Reducing the cost of complexity for greater farming systems change

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Introduction

Complexity consumes management time, attention and labour. This has a cost (Kingwell 2010). Simplicity, ease and convenience are therefore highly valued by modern farmers. The remarkable rate and level of adoption of disease and herbicide tolerant crops provides evidence of this (Piggott and Marra 2008). These non-pecuniary benefits or costs can have a large influence on the overall relative advantage of a technology for growers and it is likely that they will become more important as farm size increases and management demands increase. In Australia, ABARES (Hooper and Levantis 2011) use an index of land use intensity that integrates crop and livestock activity to show trends towards increasing land use intensity per hectare in major grain growing regions since the 1990’s. This typically reflects increasing cropping frequency and in some cases a shift from wool to more intensive prime lamb production. In addition, farmers are facing increasing demands from other aspects of the farm business such as marketing and regulatory requirements.

Introducing a new practice to a farming system usually involves, at least in the short-term, increasing management demands (Pannell et al 2006). However, some practices and technologies offer benefits that do not involve large information and learning requirements. The benefits of such technologies are part of the technology and are obtained relatively simply through its direct use. An example of an embodied technology is a disease tolerant crop variety. In contrast, some technologies do not have embodied benefits and require information, learning and knowledge for the benefits to be obtained. An example of technology that is not embodied is a decision support tool or new soil test. These deliver their benefits to farm productivity, not by direct use, but indirectly through improved decisions and subsequent implementation by the farmer. It follows that where a farm or farmer has greater management capacity, whether it is through greater skill, knowledge or access to expertise, their ability to gain benefits from non-embodied technologies can be greater (Waibel and Zilberman 2007). The nature of embodied innovations means that they are often able to be successfully delivered through the commercial sector. In farming systems research and extension we are not often dealing with simple embodied innovations (Ekboir 2003).

An example of a technology involving complex knowledge demands before full farm productivity benefits can be gained is provided by Gray (2010). His insightful description of the information and knowledge requirements involved in the development of no-tillage cropping in Canada includes mechanical innovations, agricultural knowledge, manufacturing scale, on-farm capital and prices in a chain of drivers. While some drivers of the value of the innovation such as grain and fuel prices were external to the innovation process, others are internal to the innovation development process e.g. the evolution of local farmer conservation tillage organizations, the emergence of specialist cropping consultants, researcher expertise. These all contributed to accumulating stocks of knowledge and information that increased the potential benefit to be gained by using the innovation and thereby eventual widespread
adoption. It was a knowledge-intensive process and extended over decades. It would not have been required for a typical embodied technology.

In this paper results from a study of agricultural innovation adoption by Australian grain growers are used to examine the role of learning and information-related constraints and opportunities to reduce their impact on practice change. Data on the diffusion of no-tillage systems in Australia is presented and the drivers compared to the conceptual framework presented above. An analysis of an information-intensive innovation currently in the early stages of diffusion, variable rate technology, is then presented with comparisons made with precision agriculture technologies with more embodied characteristics. The aim is to 1) identify aspects of complexity and information intensity affecting farming systems change and 2) identify opportunities for research and development to address management capacity constraints in a way that enables greater use of beneficial practices.

**Materials and Methods**

The study draws upon data on precision agriculture (PA) and cropping practices from a study of grain growers from across major grain growing regions of Australia. Interviews were conducted by phone in 2008 as part of a larger study of factors influencing adoption of cropping practices. The farmers were randomly selected from a comprehensive commercial farmer database. Of all suitable households with a primary cropping decision maker contacted, 14% refused to complete the survey. Data were collected from 1170 primary cropping decision makers on farms cropping greater than 200 ha in a typical season. The questionnaire was developed to be as quantitative as possible to allow for cross-region regression analysis. A relatively broad definition of no-till seeding was used in the study based around seeding with low soil disturbance (points or discs) and no prior cultivation. Precision agriculture-related practices include yield mapping and use of variable rate fertiliser on paddock zones.

**Results and Discussion**

After three decades, the diffusion of no-tillage systems in Australian agriculture is now reaching a plateau in many districts. The information-intensive nature of the process has been demonstrated not only in the adoption process (D’Emden et al 2008) but also in the ongoing extensive use of the technology. The factors significant in explaining no-till use in logit models demonstrate the range of knowledge requirements, with understanding of herbicide efficacy, disease management, seeding reliability and soil moisture retention all represented. Higher education is significantly associated with a greater rate of adoption. Use of a paid farm consultant is significant in explaining both adoption and extent of use. In most regions the use of consultants is more than twice as likely among no-till users.

Some precision agriculture technologies such as GPS-guidance do not have high knowledge requirements and can readily contribute to simplicity and convenience of farm operations. Autosteer is an example of an embodied innovation that allows direct benefits (e.g. reduced overlap, reduced operator fatigue) and has been widely adopted (Robertson et al 2011). However, use of PA technologies for site-specific management is still in the early stages of adoption with less than 10% of growers found to be using variable rate fertiliser with yield mapping. Growers using yield mapping (and using variable rate fertiliser with yield mapping) are more likely to use consultants but it is not a strong association. This is because most growers use a consultant, but not one that provides precision agriculture expertise. In regions where well-understood and highly observable soil variation (e.g. in a dune-swale land
system) has allowed for more simple ‘convenient’ zoning there has been strong advisory support for spatial management and there has been greater early adoption of variable rate application technology. Before the majority of potential PA adopters apply PA technology to spatial management, a greater proportion of advisors will need to be supporting its use. Some non-embodied technologies generate increased demands for purchased inputs that can then lead to the commercial sector offering increasing levels of advisory support. This was the case for no-till, where demand for herbicide inputs increased, which supported an increasing supply of crop advisors. In the case of variable rate fertilizer, a likely scenario is no major increase in purchased fertilizer inputs (Robertson et al. 2011).

After more than 20 years we still see very different levels of use of no-till between districts. In the same way we should expect to see very different peak levels of variable rate technology use between regions in the future. A RandD challenge is to identify where the greatest potential for highly profitable use of in-paddock spatial management is likely to be, based on the type and level of inherent within-field variability. This will allow investment in development of more embodied technologies and support services to be better targeted. Whilst many of the technical PA hardware-software complications are likely to be overcome soon, it will always be the case that variable rate technology requires ongoing information analysis and decision-making to gain value from it. By nature it is information intensive and potentially complex so 1) rapid adoption rates should not be expected; 2) a major role for advisory and support services will be important. However, opportunities exist for research understanding and technology to reduce data and information processing demands required to gain benefits from variable rate technology.

Convenience and simplicity for farm managers are likely to be an increasingly important determinant of the relative advantage of new practices. As a result, the complexity of innovations and the demands on management time and attention will increasingly determine peak adoption, not just the time to adoption. This places increasing demands on research, not just extension. One way for agricultural research to meet these demands is to look for opportunities to internalise additional stages of the innovation development process. RandD aimed at facilitating an active role for advisors can also lead to reduced complexity costs for a particular innovation. Research that generates innovations with greater embodied knowledge and reduced management demands for farmers is likely to be of increasing value and impact.

References


