergent phenomena is what drives the other benefits' (Bonabeau 2002: 7280).

Diffusion applications of ABM have included Delre et al. (2007), Midgely et al. (2007), Schwarz (2007) and Zhang and Nuttal (2011). The flexibility of the ABM approach

enables incorporation of salient aspects of adoption models, for example, into diffusion simulation models. Schwarz (2007), for example, included innovation characteristics (after Rogers), TPB, lifestyle data and decision style (deliberate or heuristic) in a model to explore the diffusion of environmental innovations in Germany. Zhang and Nuttal (2011) incorporated TAM, TPB, aspects of Bagozzi's model, psychological variables (e.g., self-efficacy and anxiety) and psychological mediators (autonomy, competence, relatedness) to project policy impacts on smart meter diffusion in the UK.

As might be expected, the flexibility ABM allows leads to some concern with model validation (Garcia et al. 2007; Midgely et al. 2007). The possible relevance to studying the diffusion of agricultural innovations seems apparent.

4.2 Integrating adoption models, types of innovation and diffusion

Diffusion, properly measured over the true potential market, tracks the rate of adoption of an innovation over time. Assuming the true potential market can be estimated with high accuracy, diffusion measures the extent of the delay in adoption across adopters. Why there may be delay is of interest, arguably, to the extent that promulgators of innovation may be able to use such knowledge to reduce the delay. Whether for reasons of extracting as much economic rent as possible from patent protection, or maximising aggregate public benefits from productivity enhancement, reducing delays in adoption has appeal.

Assuming that modifying causal adopter characteristics is normally impossible, promulgators will need to contemplate changes to the innovation itself or communication about it. The research challenge is to relate innovation characteristics and information to delay. A first step in that process is to identify a useful schema for classifying innovations.

In regard to changing the innovation itself, the relative advantage of an innovation plays a defining role in the rate of adoption and should be optimised prior to launch. Unless preferences are changing through time, they should inform the design of an innovation prior to launch. Given preferences are stable, the notion that modifications need to be made to an innovation to better match adopter preferences could easily be interpreted as reflecting incompetence in product development. Modifying an inadequate design after launch and defining this as 'speeding diffusion' is a self-serving misrepresentation.

The use of diffusion analysis in marketing as a basis for marketing management often involves changes to the design of the offer but this is to meet different preferences of different adopter categories or market segments, and is commonly partly a response to increasing competition from other suppliers post launch (Mahajan et al. 2000). In the context of agricultural innovations, and given farmer

preferences are stable, there would seem to be little scope for justification of post-launch product modification. An implication of this is that the scope for manipulating diffusion of such innovations is limited. A corollary is that diffusion should be susceptible to reliable forecasting and, ideally, able to be explored with policy experiments, such as different promotional strategies from launch onwards.

One innovation classificatory schema that may be used to assess likely delay classifies innovations as product (and service), process or ancillary, the latter referring to changes along organisation-environment boundaries (see Walker 2006). This approach seems unlikely to integrate well with adoption models. The schema that has greatest popularity in research is that of Henderson and Clark (1990). It characterises innovations in terms of location on two continuums: degree of component change and degree of architectural change. 'Component change' refers to modifications to the parts of a system and 'architectural change' to changes to the way components are linked (see Kaine et al. 2008). Major change to, or new, components are accompanied by change to the core design concept of the system.

The usefulness of this schema derives from what it reveals about the magnitude of the impact of adoption of an innovation. This is particularly so in terms of disruption to system activity and destruction of competencies/demand for new skills.

As noted earlier, the prevailing presumption in diffusion literature is that delays in adoption reflect time taken for potential adopters to learn about, or have uncertainty reduced about, an innovation; the 'upward revision of the consumers' estimates of the commodities' want-satisfying powers' as Ironmonger (1972: 80) expressed it. As common, and seemingly sensible, as this perspective is, it is predicated on the implicit notion that full information leads to immediate decision and action. Thus, any delay has to involve some kind of information shortfall, the remedy of which will lead to prompt action. This is an absurd assumption. Relevant motivation is assumed to be endemic.

The distinction between 'consumer behaviour', or the process of creating behavioural intention, and 'consumer action', the outcome of trying to consume (or adopt), has already been made at length. This is one source of, potentially extensive, delay. The potentially complex and iterative process of goal setting and the operation of the core of the action model takes time. Until motivation to decide is aroused, and until deciding has run its course, action will not proceed.

As suggested above, valid interest in diffusion relies on possible interventions in innovation design or promotion to accelerate the rate of adoption. In addition to personality traits such as dispositional resistance to change, this rules out sources of delay in adoption decision making that are caused by factors that only time can reveal, such as the experience of earlier adopters, extent of adoption among peers and the revelation of unexpected attributes.

A better starting point for consideration of the diffusion of an innovation may be contemplation of the factors that would favour speediest diffusion, thereby removing extensive weighing of decisions or delays in striving to adopt. That is, what determines the time span of total market uptake? What lends urgency to the adoption of an innovation? What motivates, rather than justifies, adoption? What prompts high attention to the possibility of adopting an innovation?

Anticipated emotions are potentially important determinants of overall goal desire following the encounter of an innovation. Both the scale, or materiality, and the symmetry of positive and negative anticipated emotions will play into this. On the one hand, if imagined goal achievement and goal failure are perceived to have trivial emotional content, anticipated emotions will play a limited role in goal setting. Consequently, goal desire would depend primarily on imaginings by the farmer of the time paths, and reliability, of costs and benefits of adoption. This may be the case with incremental and modular innovations

On the other hand, if either positive or negative anticipated emotions have significant emotional implications, they will influence whether the farmer adopts an approach of avoiding goal failure or pursuing goal success, that is, goal desire (Bagozzi 2006a: 25).

Anticipatory emotions, too, will impact on goal desire according to the subjective probabilities of goal achievement and goal failure. These are not weighted by the value of outcomes; they are measures of hope and fear. Plainly, they will be influenced by perceived behavioural control (self-efficacy), dispositional resistance to change and anticipated difficulties in striving.

One may imagine both anticipated and anticipatory emotions may play a substantial role in the adoption of architectural and radical innovations because of the complexity of, these kinds of innovations and challenges they may pose to farmer competence.

Likewise, affect towards the means expected to be employed to pursue the goal will impact on goal desire.

Innovation typologies will be most informative about adoption, and diffusion, to the extent that they suggest intensities of motivation to adopt: goal desire. Goal desire plainly plays the key role in determining the urgency a farmer will attach to an adoption possibility in terms both of promptness and persistence of attention to the question.

5. Conclusion

It will be recalled that Bagozzi argued that, apart from the exercise of human agency through self-regulation, the consumer action model we are focusing on is deterministic. That is, just as proper identification of the usage context for an agricultural innovation enables reliable estimation of market potential (via comprehensive assessment of relative advantage; Kaine et al. 2007), we should expect that proper identification of this, and of salient personality characteristics and other inputs into goal desire, and proper estimation of goal striving potential, would enable estimation of delays in adoption. That is, diffusion does not reflect, necessarily, a process that is readily manipulated. It may be substantially, even totally, deterministic.

Importantly, the subset of causes of delay over which the promulgator of an innovation has control, such as information, will be few and their role in adoption readily assessed in any given context. The remaining issue is to determine the extent to which determinants of goal desire, and impediments to goal striving, need to be assessed to be able to identify likely rates of adoption and the scope for manipulation of diffusion.

The framework to enable such outcomes could only, at this stage, be agent-based modeling. All other models bear too little connection to the richness of adopter contexts to warrant consideration. Specification of such models will require research to identify salient variables, and their values, from Bagozzi's action model since it is the most comprehensive and current model of adoption. It will also be necessary to explore, through research, interactions between types of innovation and these salient variables.

The interpolation into adoption theory of current psychological insights into purchase decision making renders indefensible the reliance on approaches that treat such decision making as a black box when studying adoption. This, and the capacity to simulate quite complex models, displaces the acceptability of using coarse and parsimonious models of diffusion of innovations through the agriculture of developed economies.

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