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An interdisciplinary framework to study farmers' decisions on adoption of innovation: Insights from Expected Utility Theory and Theory of Planned Behavior

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This study presented a conceptual framework based on Expected Utility Theory (EUT) and Theory of Planned Behavior (TPB) to study farmers' decision on adoption of innovations. The framework explains the adoption decisions as a dynamic process, assuming a complex interaction of groups of variables coming from both theories. The combination of EUT and TPB overcomes some restrictions that arise when just one theory is used to study the adoption decision.

Key words: Adoption, farmers' decisions, expected utility theory, theory of planned behavior.

INTRODUCTION

One of the concerns of agricultural economists is understanding and modeling the processes and consequences of decision-making among farmers (Willock et al., 1999). Since Griliches' (1957) pioneering work on farmers' decisions to adopt an innovation, this topic has been studied intensively. These studies have been conducted by separate lines of research, e.g. economic, sociology, psychology, marketing, agricultural extension and anthropology (Pannell et al., 2006). Therefore, most of the theoretical models on adoption of innovation have tended to present discipline guided explanations to the adoption decision, although adoption is subject to a combination of social, economic, psychological, as well as cultural factors (Boahene et al., 1999; Edwards-Jones, 2006). From a theoretical point of view, there is a gap in the literature providing a formal integration of sociologic, economic and psychological variables in the relevant models (Edwards-Jones, 2006).

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Then, how can these disciplines be linked to better comprehend farmers' decision on adoption of innovation?In this paper, innovation is defined as an idea, practice, or object that is perceived as new by an individual or other unit of adoption (Rogers, 2003). For instance, conservation practices, environmentally friendly innovations, agricultural best management practices, water conservation practices, etc. are all considered innovations.

The purely economic literature regarding farmers' decisions is based on normative theory and on the assumption that decisions can be modeled only in terms of the individual acting to maximize profit (Austin et al., 1998; Willock et al., 1999). However, this literature cannot capture the full complexity of farmers' decisions (Austin et al., 1998). Additionally, such models fail to recognize that farmers' behavior is not driven only by the maximization of profit (Willock et al., 1999). In the field of agricultural economics, farmers' decisions and behaviors have been studied by two main different approaches: one is based on purely economic models, where Expected Utility Theory (EUT) plays a central role. The second approach is based on socio-psychological theories, where psychological constructs explain farmers' behavior, for instance the decision to adopt an innovation. One of the most relevant theories used by researchers to understand farmers' behavior was developed by Fishbein and Ajzen (1975), the Theory of Reasoned Action (TRA). TRA was extended by Ajzen (1991), resulting in the Theory of Planned Behavior (TPB).

The aim of this paper is to present a conceptual framework based on EUT and TRA/TPB to study farmers' decisions on adoption of innovations. The present paper does not aim at reviewing all the variables that may influence adoption decision, but rather, classifying, integrating and rearranging them in a generic framework. A general review about variables that may influence the adoption decision is given in Wejnert (2002). A review about innovations in agriculture are given in Feder et al. (1985), Feder and Umali (1993), Knowler and Bradshaw (2007), Pannel et al. (2006) and Prokopy et al. (2008).

The framework is in line with Wauters and Mathijs (2013), who observed a rising interest by scientists in socio-psychological methods to study adoption decisions. They argue that this interest has been induced by a growing discontent with the use of classic variables in adoption studies. For instance, a recent meta-analysis found in Knowler and Bradshaw (2007) showed that such variables tend to be mostly insignificant. Therefore, we build upon earlier work, bringing insights from discipline guide models into a generic conceptual framework in order to allow scientists to better formulate research on the topic.

Theories to study farmers' decisions to adopt an innovation

Expected Utility Theory (EUT)

EUT states that a farmer compares the innovation with the traditional technology and adopts it if the expected utility from adopting exceeds the expected utility of the traditional technology (Batz et al., 1999). Although the utility function is unobserved, the relation between the expected utility corresponding to each alternative is postulated to be a function of the vector of observed variables and an error term (Adesina and Zinnah, 1993; Batz et al., 1999). Using econometric models, mainly logit, probit and tobit, empirical studies analyze the impact of different and diverse variables on individual adoption decisions (Batz et al., 1999).

Theory of Reasoned Action (TRA) and Theory of Planned Behavior (TPB)

These theories attempt to frame human behavior in a limited number of psychological constructs (Beedell and Rehman, 2000). Both theories assume that people's behavior originates from their intentions to perform a specific behavior (Hansson et al., 2012). Introducing behavioral intention models are restricted to those behaviors which may be considered to be under the volitional control of the individual (Burton, 2004).

In TRA, intention (BI) is determined by two central constructs, attitude (Aact) and subjective norms (SN) (Martínez-García et al., 2013). The original reason to include subjective norms in models was that individuals do not act independently of cultural/social influences, but are continually referring their behavior back to important reference groups (Burton, 2004). In addition to these constructs, perceived behavioral control (PBC) is also assumed to influence intention in TPB (Beedell and Rehman, 2000). These constructs are represented in the following equation:

$$BI = Aact + SN + PBC$$

Where, according to Beedell and Rehman (2000) and Wauters et al. (2010): *BI* is the intention to perform the behavior; *Aact* is the degree to which execution of the behavior is evaluated positively or negatively; *SN* refer to people's perceptions of the social pressures upon them to perform or not a behavior; and *PBC* is the perceived own capability to successfully perform a behavior;

Together, attitude, subjective norm and perceived control lead to a positive or negative intention to perform the behavior (Wauters et al., 2010). A positive intention

may not result in execution of the behavior, namely in cases where - according to people's perceptions - there is not sufficient availability of required prerequisites in terms of capital, knowledge, skills and opportunities (actual behavioral control) (Wauters et al., 2010). The concept of perceived behavior control is included only in TPB (Beedell and Rehman, 2000).

Attitude, subjective norm and perceived behavioral control originate from behavioral beliefs, normative beliefs and control beliefs, respectively (Hansson et al., 2012). These beliefs are indirect measures of the respective constructs, as in the following equations:

$$Aact = \sum_{i=1}^{n} bs_i \, oe_i$$

$$SN = \sum_{j=1}^{p} nb_j \, mc_j$$

$$PBC = \sum_{k=1}^{q} cb_k \, pb_k$$

Where, according to Beedell and Rehman (2000) and Wauters et al. (2010): *bs* is a person's perceived probability that performing the behavior will lead to a particular outcome; *oe* is a person's subjective evaluation of how good or bad a particular outcome of performing the behavior is, that is what is the utility of the outcome to the decision maker; *i* is the ith outcome; *n* the total number of possible outcomes; *nb* is a person's assessment of whether important referents think he should or should not perform a behavior; *mc* a person's assessment of how much he wants to comply with the important referents, utility from complying with the referents; *j* the jth referent; *p* the total number of referents; *cb* is a person's assessment of the probability of the belief affecting behavior; *pb* is person's subjective evaluation of the power of the control belief to affect performance of the behavior; *k* the kth control factor; and *q* the total number of possible control factors.

METHODOLOGY

This study used a qualitative approach to review papers on the adoption of innovation in agriculture that use either EUT or the TRA/TPB. To identify the relevant papers on the topic of adoption of an innovation in agriculture, a comprehensive search in the databases, such as Scopus, Web of Science and Google Scholar, was used. After identifying the papers a desk review was conducted. The aims of the desk review were: first to identify which variables have been used to understand farmers' decisions on adoption of an innovation; second to categorize the variables in groups. After identifying and classifying the variables, a framework was developed to integrate and rearrange them in a generic framework, which uses insights from both theories.

RESULTS AND DISCUSSION

EUT and TRA/TPB papers are summarized on Tables 1 and 2, respectively. Papers that bring insights but not explicitly using EUT or TRA/TPB are also briefly discussed.

Table 1 shows that EUT has been used to study different types of innovations worldwide. One could expect that, since one of the main assumptions in EUT is that farmers have the objective to maximize profit, this theory would be used to study innovations that are expected to increase profitability. Interestingly, EUT is not only used to explain adoption of innovation that are expected to increase profitability, for instance in Wubeneh and Sanders (2006), but also to explain adoption of sustainable and conservation techniques.

Table 2 indicates that TRA/TPB have been used in agricultural economics with at least two objectives: Explain a generic behavior, for example conservation behavior (Beedell and Rehman, 2000) and entrepreneurial behavior (Bergevoet et al., 2004) or a specific one (Martínez-García et al., 2013; Reimer et al., 2012; Wauters et al., 2010). These theories have been used to explain different types of innovations mainly in developed countries. Instead of using the "decision" concept, TRA/TPB papers that study adoption consider farmers' decisions as a specific behavior.

Variables are categorized in the following groups: beliefs; perceptions about characteristics of the innovation; psychological constructs, encompassing intention, attitude, subjective norms and perceived behavioral control; farmers' objectives and goals; background factors, including farmer characteristics, household characteristics, farm characteristics, farming context and acquisition of information/process of learning.

Farmers' perceptions

Some papers that use EUT to explain the adoption decision include measures of farmers' perceptions as explanatory variables. These papers can be divided in two categories: Perceptions about characteristics of the innovation and perceptions about benefits, risks and costs associated with the innovation. To justify the use of perceptions about characteristics of the innovation in EUT models, Adesina and Zinnah (1993) argue that adoption (rejection) of innovations by farmers may reflect rational decision making based upon farmers' perceptions of the appropriateness (inappropriateness) of the characteristics of the innovation under investigation.

Table 1. Reviewed papers on EUT.

Authors	Type of Innovation	Country of application
Adesina and Zinnah (1993)	Rice varieties	Sierra Leone
Adesina and Baidu-Forson (1995)	Sorghum and rice varieties	Burkina-Faso and Guinea
Asfaw and Admassie (2004)	Chemical fertilizer	Ethiopia
Baidu-Forson (1999)	Land-enhancing	Niger
Boahene et al. (1999)	Hybrid cocoa	Ghana
D'Emden et al. (2006)	Conservation tillage	Australia
Jara-Rojas et al. (2012)	Water conservation practices	Chile
Kassie et al. (2013)	Sustainable agricultural practices	Tanzania
Kebede et al. (1990)	Fertilizers and pesticides	Ethiopia
Khan et al. (2008)	Techniques to control pests	Kenya
Mazvimavi and Twomlow (2009)	Conservation techniques	Zimbabwe
Negatu and Parikh (1999)	Wheat varieties	Ethiopia
Roberts et al. (2004)	Precision farming technologies	United States
Wubeneh and Sanders (2006)	Technologies for increase sorghum productivity	Ethiopia

Table 2. Reviewed papers on TRA/TPB.

Authors	Type of innovation or behavior	Country/region of application
Beedell and Rehman (2000)	Conservation behavior	United Kingdom
Bergevoet et al. (2004)	Entrepreneurial behavior	The Netherlands
Martinez-Garcia et al. (2013)	Improved grassland management	Mexico
Reimer et al. (2012)	Best management practices	United States
Wauters et al. (2010)	Soil conservation practices	Belgium
Willock et al. (1999)	Business and environmentally-oriented behavior	Scotland

Adesina and Zinnah (1993), Adesina and Baidu-Forson (1995), Negatu and Parikh (1999), Khan et al. (2008) and Wubeneh and Sanders (2006) tested the hypothesis that farmers' perceptions about characteristics or attributes of innovation impact on the decision to adopt it. Their results support that farmers' perceptions of innovation-specific attributes have a highly significant effect on adoption. The other perception group is based on the assumption that what is relevant is how farmers perceive benefits, risks and costs associated with the innovation. Roberts et al. (2004) used perceived benefits and costs associated with an innovation as a potential explanatory variable. Their hypothesis was straightforward: farmers who are more informed about the innovation, perceiving higher profits and lower costs are more likely to adopt it. Their results confirmed the hypothesis. These variables were measured by asking farmers about their perceptions about profitability of the innovation (benefit), the cost associated with the innovation (costs) and how they perceive the innovation as being important to them in the future. In addition to perceived profitability, Abadi Ghadim et al. (2005) in a model based on ideas from EUT, used farmers' perceptions of the riskiness of the innovation as another explanatory variable on adoption decision. Their findings support that this variable plays an important role on adoption, as well as perceived profitability.

Beliefs and psychological constructs

As expected, papers based on TRA/TPB always use beliefs and/or the psychological constructs intention, attitude, subjective norm and perceived behavioral control varying the emphasis in each of them and how they are measured (Burton, 2004). Regarding the application of TRA to explain adoption decision, Martinez-Garcia et al. (2013) used this theory to study farmers who were already engaged in the use of improved grassland management (innovation) in Mexico. They found that farmers' intention to continue to use the innovation was influenced by salient referents (mainly male relatives) as well as by their own attitudes, confirming TRA

hypotheses. An example of application of TBP in adoption decision is found in Wauters et al. (2010). They studied adoption of soil conservation practices (cover crops, grass buffer strips and reduced tillage) by Belgian farmers. Their results showed that the most important factor regarding adoption was farmers' attitudes towards the soil conservation practice.

Farmers' objectives and goals

EUT and TRA/TPB approach farmers' objectives and goals in different ways. While in TRA/TPB the role of these variables is not explicit, in EUT farmers are viewed as having only the objective of profit maximization.

In EUT the main assumption is that the farmer acts to maximize his level of utility. As utility is difficult to measure, profit is usually used by researchers as a substitute for this concept (Edwards-Jones, 2006). By adding risk attitude, farmers maximize expected utility of profit, rather than the expected profit (Abadi Ghadim and Pannell, 1999). As a result of this argument, if an innovation has a higher expected utility of profit than the old technology, adoption will occur.

As the role of farmers' objectives and goals are not explicit in TRA/TPB, some authors try to include them in the models. For instance, Willock et al. (1999) used the TRA construct attitude and additional variables related to farm objectives to explain two generic farmers' behaviors (business and environmental). As expected by TRA, they found that multiple attitudes influence both behaviors. Interestingly, some of attitudes influence behavior directly, while others are mediated by objectives. Bergevoet et al. (2004) used TPB to explain entrepreneurial behavior of Dutch dairy farmers. Remarkably, they used farmers' goals instead of intention in a TPB model. Then, goals were considered to be formed by farmers' attitudes, subjective norms and perceived behavioral control and entrepreneurial behavior a result of farmers' goals. Their findings confirmed that goals are one of the determinants of farmers' behavior. Additionally, Greiner et al. (2009) in an exploratory study hypothesized famers' goals or motivations to be related to adoption of Best Management Practices (BMP). They found a correlation between farmers categorized in a group with the goal (motivations) of "conservation and lifestyle" and BMP adoption.

In summary, although TRA/TPB do not use objectives and goals explicitly as a determinant of behavior, some authors (Bergevoet et al., 2004; Willock et al., 1999) include these variables in their models to better predict farmers' behaviors, highlighting the importance of objectives and goals on decisions. Note that objectives and goals were not used to explain a specific behavior, but rather generic ones.

Previous literature on the topic has identified farmers' objectives and goals to be heterogeneous, including, for example: Material wealth and financial security, environmental protection and enhancement (beyond that related to personal financial gain), social approval and acceptance, personal integrity and high ethical standards and balance of work and lifestyle (Pannell et al., 2006). There are many other farmers' objectives and goals identified in the literature. A list with farmers' objectives and goals are given in Bergevoet et al. (2004) and Solano et al. (2001).

Background factors

Background factors are not explicitly used in TRA/TPB models. As highlighted by Beddel and Rehman (2000), a criticism of TRA/TPB is that variables like age, gender, social class, etc. are not explicitly included in models. For these authors, a counter point to this is that all such variables are included, implicitly, through their effects on attitudes and intentions.

One exception is found in Reimer et al. (2012). In a qualitative approach they studied the adoption of Best Management Practices (BPM) by farmers in the United States. They based their analysis on an extension of TPB, namely Reasoned Action Approach (RAA) (Fishbein and Ajzen, 2010). RAA claimed that beliefs come from background factors, for example individual characteristics and past experiences (Reimer et al., 2012). Reimer et al. (2012) divided background factors from RAA in three main categories: Farmer and farm characteristics and farming context. They hypothesized these groups of variables to influence farmers' perceptions about characteristics of the BPM, which in turn influence farmers' beliefs. Characteristics of practices were based on Rogers' (2003) Diffusion Innovation Theory. They found that perceived characteristics of BPM play a role in adoption. However, they did not find many links between personal demographics and practice perceptions.

In EUT variables related to farm, household and farmer characteristics, farming context, acquisition of information/learning process are expected to influence farmers' adoption decisions. As explained before, the utility function is unobserved but the relation between the expected utility of adopting an innovation is postulated to be a function of the vector of observed variables.

There are numerous published papers relating variables classified to background factors with the decision to adopt. Examples of these variables are presented on Table 3, but the list is not intended to be

Table 3. Variables that may influence adoption decision.

Variable	Group
Experience	Farmer characteristics
Risk aversion	Farmer characteristics
Age	Farmer characteristics
Village head	Farmer characteristics
Gender	Farmer characteristics
Education	Farmer characteristics
Farmers moral concerns and emotions	Farmer characteristics
Farmer health	Farmer characteristics
Farmer full-time	Farmer characteristics
Awareness of a problem that an innovation may solve	Farmer characteristics
Education of family members	Household characteristics
Family size	Household characteristics
Home consumption	Household characteristics
Relatives in and outside the village that a household can rely on for critical support	Household characteristics
Off-farm employment	Household characteristics
Illness or death	Households characteristics
Availability of resources (machinery, labor, etc.)	Farm characteristics
Income	Farm characteristics
Farm size	Farm characteristics
Land tenure	Farm characteristics
Distance to markets	Farm characteristics
Hired-Labor	Farm characteristics
Plot access	Farm characteristics
Credit	Farming context
Modern environment	Farming context
Agro-climatic conditions	Farming context
Subsidies	Farming context
Pests and diseases	Farming context
Contact with extension	Acquisition of Information
Participation in on-farm trials	Acquisition of Information
Participation in workshops	Acquisition of Information
Social Network	Acquisition of Information
Membership in farmers' groups or associations	Acquisition of Information
Farmers confident in skill of extension agents	Acquisition of Information

exhaustive. There are many more variables that could be classified under this broad category. Here, our aim is to present justifications why variables were included in previous models or, if no explanation is found, the expected sign of the variable on the adoption decision. For this reason, the discussion is based mainly on hypothesis rather than on results.

Years of experience is expected to be positively related to adoption, because it may influence the ability of the farmer to obtain, process, and use relevant information (Adesina and Baidu-Forson, 1995; Adesina and Zinnah, 1993). Lower risk-aversion is expected to increase the probability to adopt an innovation (Baidu-Forson, 1999). In addition, to be a head of a village is expected to positively influences the adoption decision (Adesina and Baidu-Forson, 1995). The expected sign on age is unknown: Older farmers have more experience and then are better able to assess the characteristics of innovations than younger farmers; or it could be that older farmers are more risk averse than younger farmers and have a lesser likelihood of adopting new technologies (Adesina and Baidu-Forson, 1995). The hypothesis regarding gender is that male-headed farmers are more likely to get information about new technologies

and take risky business decisions than female-headed farmers (Asfaw and Admassie, 2004). The argument to justify the inclusion of education as an explanatory variable is that education enhances the ability of farmers to acquire, synthesize, and quickly respond to disequilibria, thereby increasing the probability of adoption of an innovation (Asfaw and Admassie, 2004). Therefore, the level of education is expected to have a positive sign on the adoption decision. Mzoughi (2011) studied the role of farmers' moral and social concerns on the adoption decision. He argues that moral concerns are those related to individuals' (intrinsic) ethics, such as personal satisfaction, and this is useful for our discussion. Mzoughi measured moral concerns by asking whether the farmer thinks that do not feel guilty about his own choices is important and if the farmer thinks that doing the right thing is important. Although Mzoughi's study does not use any theory, it brought the argument that farmers' moral and emotions influence the adoption decision. Moreover, Hounsome et al. (2006) observed that one of the potential factors neglected on adoption studies is farmer health. These authors conducted an exploratory study and found that farmer mental health is correlated to agri-environmental schemes adopted by farmers. Full-time farmers are more likely to adopt an innovation, especially when an innovation involves the partial substitution of management for other factors of production and is therefore more time-intensive (D'Souza et al., 1993). Farmer awareness of a problem that an innovation may solve is likely to increase the likelihood of adoption, for instance farmer awareness of ground water contamination increases the probability that a farmer will adopt innovations that help him solve this problem (D'Souza et al., 1993).

Oftentimes, the adoption decision is not necessarily made by the head of the household alone but also by other educated adult members of the household (Asfaw and Admassie, 2004). Therefore, in general, higher education levels of household members increase the probability of adoption (Asfaw and Admassie, 2004). Family size is expected to have a positive sign on the adoption decision (Jara-Rojas et al., 2012). In addition, home consumption is expected to be inversely related with adoption (Jara-Rojas et al., 2012). The sign of the number of relatives in and outside the village that a household can rely on for critical support is indeterminate but expected to influence the adoption decision. The reason is, as explained by Kassie et al. (2013), that households with greater number of relatives are more likely to adopt new technologies since they are able to share risks with relatives, decreasing excessive exposure to risk. However, having more relatives may reduce incentives for hard work and induce inefficiency, such that farmers may exert less effort to invest in technologies (Kassie et al., 2013). Off-farm employment by other households members has an indeterminate sign on the adoption decision, since labor outside the farm may allow better access to information about new technologies or the capacity to finance investments, but it may also divert time and effort away from agricultural activities, reducing investments in technologies and the availability of labor (Kassie et al., 2013). Mazvimavi and Twomlow (2009) argue that farmers who have recent experience with death or illness (HIV/AIDS) in their households are more likely to reduce the intensity of adoption of innovations based on farmers' access to labor and resources. One of the justifications to include income as an explanatory variable is that it is needed to purchase the inputs required to adopt an innovation (Boahene et al., 1999). The hypothesis regarding distance to markets is that the further away a village or a household lies from input and output markets the smaller the likelihood that they will adopt a new technology (Kassie et al., 2013). When an innovation is labor-saving, the use of hired labor on the part of the farm is hypothesized to be negatively associated with the adoption decision (D'Souza et al., 1993). Farm size is hypothesized to have a positive impact on the adoption decision (Adesina and Zinnah, 1993). Land tenure can also affect the adoption decision, because a farmer is likely to manage owed land more intensely than rented land and to preserve its productivity for future generations (Roberts et al., 2004). Better access to the plot increases the probability of adoption because it influences the availability of the innovation, the use of outputs and inputs markets and availability of information and support organizations (Kassie et al., 2013). Agro-climatic conditions, for example rainfall, is expected to influence adoption decisions and depends on the type of innovation. One reason to justify it is given by D'Emen et al. (2006), who studied the adoption of conservation tillage practice. They argued that "the soil moisture conservation benefits of no-till would be more apparent in a drier than average season, and that observation (learning) of these benefits on nearby adopters' properties would prompt non-adopters to either trial or adopt the technology in the following season". On the other hand, Kassie et al. (2013) hypothesized that favorable rainfall has a positively impact on decisions to adopt improved seed types and fertilizer use.

Farm liquidity and credit are hypothesized to have a positive sign on the adoption decision. Farm liquidity is justified because this variable increases the credit worthiness of households and their ability to undertake risky businesses (Asfaw and Admassie, 2004). In addition, access to subsidies facilitates technology adoption and then is hypothesized to have a positive sign on adoption decision (Jara-Rojas et al., 2012). It is

hypothesized that the probability of adopting an innovation is higher in modern environments than in traditional ones (Asfaw and Admassie, 2004). In addition, the presence of pest and diseases are expected to influence farmers' decisions and the sign of this variable depends on the type of innovation (Kassie et al., 2013).

Contact with extension agents is expected to have a positive effect on adoption because exposing farmers to availability of information can be expected to stimulate adoption (Kebede et al., 1990; Osuntogun et al., 1986; Polson and Spencer, 1991; Voh, 1982). In addition, farmers' confidence in skill of extension agents is expected to have a positive sign (Kassie et al., 2013). Based on the innovation-diffusion literature, Adesina and Baidu-Forson (1995) hypothesized that participation in workshops is positively related to adoption by exposing farmers to new information. Farmers who are in a network of relation(s) with many previous successful adopters have access to a large information network and, therefore, will be more likely to adopt an innovation (Boahene et al., 1999). Farmers may acquire information about new technologies from their peers and therefore, to be a membership in farmers' groups or associations is hypothesized to be positively associated with adoption of innovations (Kassie et al., 2013). Finally, participation in on-farm experimental trials is hypothesized to be positively related to adoption (Adesina and Baidu-Forson, 1995).

Overlaps and gaps in EUT and TRA/TPB studies on adoption of innovation

It was identified an overlap between theories regarding attitudes coming from TRA/TPB and perceptions of benefits and costs from EUT. As explained before, attitudes originate from beliefs about the probability that performing the behavior will lead to a particular outcome and subjective evaluation of how good or bad a particular outcome of performing the behavior is Beedell and Rehman (2000). In practice, a positive attitude towards adoption emerges when a person evaluates that performing the behavior has higher probability to lead to positive outcomes (benefits) than to negative ones (costs). Important to note that benefits and costs may include more than only economic ones. Therefore, in the framework, attitudes and perceptions about benefits, risks and costs are included in one block, as presented on Figure 1. This overlap is also highlighted by Lapple and Kelley (2013) who argue that attitudes can be interpreted as equivalent to utility.

After reviewing previous papers based on EUT and TRA/TPB, it was identified some gaps in the literature when only one of the theories are used. While the role of farmers' objectives and goals is differently stressed in papers based on EUT and TRA/TPB, perceptions and background factors are manly used in papers based on EUT and beliefs and psychological constructs only in the ones that use TRA/TPB.

Papers based on EUT assume that farmers have only the objective of maximize expected utility of profit. These papers do not consider that farmers may have more than one objective and goal. In addition, EUT papers do not consider social pressure upon farmers to adopt an innovation, what TRA/TPB papers consider using the psychological construct subjective norms. On the other hand, papers that use TRA/TPB do not consider explicit background factors, specially the role of acquisition of information/learning process.

New framework on adoption of innovation

The framework explains the adoption decisions as a dynamic process, assuming a complex interaction of groups of variables as presented on Figure 1. To start the process, a farmer must be aware about the innovation. Awareness means that a farmer knows that the innovation exists and that it is potentially of practical relevance to him (Pannell et al., 2006). The framework starts with the assumption that a farmer is aware of the innovation. It is recognized that there are many variables influencing farmer awareness, mainly ones related to acquisition of information (Adegbola and Gardebroek, 2007). However, it is argued that as the framework is dynamic, a farmer that is not aware of the innovation may acquire more information and becomes aware of it.

If a farmer is aware of the innovation, he/she has the following options: immediately adopt, partially adopt or trial the innovation and do not adopt. In addition, for some innovations, there may be an additional step, in which a farmer may decide to modify the innovation in order to adapt it more closely to his individual conditions (Adegbola and Gardebroek, 2007).

As stressed by TRA/TBP, intention is a predictor for a specific behavior, and we keep this assumption. In our discussion, a farmer has the intention to adopt an innovation if he wishes consciously to adopt it. In TRA/TPB, attitude, subjective norm and perceived behavioral control originate intention and we also keep this assumption but with one modification: perceptions about characteristics of the innovation also influence farmers' intention to adopt.

In order to define characteristics of the innovation that are expected to influence intention and make the framework easier to follow we based on Diffusion Innovation Theory. In this theory there are five characteristics of innovations that affect adoption:

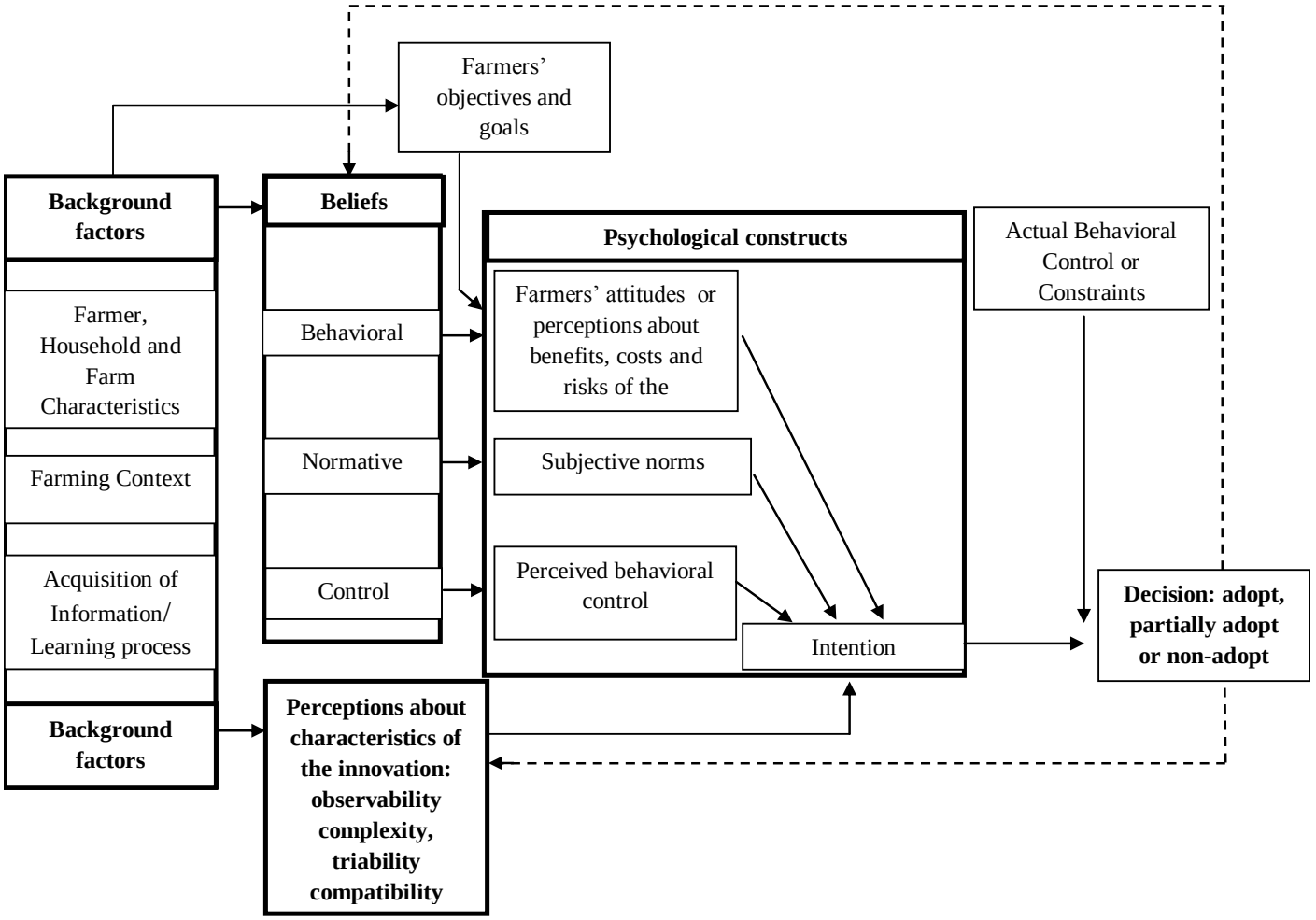

Figure 1. Conceptual framework to study farmers' decisions on adoption of innovation.

Relative advantage, compatibility, complexity, observability and triability (Rogers, 2003). The framework presents four, because relative advantage is already included in the framework in a different group of variables, namely attitude or perceptions about benefits, costs and risks. Rogers (2003) defines these characteristics as follows: Compatibility is "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters"; trialability is "the degree to which an innovation may be experimented with on a limited basis; observability is "the degree to which the results of an innovation are visible to others; and complexity is "the degree to which an innovation is perceived as relatively difficult to understand and use".

As stressed by TPB, normative and control beliefs form the constructs subjective norm and perceived behavioral control, respectively. Attitude originates from behavioral beliefs and is hypothesized that objectives and goals also influence this construct. This hypothesis is explained because behavioral beliefs are related with a person's subjective evaluation of how good or bad a particular outcome of performing the behavior is (Beedell and Rehman, 2000). This hypothesis is exemplified as follows. A farmer that has the belief that an innovation increases profitability evaluates this outcome better if he has the objective of increase profit.

Together the psychological constructs coming from beliefs and perceptions will result in a positive or negative intention to adopt or not an innovation. However even when there is a positive intention, the adoption may not occur because there is insufficient availability of required prerequisites, that is, control beliefs or constraints.

Beliefs, perceptions and objectives and goals are

influenced by variables coming from background factors encompassing three blocks: Farmer characteristics, household characteristics, farm characteristics; farming context; and acquisition of information/process of learning. Finally, it is expected that a famer who adopt or trial the innovation, modifies his beliefs and perceptions.

The framework brings some insights that must be considered in adoption studies. Farmers' are not expected to consider only expected profit as the benefit to adopt an innovation. Additionally to the trade-off between perceived expected profitability and perceived riskiness associated with the innovation, farmers may also consider other benefits, costs and risks, for instance, social and environmental ones to make the decision. An example of this argument is found in Khan et al. (2008). They asked farmers what were the benefits associated with adoption of "push–pull' technology for control of cereal stemborers and *Striga* weed in western Kenya. The main benefits of the innovation cited by farmers were reduced infestation by pests, improvement in soil fertility, increase in maize grain yields, improved fodder and milk productivity. This insight is exemplified as follows. Suppose that a farmer perceives that an innovation has a higher expected profitability (benefit) compared to an "old" technology that has been used by him. But he also perceives that there are other costs associated with the innovation that are not economic ones, for instance environmental. Then, although the innovation has a higher expected profitability compared with the "old" technology, a farmer does not adopt it because he perceives high non-economic costs.

Other insight is to make explicit the role of social pressure on the adoption decision trough the construct on farmers' subjective norms. A positive influence on his intention to adopt an innovation comes from beliefs that adopting will be supported by "salient referents". This argument is reinforced by Mzoughi (2011). He observed that social concerns drove farmers' adoption decisions, where social concerns are those "which shape the individual's behavior in relation to his/her reference group, for example, the other similar farmers in the same region."

In the framework it is also considered that farmers may have more than one objective and goal and these may vary in time. In addition, a farmer may not take all of his objectives and goals into account on adoption decision. Therefore, this point of the framework is more in line with some findings from the psychological approach. Instead of maximizing expected utility of profit we based on Simon's (1957) 'satisficing' concept. As explained by Burton (2004), this idea acknowledges that people do not necessarily engage in economically optimal decision-making, but instead may optimize social, intrinsic and/or expressive goals. This argument can be illustrated with the following example. A farmer has many objectives and goals, for instance he wants to have a high income, but also wants to have some leisure time and be recognized as leader in his community. When he makes the decision to adopt an innovation, he may take into account if the innovation helps him to achieve his objectives and goals. As time goes, he may change his objectives and goals and then an innovation that at the beginning was not expected to help him to achieve his "old" objectives may now be in line with the new ones.

Therefore, the framework's hypotheses are: a positive attitude about the outcomes of adoption, a positive evaluation about how important others support the decision (subjective norm), positive beliefs that one has the resources to adopt an innovation (perceived behavioral control) increase the probability to adopt it, by a positive impact on intention. In addition, a positive impact of observability, triability and compatibility is expected on intention, while complexity is expected to have a negative effect on intention. Moreover, a positive impact on farmer attitude is expected when the innovation is in line with farmer' objectives and goals and if the farmer considers them when making the decision.

Perceptions about characteristics of the innovation and the psychological constructs attitudes, subjective norms and perceived behavioral control result in a positive or negative intention to adopt an innovation. However, perceived benefits, costs and risks, important salient referents, perceived availability of resources, perception about characteristics of the innovation and farmers' objectives and goals may vary over time. Therefore, what is important is what are farmers' beliefs, perceptions and objectives and goals at the time of the decision.

In previous studies from EUT variables classified in the background factors were assumed to directly influence the decision to adopt or not an innovation. An exception is a framework on adoption of innovation developed by Abadi-Ghadim and Pannel (1999). These authors hypothesized that social and demographic factors, like age and experience, influence the adoption decision by influencing farmer's subjective perceptions, uncertainty and/or attitudes. Therefore, in the present framework these variables are not assumed to directly influence farmers' decisions, but they are expected to have an indirect impact on farmers' perceptions and beliefs, being somehow in line with Abadi-Ghadim and Pannel (1999) hypothesis.

Positive or negative impact of farmer, household and farmer characteristics and farming context groups depends on the variable itself and on which beliefs or perceptions are considered. For instance, it is expected that a farmer who has more experience also has more "correct" behavioral beliefs about the innovation. But it is also expected that experience influences perceptions

about the characteristics of the innovation.

As a farmer acquires more information about the innovation by adopting it or partially adopting (trial) or other sources (workshops, social network, etc.) his perceptions and beliefs are expected to change, as highlighted on Figure 1. The relevance to the process of acquiring more information and learning in a dynamic framework were also stressed by Abadi-Ghadim and Pannel (1999), who showed in a formal model that information from trialling an innovation has two important aspects: skill improvement, and better decision making.

Conclusion

A detailed framework on the adoption decision has been presented. In order to bring useful insights for future studies on the topic, our concern was more related on how famers make decisions in practice, because, as observed by Öhlmér et al. (1998), most research on farmers' decisions has been conducted on how they should make decisions. It is important to recognize that the adoption decision depends on complex factors (Negatu and Parikh, 1999). Therefore, based mainly on empirical models that use EUT and TRA/TPB this dynamic framework highlighted what is already known, that the adoption decision is influenced by an array of variables. However, we argue that using only one of these theories, instead of a combination of both, may restrict researchers on their findings by not considering results from different approaches for the same topic. For instance, studies on adoption based on TRA/TPB do not consider explicitly the role of acquisition of information. Moreover studies based only on EUT assume that farmers' have the single objective of maximizing expected utility of profit. The combination of EUT and TRA/TPB overcomes the above-mentioned restrictions. We are aware that the way variables are grouped, especially in the background factors, may generate controversy. Other researchers could choose to group variables differently. The counter point is that what is important is the idea that those variables influence the farmers' adoption decision by having an indirect impact on their perceptions and beliefs, instead of by a direct impact as assumed by EUT studies. Finally, including all these variables and their interrelations in an empirical study is a considerable challenge. However, we consider that the framework provides a broad and comprehensive view of the adoption decision, allowing scientists to better formulate their research in this topic.

Conflict of Interest

The authors have not declared any conflict of interest.

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