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Adoption pathways for new agricultural technologies: An approach and an application to Vertisol management technology in Ethiopia

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The literature on technology adoption distinguishes between diffusion (generally viewed as a dynamic process) and adoption (usually seen as static and specific to a point in time). Consistent with this, empirical studies on agricultural technology adoption generally divide a population into adopters and non-adopters, and analyse the reasons for adoption and non-adoption at a point in time, principally in terms of the socio-economic characteristics of the studied population.

This study discusses the deficiencies of static approaches to technology adoption, particularly at the early stages of diffusion. It proposes a dynamic approach to technology adoption in which information gathering, learning and experience play pivotal roles. The characteristics of both the user and the technology are considered important in explaining adoption behaviour and the resultant pathway of adoption. The proposed approach has implications for the time frame and potential impact of new technology adoption.

Conceptual framework

As indicated earlier, conventional adoption pathway models for new technology usually divide a population into adopters and non-adopters. Such models implicitly assume that the entire population will eventually adopt the innovation and that, once adopted, the innovation is never rejected, or in the event that it is rejected the innovation is never adopted again. In reality, neither 'never rejected' nor 'for ever rejected' are realistic assumptions for most new agricultural technologies.

Most agricultural innovations change or get modified in the process of adoption and diffusion. Potential technology adopters or farmers play an important role in the process of technology generation. When farmers are not involved in technology generation, awareness and knowledge about a new technology precede any adoption decision. Although, empirical evidence on the complex relationships existing between learning and adoption is rare, several researchers emphasise the importance of information gathering and updating through a learning-by-doing adoption process.

On the basis of knowledge at a point in time, a perception about the technology is developed and a decision to adopt, reject or defer a technology may be taken. The subsequent decision may follow two pathways. In the first pathway, a decision to adopt a technology is followed by a decision about the intensity or extent of adoption, this involving learning-by-doing. In the second pathway, the initial perception or belief is modified on the basis of new knowledge and/or observed performance of adopters, and a new decision about adoption is taken. Thus, a decision to adopt a technology takes a farmer along the first pathway while a decision to reject or defer decision will keep the farmer within the second

pathway.

The possibilities of permanent or temporary discontinuation and re-adoption of a technology imply that a distinction needs to be made between 'new adopters' and 'net new adopters' in period t . Net new adopters are defined as new adopters excluding those who discontinued use of the technology but including re-adopters. If net new adopters are considered for defining the logistic curve, a much longer period will need to elapse before a majority of potential adopters come to use the technology in a sustained manner.

Testing the adoption pathway with Vertisol technology in Ethiopia

Vertisol technology development in Ethiopia

Nearly 30% of Vertisols (heavy black clay soils) in sub-Saharan Africa are found in Ethiopia, particularly in highland areas. Vertisols are productive soils but difficult to manage due to their poor internal drainage and resultant flooding and waterlogging during the wet season. In Ethiopia, farmers in some Vertisol areas have traditionally resorted to hand-made broadbeds and furrows, mainly using female and child labour, or soil burning to minimise waterlogging and drainage problems. However, these traditional techniques have proven to be quite labour intensive and technically inefficient. As a result, Vertisols in Ethiopia remain underutilised, and are largely used for dry-season grazing. Where cultivated, they give low yields and are exposed to soil erosion because fields are ploughed before the onset of the main rains and sown towards the end of the rainy season to avoid waterlogging.

A recent technology developed by the Ethiopian Joint Vertisol Project (JVP) is the broadbed maker (BBM). The principal component of the BBM is a metal wing that can be attached to a traditional plough (*maresha*) and be drawn by a pair of work oxen. By facilitating drainage, the BBM helps solve problems of waterlogging and can allow early sowing and longer growing periods, especially of improved wheat varieties.

Data source and analytical methods

The validation of the conceptual framework proposed earlier relies on data collected in three on-farm research sites where the BBM package was tested during 1986–89. The three research sites, namely Inewari, Hidi and Ginchi, are populated by 1553 households living in 10 Peasant Associations. Out of these households, 598 (28%) participated in the on-farm research from 1989 to 1995, and as such could be considered as adopters. In late 1995 and early 1996, a survey was conducted which generated usable records for 585 households.

Two sets of classification were used for the total sample of 585 households. In Panel A, the sample was first classified into adopters 485 and non-adopters (111); the adopters were categorised into those with discontinuous or continuous BBM use and the non-adopters into those with or without BBM knowledge. In Panel B, the sample was first classified into groups with BBM knowledge (531) and without BBM knowledge (54). Those with BBM knowledge were further categorised into adopters and non-adopters, and within the adopters into discontinuous and continuous users. Given our earlier argument that acquisition of knowledge and information precedes any decision to adopt a technology, Panel B was considered as more appropriate for correctly depicting the sequence of learning, adoption, continuous or discontinuous use.

Logit analysis was used to test whether the pathway depicted in Panel B was more appropriate than in Panel A in terms of identifying factors that play an important role at each stage of the adoption process. Since variables affecting the decision of whether or not to adopt a technology may not be the same as those

affecting the duration of its use, Tobit analysis was also used to simultaneously identify the influence of these factors.

Logistic regression analysis

When the dependent variable is binary and can only take two values, using ordinary multiple regression techniques or discriminant analysis is not suitable. In such cases, an alternative is to use logistic regression models requiring fewer assumptions but directly estimating the probability of an event occurring or not.

Several logistic regression equations were estimated to identify factors influencing the probabilities of farmers acquiring BBM knowledge, adopting BBM and continuing to use the BBM, on the basis of classification Panels A and B. A comparison of results for classification Panels A and B showed that the predictive powers of the equations were significantly higher for the sequential classification in Panel B than in Panel A.

Taking Panel B as a better classification method to depict adoption pathway, the models correctly predicted 91% of cases in terms of BBM knowledge, 92% of cases in terms of BBM adoption and 78% of cases in terms of BBM use pattern. The slightly lower predictive power of the model describing use pattern indicates that factors other than those included in the model, like irregular rainfall, contributed to differences in use patterns.

The logistic regression results showed that the set of significant factors influencing the binary dependent variables of BBM knowledge, BBM adoption and BBM use patterns were different. In general, problem awareness and opportunities to learn, BBM training, access to credit, size of cropland owned, cropland area under Vertisol and extent of waterlogging, number of work animals owned, family size and distance from market influenced the three dependent variables but to widely varying degrees. For example, BBM training significantly increased the odds of adoption but had no influence on use pattern. Similarly, among those who adopted BBM, area under Vertisol, area with heavy waterlogging, perception about operational problems with the technology and access to credit had significant influence on whether BBM was used continuously or discontinuously.

Tobit regression analysis

In the logistic regression models, BBM adoption was considered a binary dependent variable, and factors influencing the probability of adoption were identified. But the models did not allow the simultaneous identification of factors influencing BBM adoption and duration of use. To do this, BBM adoption can be defined as a truncated continuous variable with non-adopters taking zero value and adopters taking different positive values.

Based on such a definition, a full Tobit regression model was first used on the entire sample of 585 households to estimate the joint effect on both the probability of the dependent variable being non-zero, i.e. probability of BBM adoption, and the duration of BBM use. A truncated Tobit model was then applied to only adopters (474 households) with different duration of adoption to estimate the effect on the probability of longer duration of BBM use.

The Tobit regression results showed that the set of factors significantly influencing the probability of adoption and duration of use are different from those influencing adoption as a binary variable. In the full Tobit model, only BBM training, cropland area, number of work animals and duration of access to credit had a significant positive influence on the probability of adoption and duration of BBM use; family size

had a significant negative influence. In the truncated Tobit model, except for cropland area, all the factors that significantly influenced the probability of adoption and duration of use also influenced, in the same manner, the probability of longer period of use. Of all the variables, access to credit had the most significant influence on both the probability of adoption and the duration of BBM use.

Policy implications

The conceptual framework for technology adoption proposed in this study hypothesises that farmers move from learning to adoption and to continuous or discontinuous use of a new technology over time. When applied to the adoption pathway for Vertisol management technology in highland Ethiopia, the framework showed that over a period of eight years, farmers in the research sites responded differently to the BBM technology. Some adopted and continued to use the BBM technology; others adopted it at different times and discontinued its use, but readopted it later. Some knew about the BBM technology but had not yet adopted it while others did not appear to show any interest in the BBM technology.

These results illustrate that a simple classification of farmers as adopters and non-adopters is inadequate to understand the process of BBM technology adoption. Technology adoption is a dynamic multi-stage decision process in which farmers move from learning to adoption and to continuous or discontinuous use.

Further, the sets of factors that significantly influence decisions to acquire knowledge about BBM, to adopt and then to use it continuously or discontinuously are different. The lag between learning and adoption, and the possibilities of discontinuation and re-adoption also imply that a much longer period than commonly allowed for will be needed before a majority of farmers adopt and use a technology.

The results of this analysis indicate that corrective policy measures need to be taken mainly in the form of positive steps in terms of diffusion of information to increase awareness, removal of supply constraints to facilitate rapid and sustained technology adoption.

For further information on this issue see: Jabbar M.A., Hailu Beyene, Mohamed-Saleem M.A. and Solomon Gebreselassie. 1998. *Adoption Pathways for New Agricultural Technologies: An Approach and an Application to Vertisol Management Technology in Ethiopia*. Socio-economic and Policy Research Working Paper 23. Livestock Policy Analysis Project. ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. 27 pp.