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Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy

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ABSTRACT

There is much existing knowledge about the factors that influence adoption of new practices in agriculture but few attempts have been made to construct predictive quantitative models of adoption for use by those planning agricultural research, development, extension and policy. ADOPT (Adoption and Diffusion Outcome Prediction Tool) is the result of such an attempt, providing predictions of a practice's likely rate and peak level of adoption as well as estimating the importance of various factors influencing adoption. It employs a conceptual framework that incorporates a range of variables, including variables related to economics, risk, environmental outcomes, farmer networks, characteristics of the farm and the farmer, and the ease and convenience of the new practice. The ability to learn about the relative advantage of the practice, as influenced by characteristics of both the practice and the potential adopters, plays a central role. Users of ADOPT respond to 22 questions related to: a) characteristics of the practice that influence its relative advantage, b) characteristics of the population influencing their perceptions of the relative advantage of the practice, c) characteristics of the practice influencing the ease and speed of learning about it, and d) characteristics of the potential adopters that influence their ability to learn about the practice. ADOPT provides a prediction of the diffusion curve of the practice and sensitivity analyses of the factors influencing the speed and peak level of adoption. In this paper the model is described and its ability to predict the diffusion of agricultural practices is demonstrated using examples of new crop types, new cropping technology and grazing options. As well as providing predictions, ADOPT is designed to increase the conceptual understanding and consideration of the adoption process by those involved in agricultural research, development, extension and policy.

1. Introduction

Adoption of new farming practices has been studied intensively, but predicting such adoption remains a challenge (Ekboir, 2003). To date there has been no successful attempt to distil the vast body of research knowledge into a model for making quantitative predictions of adoption of agricultural practices. This is despite ongoing demand for improved evaluation of potential investments in agricultural research, development and extension (Alston et al., 1995) or policy adjustments (Pannell et al., 2006) that depend crucially on assumptions about rates of adoption of new practices.

There is also increasing demand for agricultural researchers to have a greater understanding of the farming-systems context of practice change, and the broader innovation system (Leeuwis 2004; Foran et al. 2014). This is seen as necessary in order to improve the relevance and impact of their research (Van de Fliert, 2003; World Bank, 2006) or to prepare agricultural agencies for the process of 'scaling' a new farming practice (Wigboldus et al. 2016). A number of frameworks and approaches have been developed to facilitate deeper understanding of the context for agricultural innovation systems (e.g. Schut et al. 2015). These can often involve structured workshop programs to create comprehensive impact pathways and logic models (e.g. Douthwaite et al. 2008; Wigboldus et al. 2016) and to assess societal impacts of research (e.g. Joly et al. 2015). These approaches are capable of qualitatively capturing complex innovation contexts and outcomes. However, there are situations where simpler, less burdensome approaches are needed

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(Thornton et al. 2017), or where quantitative prediction are needed. We set out to develop a tool with the joint aims of predicting the future level of adoption of a new farming practice by a particular population of farmers, and of enhancing the understanding of practice adoption by diverse agricultural stakeholders. The relatively narrow focus on prediction of adoption for a specific practice was selected to allow for a tool that could be applied in a relatively rapid consultation and elicitation process. In this paper we present the resulting tool, ADOPT (Adoption and Diffusion Outcome Prediction Tool).

The conceptual framework and functional design of the ADOPT model is described, after which we present its application to several case studies of practice adoption in Australian agriculture. We use these case studies to test the validity of outputs from ADOPT. Demonstrated and potential roles for the tool are discussed. This includes provision of information for those investing in agricultural research and development, and building knowledge of the adoption process among those engaged in projects that are intended to result in changed farming practices.

2. Existing approaches to predicting adoption in agriculture

The most prominent and influential attempt to organize and classify the factors influencing adoption and diffusion of practices is that of Rogers (2003). However, Rogers' framework is designed for conceptualizing adoption rather than for quantitatively predicting adoption of novel practices.

There have been a number of efforts to predict diffusion of technologies among a population, particularly in the field of marketing and consumer technologies (see reviews by Mahajan et al., 1990; Turner et al., 2010). These approaches have not been widely used in agriculture. They tend to focus on awareness and imitation but neglect profitability and other non-profit related factors such as environmental or risk-related benefits that we know are important drivers of adoption in agriculture. Also, they are not usually designed to account for the complexities of farming systems and the specifics of practice adoption by farmers.

For agricultural systems there is a comprehensive body of research explaining the broad range of factors influencing adoption and diffusion of practices. See Feder and Umali (1993), Knowler and Bradshaw (2007) and Pannell et al. (2006) for reviews or Alcon et al. (2014) or Kassie et al. (2013) for recent research studies. However, there have been relatively few attempts to develop approaches to make predictions about adoption outcomes using those factors. In agricultural research and development, policy and extension, unstructured guesswork has been a common approach among practitioners for making such predictions.

A technology that received particular attention in *ex-ante* adoption studies was bovine somatropin (bST) for use in the U.S. dairy industry (Caswell et al., 1998; Lesser et al., 1999; Zepeda, 1990). From these studies Caswell et al. (1998) identified three main approaches used in the prediction of adoption and diffusion. These were: 1) a survey of producers' intentions (e.g. Kaine et al., 2011; Karali et al., 2014; Lesser et al., 1999); 2) an expected-profits approach which uses farm-level financial and other data to determine which producers would find practice adoption profitable and would therefore probably adopt it; and 3) an historical market trends approach which predicts adoption through extrapolation. Dearing and Meyer (1994, p. 45) used a different qualitative approach and predicted diffusion by identifying perceptions of both the potential adopters and the 'innovator' delivering and communicating the new practice. They suggested that this approach is especially useful when attempting to determine the likelihood of adoption of practices with similar characteristics. A method based on a panel of experts and the development of heuristic models and rules for the behavior of people as part of the adoption process has also been described (TAMU, 2000, Section 6.8).

Models based on attitudes, beliefs and norms (e.g. Ajzen 1991) have had agricultural application in improving understanding of adoption (e.g. Jansen et al. 2009; Meijer et al. 2014). However, these generally demand specific survey data from the population and are often not suited to ex ante scenarios where there is little awareness of a new practice. Limitations of survey-based methods include their cost, the time required to collect and analyze data, and the potential lack of familiarity with the new practices among respondents (Dearing and Meyer, 1994). The expected-profits approach (Caswell et al., 1998), although widely used by economists, neglects non-profit-related factors that are known to influence adoption of new practices in agriculture (Alston et al., 2002; Lewin, 1939). The historical-trends approach or surveys of past adoption behavior to predict farmers' adoption of a new practice is of limited usefulness when there has been no corresponding similar practice or if relevant data is unavailable (Caswell et al., 1998; Langley et al., 2005).

There is a gap in the availability of a tool that is based on a strong understanding of the literature on adoption by farmers of agricultural practices, but could be applied effectively and efficiently to new scenarios without requiring additional research. We set out to fill this gap.

Earlier we noted the recent development of approaches that emphasize the complex social, economic, and institutional environment within which agricultural innovation occurs, and that aim to help off-farm stakeholders to better support the processes of innovation and scaling up of usage (e.g., Schut et al. 2015; Wigboldus et al. 2016). ADOPT's quantitative predictions may complement the qualitative approaches used in those approaches. In turn they may add value to ADOPT by providing a more detailed overview of what hinders or enables changes in the innovation system, and by assisting researchers to engage better, such as by creating more appropriate technologies or catering better for farmer diversity.

3. Model development

3.1. Procedure

The development of ADOPT commenced with establishment of a research team, which included experienced researchers in agricultural practice adoption and agricultural systems from several disciplinary backgrounds including rural sociology, agricultural economics, and farming systems research.

The first stage of the model development was to establish a set of guiding principles for the study. We agreed that the framework should:

- account for a comprehensive range of practice-specific and population-specific factors that influence adoption by farmers;
- build on and be consistent with evidence from the established literature;
- predict adoption for a population of farmers, rather than for any individual farmer;
- be relevant to agriculture in a developed-country context;
- not have high data demands because there is usually a lack of available data and resources to collect extensive data for prediction of adoption;
- be simple enough to be readily used and understood by project practitioners who are not specialists in adoption; and
- promote systematic and structured consideration of the factors influencing adoption of new farming practices.

The second stage was to identify variables that most often have substantial, predictable and consistent influences on adoption outcomes for inclusion in the model. The set of 22 primary variables included in the model is outlined in later sections, and presented in Table 1 and Fig. 2. The starting point was the extensive set of variables included in existing review articles and syntheses from various disciplinary backgrounds (Feder and Umali, 1993; Lindner, 1987; 2006; Rogers, 2003; Vanclay, 2004).