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A Framework for Building Technological Learning: Evidence from the New Zealand Dairy Industry

Abstract
One aspect of the process of technology adoption is "technological learning" (TL), the way farmers gather "information" and turn it into "knowledge." In a study of the New Zealand dairy industry, researchers examined the factors that affect TL. Findings suggest that the speed with which farmers engage in TL is influenced by the efficiency of the innovation system, the maturity of the farm system, and the individual characteristics of the farmer. The article presents a model demonstrating how these three sets of factors may affect TL that can be used by Extension agents to help them develop a strategy for engaging farmers in TL.

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Introduction

A critical issue for industry bodies and governments everywhere is the need to encourage innovation and change amongst industry members in order to increase their levels of productivity, and enhance the industry's competitive position. In order to achieve this objective, it is important that all those involved in making decisions that affect productivity improvement and industry development understand the complex processes and dynamics that are at work within and between organizations and individuals that are also involved in the context of the 'innovation system'.

This article presents a summary of the findings from an ongoing project (funded by the New Zealand Foundation for Research, Science and Technology) of capability building in the New Zealand dairy industry. In earlier work, the researchers explored the specific factors relating to small and large farms (Parker, Stantiall, Allen, Hurley, Kuiper, & Massey, 1998; Massey & Hurley, 2001) and the changing ways in which Extension services are being delivered to the industry (Hurley, Parker, & Stantiall, 1997) and examined some of the groups that in different ways contribute to the dairy industry in New Zealand, including women (Hurley & Massey, 1999) and Maori farmers (Kingi, Kuiper, & Clough, 2000).

This phase of the project examined the factors that affect technological learning (TL) in the on-

farm sector of the dairy industry, where TL refers to the way in which individuals gather information from research or other sources and turn it into useful knowledge. The researchers' goal was to identify factors that affect the speed with which farmers engage in technological learning. Their starting point was the research on technology adoption, and Table 1 provides a summary of this literature.

Table 1.
Technology Adoption Happens Quickly

The individual is	In a position in the farm system to access economic resources and make decisions.	Buttle & Newby (1980)
	Highly or 'better' educated.	Bultena & Hoiberg (1983); Lambur et al. (1985); McGregor et al. (1996)
	Receptive to new ideas (i.e. is innovative) and is a risk-taker.	Bultena & Hoiberg (1983)
	Able to unlearn non-innovative behaviors and break with traditional paradigms.	Nooteboom (1999)
	Younger and less experienced.	Ervin & Ervin (1982)
	Self-confident.	Bagozzi, Davis & Warshaw (1992)
The farm system is	Large.	Lambur et al.(1985)
	Linked to knowledge networks.	OECD (1997)
	Endowed with absorptive capacity.	Cohen & Levinthal (1990)
	Able to transfer information.	Nooteboom (1999)
	Profitable.	Byerlee & de Polanco (1986)
	Linked to other firms and networks.	Bala & Goyal (1998)
	Successful in terms of previous technology adoption.	O'Neill, Pouder & Buchholtz (1998)
The innovation system is	Linked or in contact with farmers (e.g. through Extension services, field days etc.)	Steffey (1995); Harper et al. cited in Herbert (1995)
	Significantly involved in management-intensive technology, but not as significantly involved for capital intensive technology.	Zepeda (1990)
The Extension process is	Supported by activities that inform the farmer of the incentives of adopting the technology.	Wearing (1988); McNamara, (1991)
	Designed to promote effective	Contant (1990)

	communication, problem identification and problem solving.	
	Based on personal interactions of a formal or informal nature.	OECD (1997)
	Not free (farmers are willing to pay for information if they believe the innovation will bring them an economic return).	Feder & Slade (1984)
	Not just fact based (e.g. computer based decision support systems are useful).	Hamilton et al.(1991)
	Stimulating, provides contacts and facilitates collaboration.	Feather & Gregory (1994)
	Timely and available.	Wall et al.(1985); Korsching & Hoban (1990); Premkumar & Roberts (1999)
	Delivered by individuals who are perceived as credible.	Rogers (1983); Korsching & Hoban (1990)

Method

Building upon the literature and the previous phases of the project, the researchers used four data collection methods. These methods (which were designed to complement each other in terms of data collection, analysis, and verification) included an industry forum, interviews with industry members, case studies with farmers, and a questionnaire.

The 1-day forum brought together farmers and invited industry representatives to discuss the issues facing the industry, particularly in relation to learning about technology. The primary purpose was to generate issues that could be developed further in the interviews, cases, and the questionnaire.

Interviews with key informants (who were selected after consultation with industry organizations and institutions and the project reference group) were used to build on the researchers' understanding of issues identified in the literature and raised in the forum. They also provided data about the interviewees' perceptions of the institutional activities, linkages and interactions, and generic technological learning competencies required of dairy farmers to achieve on-farm productivity gains. A semi-structured, focused approach was utilized, and the interviews yielded in-depth opinions and perceptions, which were combined with the propositions from the workshop and used as the basis for further inquiry in the survey and the farm-level case studies.

The questionnaire provided data that would allow some understanding of the psychological variables that affect TL. Questions focused on:

- Exploring the aspects of farming that are important to farmers (to understand the decision-making context);
- Identifying what practices have already been adopted (to gauge the extent to which technological learning has already occurred); and
- Exploring the perceived relationship between stress and technological innovation.

The questionnaire was based on the Technology Acceptance Model, which suggests that the use of new technology depends on two key beliefs: perceived usefulness and perceived ease of use (Davis, 1989). Questionnaires were distributed to 3,000 farmers, and responses were received from 998 (indicating a 33.2% response rate). As well as providing data for analysis in its own right, the questionnaire data underpinned the case selection process and the composition of comparison groups for the more intensive part of the study.

The cases were purposefully selected (from the farmers who volunteered via the questionnaire) to provide examples of large and small farms (based on herd size), rate of farm growth (based on the farmer's self-assessment), and the role of the farmer in terms of decision-making (e.g., owner/manager or sharemilker). The fieldwork for the cases consisted of two on-farm interviews

and a journal in which the interviewees recorded data regarding their technological learning for the 7 days following the initial interview. In some instances the farmer's spouse or partner participated in the interview, which provided a degree of informal data triangulation.

Results

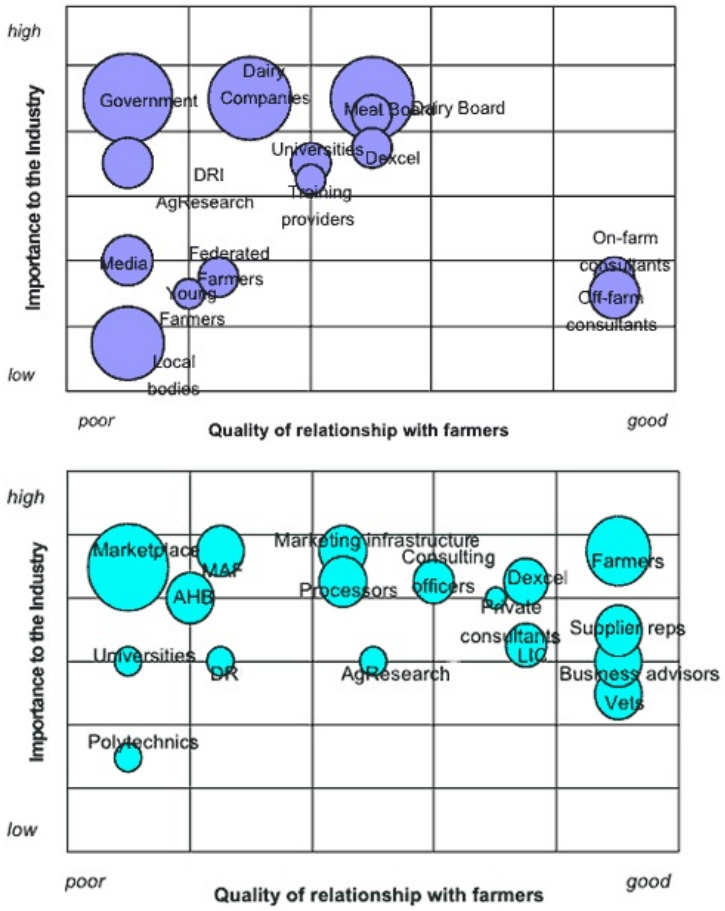
This section presents some of the key findings from the data collection phase, except for the questionnaire, which is reported upon elsewhere.

Forum

While the primary purpose of the forum was to help the research team identify issues that could be further developed in the cases, interviews, and questionnaire, it also produced a set of stand-alone results. The participants started by producing a list of the key institutions involved in the New Zealand dairy industry. In an exercise that asked them to assess the relative importance of each of the institutions, they produced "maps" of the way in which these institutions interact. While the results produced from the groups differed (see Figure 1 for two maps that were both produced by groups of farmers), there were a number of points of agreement between the groups. The researchers concluded that:

- Organizations/institutions of importance within the industry are easy to identify.
- Industry participants found it easy to assess which organizations and/or institutions had better relationships with farmers.
- Industry participants could see where barriers lie.
- The industry has been undergoing significant change and this has created a situation where institutional/industry structures, dynamics and inter-relationships have impacted negatively on on-farm technological learning.

Figure 1.
Relationships Between Farmers & Industry Organizations/Groups



Interviews

These themes were developed further in the industry interviews, where a key message was that farming systems have changed substantially in the last two decades. For example, 20 years ago Extension agencies were seeking to facilitate the adoption of what could be described as "generic" technologies, i.e., those that had application for the majority of dairy farms (e.g., milking techniques, pasture measurement, and high stocking rate systems).

Those interviewed suggested that far fewer "new" technologies and systems had been developed

in the last 15 years. The main farming systems change in recent years has been one of scale, with a significant increase in average herd size and rapid growth in the number of large herds (500+ cows). There is now far greater diversity in farm business structure and goals of farmers. Therefore, the context for Extension agents now is one where on-farm change pertains to very personal decisions. This implies a greater need for one-to-one change support systems than a generic Extension service can and does provide.

One clear point from the interviews was that the on-farm dairy innovation system is much more fragmented than it was in the past. There are many more organizations involved in on-farm research and in facilitating change on farms, and each of these organizations is individually commercially motivated. This has created a less cooperative and more competitive innovation environment, despite the industry retaining the cooperative structure.

In this environment, there is a greater need to provide clarity as to where farmers should and can go to get the information they seek. Currently, roles and responsibilities in the innovation system are not at all clear. It was suggested that there was institutional overlap developing, for example, between the dairy companies funded from milk sales proceeds and between Extension organizations funded in the future from farmer levy.

Within this fragmented innovation system, with potential and actual overlap, the question of industry co-ordination was raised, particularly in relation to research. An unanswered question at this stage is to what extent the industry should seek to co-ordinate the activities of participants in the innovation system as against allow a competitive market to dictate its direction.

Case Studies

The researchers used data from the forum and the interviews as the basis for collecting data from the farmers who had agreed to participate as case studies. For example, the researchers showed the farmers the maps from the forum and asked them to comment on how their perceptions matched those expressed in the maps. They also asked them to respond to different theoretical statements that had been developed at the beginning of the project on the basis of the literature, e.g., "the speed with which farmers engage in technological learning will be influenced by their age."

The purpose of this exercise was primarily to stimulate discussion between the farmers and the researcher, and to help the farmers to clarify their thinking about the way in which they approach TL and its components. Not surprisingly, there were instances when the farmers agreed with the statement derived from the literature (e.g., the influence of a farmer's goals on the speed with which he or she engages in technological learning), as well as instances where they disagreed. There were a number of instances where the responses of farming couples differed.

The main focus of the cases was on gaining a deeper understanding of the actual process of TL, and to achieve this the farmers were also asked to keep a diary. Here they were asked to describe a practical situation where they felt TL had occurred in the past (see Figure 2 for the instructions). They were then asked to describe any aspects of technological learning that occurred in the 7 days following the initial interview. The entries in this diary were explored in detail in the second interview.

Figure 2.
Diary Instructions to Respondents

> On the blue pages we would like you to describe a situation where you were engaged in 'technological learning', i.e. where you were able to turn information gained from research or other sources into knowledge that could be used by you on the farm. The situation will be specific to your farm and we want to know how you dealt with it, using the boxes provided.
>
> In the 'what' section describe the situation in as much detail as you can. In the 'who' section describe who you consulted and how or why they were useful. In the how section describe what actions you considered and what actions you took.
>
> Finally, in the 'skills' section describe the skills or knowledge that was useful or essential. It would also be helpful if you indicated the timing related to the situation (i.e. how long it took you to make a decision or find someone appropriate to talk to etc.). In order to give us as complete a picture as possible it would be helpful if you revisited this section of the journal each day you looked at the other daily section and added any other details you recall.

At the end of the case studies, the researchers concluded the following.

- TL is not an intermittent event. Some aspect of it occurred almost daily for all of the case subjects.
- Almost all the participants had a regular routine for some aspect of TL, such as information

gathering (e.g., "I log on to the Net when I come in to make my lunch"). However, routines could also be disrupted (e.g., "I didn't do anything at all for three days in a row--the cricket was on TV"). Enacting the routine was also dependent on other priorities (e.g., "If it is raining outside, and I have nothing else to do, *then* I will pick up the *Exporter*" [the main magazine for the dairy industry in New Zealand]).

- Family members (usually the wives, but sometimes a father or a son) can play a key in one of the elements of the TL process (or sub-processes) (e.g., "My wife puts everything she thinks I should read on my desk, after putting the obvious junk in the bin").
- There were two types of TL: in the first, TL was undertaken in the context of a specific context (e.g., "I decided to give maize silage a try, so I went out and found some information on it"). In the second, TL was not context specific (e.g., "I always have a bit of a browse through the *Exporter*--you never know what you might pick up").

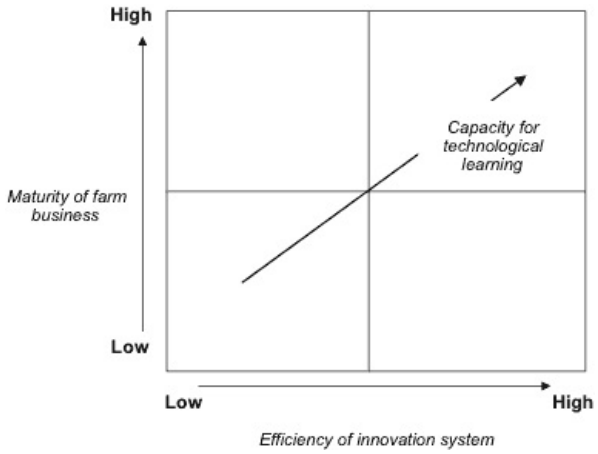
These cases enabled the researchers to confirm some of the suggestions of previous research; namely, that there are a number of situational influences on whether individuals engage in technological learning.

Conclusions

As noted in the introduction, past research on technology adoption suggests that different factors influence adoption and the speed with which it is undertaken. Some of these general factors were also confirmed by our data, and in a closely related context (that of technological learning), it can be seen that the characteristics of the individual, the farm system, and the innovation system all interact to influence the rate at which individuals engage in TL.

Figure 3 provides a way of conceptualizing the different influences on TL that were derived from the research data, grouped into three broad categories. The first category includes those factors that relate to the farm business (financial stability, level of debt, etc). The second category includes factors that relate to the efficiency of the innovation system, such as the presence of Extension and consultancy providers, the availability of information through magazines and newsletters, and the ease with which individuals can access information through means such as the Internet. The third category relates to the individual's characteristics, such as age, level of education, confidence, and innovation capacity--all factors that are important in forming behaviors and attitudes that are relevant to TL, such as learning styles, information source preferences, etc. As the model suggests these three sets of factors interact.

Figure 3.
Influences on Technological Learning



Additionally, by reviewing the case material in the context of the industry interviews, the forum, and the questionnaire, the researchers were also able to broaden their original concept of TL. This was initially conceived of as a simple process model whereby information inputs were transformed into knowledge (that would then be used in the context of farm management).

However, our data suggest that TL can take several different forms, in terms of a number of dimensions of comparison. First, TL can be purposeful, or it can be done without any specific objective in mind. The second difference is in the way in which the TL process is conceived. One view of TL is as a simple process where information is turned into knowledge. Here TL encompasses sub-processes such as information gathering and decision-making. But TL can also be viewed as a sub-process that is part of an organizational meta-process such as decision-making and/or management.

The implications of these findings for those concerned with the development of farm businesses are two-fold. First, it is imperative that Extension agents--who are one of the key groups interested in increasing the speed with which farmers engage in technological learning--understand the differences between generic and specific TL.

The key message is this: If TL is linked to a specific objective, then individuals will be more

motivated to engage in the process. Interventions to increase the speed should focus on identifying and targeting those individuals who are highly motivated. However, those individuals who engage in TL without any specific purpose in mind are also important; the key here may be assistance with simple interventions such as training on searching the World Wide Web.

The second implication is summarised in Figure 3. Whether individuals engage in TL (and it is likely that this applies to other developmental activities as well) is influenced by a number of factors, many of which are beyond the control of the farmer, let alone the Extension agent. From the perspective of Extension agents and others with an interest in the speed with which individuals engage in "a learning process," this on its own may be useful information.

However, even more useful is the fact that the framework provides those working with farmers with a simple means of conceptualising the situation facing each farmer. By using their judgment to assess the efficiency of the innovation system, the maturity of the farm business, and the individual farmer's capacity for TL, Extension agents will be better prepared to offer good advice.

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