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TOWARDS A RE-CONCEPTUALIZATION OF THE PATHWAY OF AGRICULTURAL TECHNOLOGY FOR A BETTER IMPACT ASSESSMENT

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ABSTRACT

There is incredibly a large consensus on research methodology and agreement on research results in agricultural technology adoption studies conducted in the past decades. This paper provides an explanation to such a consensus by questioning its foundation and wonder whether there are some conceptual alternatives. A paradigmatic analysis of adoption studies shows that innovation is generally considered as a definitively shaped idea/object to be either adopted or rejected. Such a representation of the pathway of agricultural technology led to the standardization of research designs and the underestimation of the impact of technology. Technology adoption models shifted to methodological sophistication that resulted in the oversimplification of reality. The paper suggests a re-conceptualization of the methodology for a better impact assessment of technology. Interpretive methods could be used as a complement to positivist methods that reduce the complexity of innovation pathways assessment. This would provide a comprehensive view of the adoption process and may help researchers to formulate future research in the area.

Contribution/ Originality: This study contributes in the existing literature on adoption studies by proposing a re-conceptualization of agricultural technology pathway that goes beyond adoption-non adoption dichotomous. The suggested integrative model of innovation enlarges the conceptual horizons of adoption studies. Such a theoretical framework may be useful in assessing fairly impacts of technology.

1. INTRODUCTION

The adoption of innovation has been one of the most investigated research field in agricultural economics during the past decades (Feder *et al.*, 1985; Lindner, 1987; Negatu and Parikh, 1999; Pattanayak *et al.*, 2003; Doss, 2006; Musshoff and Hirschauer, 2008; Dhraief *et al.*, 2018; Tigabu and Gebeyehu, 2018) as technological change is considered as an important prerequisite for agricultural development (Byerlee, 1996; Masters *et al.*, 1998). The findings of these studies should help accelerate the adoption and diffusion of technology, the rate and speed of which were considered as too low and slow (Leeuwis, 2004). Feder *et al.* (1985); Lindner (1987); Vanclay and Lawrence (1994); Pattanayak *et al.* (2003) and Doss (2006) provide us with very useful reviews of innovation adoption studies. Scholarly debates usually turned around factors affecting adoption decision, conceptualization of the adoption and subsequently econometric models appropriate to approach the reality of adoption. The adoption of technology is jointly determined by demand-side factors (profitability of adopting, risk and availability of technology) and supply-

side factors (profitability in supplying). Factors associated with the structure of the seed market, the organization of the seed industry, the cost of research innovation and the political importance of commodities also influenced the adoption of technology (Kosarek *et al*., 2001). Lapar and Pandey (1999) reframed adoption factors in terms of farmer-specific, farm-specific or technology-specific factors. Farmer-specific factors include the goals of the farmer and the available resources. Farm-specific factors are related to the characteristics of the production systems. Technology-specific factors are features of the technology designed to change the farmers' production systems. Recent inclusions of farmers' perception of innovation (Adesina and Baidu-Forson, 1995; Batz *et al*., 1999; Negatu and Parikh, 1999) and farmers' attitudes (Nowak and Korsching, 1983; Lynne *et al*., 1988; Baidu-Forson, 1999; Dhraief *et al*., 2018; Tigabu and Gebeyehu, 2018) in adoption studies brought new insights of adoption processes. There is a need for an integrative analytical framework that could bring together findings at different levels for a global understanding of innovation adoption factors.

Klonglan *et al*. (1971) defined diffusion of technology as the extent to which all adoption units have progressed through the adoption process. This conceptualization considers diffusion as a multi-dimensional process including sub-processes (awareness, information, evaluation, trial and adoption stages). According to their speed of "adoption", people are also classified into five different categories: innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003; Leeuwis, 2004). Consequences of innovation include desirable versus undesirable, direct versus indirect and anticipated versus unanticipated consequences (Rogers, 2003). Desirable consequences are the functional effects of an innovation for a farmer or for a social system he belongs to while undesirable consequences are the dysfunctional effects. Direct consequences are the changes to a farmer or a social system that occur in immediate response to adoption of an innovation. The changes to a farmer or a social system that occur as a result of the direct consequences of an innovation are indirect consequences. Anticipated consequences are changes due to an innovation that are recognized and intended by the members of a social system. Unanticipated consequences are changes that are neither intended nor recognized by them. An interesting question coming out from this classification is whether the goal of an innovation is its adoption or its effects or impacts to farmers or farmer communities. We won't say as Leeuwis (2004) that in the new questions concerning innovation, the idea of "adoption" itself is no longer a major concern. Innovation encompasses both individual and collective aspects. But usual conceptualization of adoption and diffusion has low or limited utility (see (Klonglan *et al*., 1971; Lindner, 1987; Vanclay, 1992; Doss, 2006)). Few studies highlight the social and cognitive transformations, pathways and impacts following the introduction of innovation in rural communities (see Vanclay (1992)). This paper aims to (i) construct an integrative framework for analyzing factors that affect adoption, (ii) analyze to which extent current definitions of adoption approached the reality, and (iii) exploring theoretical foundation and subsequent methodological considerations for a re-conceptualization of the pathways of innovation. We hypothesize that most adoption studies underestimated the effects of innovations by reducing its complex pathways and utility to the intentions of development workers. We carried out the analyses within the actor-oriented perspective. Actor-oriented analysis aims at providing a framework for understanding the processes by which particular social forms or arrangements emerge and are consolidated or reworked in the everyday lives of people (Long, 1992;2002). This approach helped focus on how differences of interests and interpretations amongst farmers may influence the pathways of agricultural technologies. We present first a review of current state of adoption research. Second, we analyze our findings in view of broader review studies on adoption of innovations. Third, we suggest a re-conceptualization of the pathway of innovation for better impact assessment.

1.1. Adoption Factors in Adoption Research

In most of the studies we considered, the main factors used to explain farmers' decision to adopt an innovation can be organized in five groups, in addition to the attributes of an innovation, relative advantage, compatibility, complexity, trialability and observability (Rogers, 1983):

- Personal objectives of the head of the farm want to achieve (financial, material, social and psychological needs and interests, etc.).
- Intellectual background of the head of the farm serving as reference framework for his perceptions and decision-making (education, trainings, experiences, etc.).
- Agri-environmental assets of the farm (quantity and quality of productive resources available: land, water, labor, etc.).
- Social capital that the head of the farm can recourse to (group contact, values, beliefs, social practices, subcultures, etc.).
- Institutional infrastructure relative to policy and legislation (market, risk, inputs/factors such as information, training and advisory services, labor, seeds, fertilizers, pesticides, credit, equipment, etc.).

Most of studies stressed on variables related to personal objectives of farmers, their intellectual background, institutional supports, and natural and physical resources they were endowed with. Few studies included social factors as variables affecting adoption of innovation.

1.2. Conceptualization of Adoption

There is an incredible large consensus on research methodology in adoption studies conducted at different time periods, geographic regions and thematic in the past couple of decades (see also Isaac *et al.* (2006)). Probit and logit models (tri- and dichotomous conception of adoption) were used mainly. Tobit models usually including speed of adoption (time-related adoption conception) and extent of adoption (ratio of covered area) serve as core methodology were also applied. Where is the foundation of such a consensus? Innovation adoption models (generally based on probit and tobit models) consider adoption as an individual binary decision to use or not use innovation.

2. RELATION TO BROADER REVIEW STUDIES ON ADOPTION OF INNOVATIONS

2.1. Integrative Framework for Analyzing Adoption Factors

Adoption factors mostly have been intensively discussed in review studies. In this section we will (i) attempt a construction of an integrative framework for analyzing adoption factors basing on our own review and past reviews of adoption studies and (ii) analyze to which extent current conceptualization of adoption approached the reality. Feder *et al.* (1985); Lindner (1987); Vanclay and Lawrence (1994) and Pattanayak *et al.* (2003) organized empirical work in various domains according to key explanatory factors affecting adoption. Basing on our more generic conceptualization we can propose an integrative framework for analysing adoption factors Table 1.

Table-1. Integrative framework for analyzing adoption factors.

Adoption factors	Feder *et al.* (1985)	Lindner (1987)	Vanclay and Lawrence (1994)	Pattanayak *et al.* (2003)
Personal objectives	-	Personal attributes	Farm and personal objectives	Preferences
Intellectual background	Human capital		Intellectual outlay Perceptional issues	-
Agri-environmental assets	Farm size Labor availability	Attributes of the farm	Capital outlay	Resource endowments Biophysical factors
Social facteurs	-	Attributes of the social system	Social issues	-
Institutional infrastructure	Risk and uncertainty Credit constraint Supply constraints Tenure	Attributes of the economic system	Risk Conflicting information	Risk and uncertainty Market incentives

Personal objectives and intellectual background of farmers, named farm and personal objectives and intellectual outlay by Vanclay and Lawrence (1994) or personal attributes of farmers by Lindner (1987) include farmers' human capital (Feder *et al.*, 1985) and preferences Pattanayak *et al.* (2003). Farm size and labor availability (Feder *et al.*, 1985) attributes of the farm Lindner (1987) capital outlay (Vanclay and Lawrence, 1994) resource endowments and biophysical factors (Pattanayak *et al.*, 2003) are different facets of farmers' agri-environmental assets. Social factors were considered in terms of attributes of the social system by Lindner (1987) and in termes of social issues by (Vanclay and Lawrence, 1994). Lastly, institutional factors include a large number of non-farmer and non-farm related variables. This framework capitalizes many important meta-studies of adoption studies in agriculture. It includes the main distinctive facets associated with adoption factors so that many other classifications can be easily lodged.

2.2. Developmentalist Representation" of Innovation as Foundation of Adoption Studies

Drawing on an extensive review of the literature on the adoption of technologies, alternative approaches for designing innovation adoption studies were suggested. Most reviewers dealt with methodological concerns with regard to the specification of econometric models (Lindner, 1987; Ghadim and Pannell, 1999; Dimara and Skuras, 2003; Doss, 2006; Musshoff and Hirschauer, 2008) and the validity of micro-level studies (Doss, 2006). Specifically, they focused on whether adoption is a discrete state with binary variables (adopter and non-adopter) or whether adoption is a continuous variable (partial adoption, gradual shifts and time-related process) with sometimes time variable specification. In fact, the representations of the use of an innovation (or the pathway of an innovation in social system) influence the management of innovation processes, research and extension strategies. The theory of diffusion of innovation (Rogers, 2003) is one of the most influential paradigms in agricultural extension. The diffusion of an innovation is "the process through which an innovation is communicated through certain channels over time among the members of a social system". This definition considers the adoption of innovation as a process of using an existing idea. Rogers defines the innovation diffusion process as the process through which an individual passes from first knowledge of an innovation to forming an attitude toward the innovation, to a decision to adopt or reject, to implementation of the new idea, and to the confirmation of this decision" (p170). An innovation is considered to be a definitively shaped idea/object to be either adopted or rejected. In the same line, Feder *et al.* (1985) define adoption as the degree of use of an innovation in the long-run equilibrium when the farmer has full information about the innovation and its potentials. We will not address in this paper the issue of availability of full information before decision-making that Dimara and Skuras (2003) pointed out to be also problematic. The concept of "degree of use" to explain adoption is of much interest in this context. The degree to which an innovation is used is considered by Feder *et al.* (1985) as providing a quantitative measure of the extent of adoption when the innovation can be divided to measurable units. For non-divisible technologies the extent of individual adoption is necessarily dichotomous, i.e. use or not. Such a representation led to modeling adoption response using a probit or logit specification for non-divisible technologies or using a tobit or other appropriate specification for divisible technologies (Dimara and Skuras, 2003). Most of the conceptual frameworks of the reviewed papers follow this thinking line. Therefore, the majority of adoption studies concerned with answering the questions: (a) what determines whether a particular farmer adopts or rejects an innovation and (b) what determines the pattern (extent, rate, etc.) of diffusion of the innovation through the population of potential adopters as noted by Lindner (1987). This "developmentalist representation [1]" of innovation as definitively shaped idea to adopt or reject in the framework of a planned change may justify the large conceptual and methodological consensus observed in adoption studies in the past couple of decades.

[1]We refer to developmentalist representation as the foundation of the directive intervention system in which development organizations should bring innovation or knowledge to farmers considered as unknowledgeable. This mode of thinking has been called 'the linear model of innovation' Kline and Rosenberg (1986).

3. TOWARD A RE-CONCEPTUALIZATION OF THE PATHWAYS OF INNOVATION

3.1. Exploring Theoretical Foundation for a Re-Conceptualization of the Pathways of Innovation

The missing link in innovation adoption models appears to be the dynamic nature of adoption decisions involving changes in farmers' perceptions and attitudes (Ghadim and Pannell, 1999). Change in the representation of the usages/pathways of technologies is required to establish this link. Like Doss (2006) we think that defining "adoption" of innovation is a complicated question with no obvious 'correct' answer because the definition of adoption encompasses a wide range of dissimilar practices. We explore in this section theoretical markers for a redefinition of the concept.

Misled by poor theoretical considerations, econometric models that have become increasingly sophisticated (see Doss (2006)) resulted into relatively poor analysis of the pathways of agricultural innovation. There is an important consideration we need to keep in mind. The ultimate goal of innovation is not adoption but a positive contribution to change process. Many interesting concepts exist in the literature to acknowledge use of innovation as not expected. Olivier (1995) refers to diversion as the use of an innovation or project for non planned objectives. Carroll *et al.* (2002) and Molony (2005) used the concept of appropriation of technology to refer to the process of reworking and personalizing an innovation by users to make it their own. Rogers (2003) refers to re-invention as "the degree to which an innovation is changed or modified by the user in the process of it adoption and implementation" (p.180). These concepts reveal that innovation adoption models are developed from the perspectives of development workers, researchers or extension workers; considering that innovation is worthwhile and that it would make sense for most farmers to adopt them. This assumption has been called the "pro-innovation bias" by Röling (1988). The pathway of innovations may be looked at differently as "adoption seen as loyal use of an idea" has potential to guide to top-down methods and practices. For instance, farmers' are sometimes categorized as being `innovative' or `conservative' in their approach to management (Ghadim and Pannell, 1999). Such a bias of perception of innovativeness is spurious stigmatization of farmers that serve as foundation to top-down intervention approaches. Innovation could be alternatively considered as neutral to emphasize the multiple and personal usage possibilities. The advantage of the representation of "innovation as neutral" is that it gives a prominent place to people, individually and in groups, making choices about how they want to use technological artefacts (Henwood *et al.*, 2000). These choices are part of the usage process in which individuals and communities encounter, engage with and adapt innovation (Molony, 2005). For instance, Ghadim and Pannell (1999) noted that "farmers often attempt to trial an innovation without investing in the "correct" machinery, but by making do with their existing machinery and making allowances for this in their interpretation of the results". "Recognition of re-invention brings into focus a different view of adoption behavior than that originally held by diffusion scholars. (…). People who use an innovation shape it by giving it meaning as they learn by using the new idea" (Rogers, 2003). Drawing from developments in the study of computer-mediated communication, multidisciplinary technology scholarship, and social psychology, Boczkowski (1999) concluded that "Artefacts are not only constructed by their designers, they are also constructed by their users".

The pathway of an innovation depends on the reference framework of the individual and the community. The reference framework is shaped by agro-environmental, intellectual, socio-cultural and institutional factors and the personal objectives of the farmer Table 1. Rather than static, the reference framework is changing through the building of new physical and social infrastructures, intermingling of cultures, institutional and organizational development, personal experience enrichment and the changes in the access to productive resources. Space is individual although it has a collective character. These infrastructures circumscribe decision and action space for individual farmers. According to the localization of an innovation in the decision and action space, the farmer decides on how to use it. The farmer rejects, adapts, stores or adopts an innovation after a subjective localization of this innovation with regard to his decision and action space. The farmer may adopt an innovation that he found profitable (in all the meanings) and localized within his decision and action space. He may reject an innovation he

localized completely out of his space. The complexity of the pathway of an innovation results from that it can be well-localized with regard to some infrastructural markers and badly located with regard to the others.

Innovation can provoke cognitive and behavioral impacts on people. Most innovation adoption models developed so far tends to consider only behavioral impacts. Most behavioral impacts go through cognitive impacts. However, cognitive impacts can occur without immediate influences on people' behavior. Therefore, the influential power of innovation cannot be limited to relatively immediate adoption, although adoption is the occurrence wished by development workers. Innovation involving knowledge incorporated in the cognitive system can (i) be communicated to peers or parents for usage, (ii) inspire the farmer in performing many activities, (iii) influence the farmer's perceptions in many situations, (iv) be stored for sometimes for later utilization, or (v) be adapted or changed and used for the purpose suggested by introducers or for other purposes Figure 1.

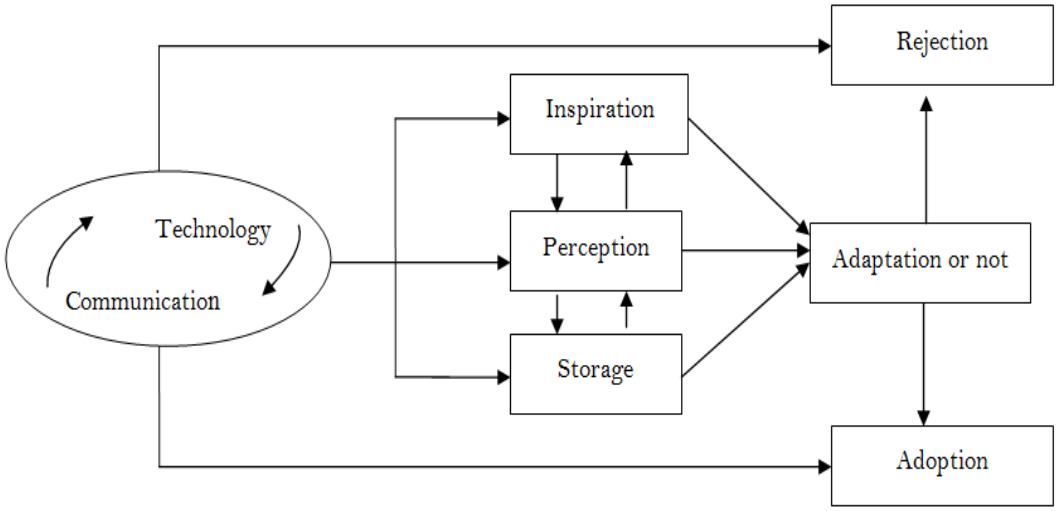

Figure-1. Possible pathways of innovation.

Apparently, better than researchers, some practitioners seems to have felt differently the complexity of innovation pathway and the limits of innovation adoption models. An analysis of the evolution over time of the concept of agricultural extension may provide some evidence. Paradigms in agricultural extension shift from the "diffusion of innovation" to "facilitation and networking for innovation" (Neuchâtel Group, 1999). "Extension requires more than transfer of technology, it requires an understanding of the world of view of farmers" (Vanclay, 2004). While development workers progressively move from top-down to participatory learning approaches which promote social learning and technological negotiation, there is a need for an adjustment from the side of adoption scientists.

3.2. Methodological Consideration for Analyzing the Pathways of Innovation

We have discussed in the previous sections of this paper the conceptualization in the literature of the pathways of innovation in its diffusion and the methods used to assess innovation pathways. We concluded that such conceptualizations oversimplify innovation to something to adopt or not and overlook the cognitive and social aspects of innovation diffusion. Indeed, rather than being simply adopted or rejected innovation can be readapted what implies a cognitive process of innovation assessment by people. People make sense of the innovation according to their specific social context and the way the innovation is framed influence why and how it is used or not or adapted by people. Thus, innovation diffusion is a social process where people continuously co-construct meanings of the innovation in interaction. For social constructionism theorists, the assignment of meaning to social phenomena is not simple or direct, but constructed and negotiated interpersonally (Rizzo *et al.*, 1992). Thus, to understand social activities such as innovation diffusion, we must investigate meanings making of people in

interaction. It appears that to uncover the usage, adaptation or rejection of innovation, conventional methods of innovation adoption assessment are inefficient. Innovation pathways must thus be assessed from the perspective of the people concerned. Such way of social process assessment is related to interpretive approach. As Orlikowski and Baroudi (1991) stated "social process is not capture in hypothetical deductions, covariances and degrees of freedom. Instead, understanding social process involves getting inside the world of those generating it." Through interpretive approach, adoption researchers could understand innovations by assessing the meanings participants assign to them (Orlikowski and Baroudi, 1991). Interpretive methods can thus enable to understand the meanings people assign to innovation and the ways they are used or not or adapted. The interpretive approach provides with a variety of methods for interpretive analysis suitable for innovation pathways assessment (see Yanow and Schwartz-Shea (2006)). Interpretative method in adoption studies implies first, to conduct critical reflection of the social and historical conditions of the introduction of innovation to show how the situation under investigation emerged. Second, farmers' own understandings and attitudes with regard to innovation should be taken into consideration. Third, the rationales of possible "incongruities" and "deviances" in relation to attitudes that development workers expect from farmers should be considered as part of the pathways of innovation. Possible "contradictions" between the theoretical preconceptions and actual findings should be given importance.

4. CONCLUDING REMARKS

The actor-oriented perspective helps highlight that innovation adoption is a process of meanings construction rather than a one-time or two-time achievement. The "developmentalist" perception of adoption considers innovation as to be adopted or not within a defined time period and space to promote a planned change. This conception of innovation adoption led to a large consensus on methodology used in adoption studies and therefore to a large agreement on research results. Such a perception contrasts with the realistic representation that considers the pathway of an innovation as a complex socio-cognitive and socio-technical process taking place, as planned by development workers or not, without time or space considerations. The developmentalist representation of the pathway of innovation (i) oversimplifies the reality of the usage of innovation by people and (ii) leads to the underestimation of the impact of innovation. The integrative model of innovation adoption/appropriation that we suggest in this paper enlarges the conceptual horizons of adoption studies. Such a theoretical framework may be useful in understanding the pathways of innovation and in assessing impacts of innovation. This implies that innovation pathways should be assessed with interpretive methods as a complement to positivist methods that reduce the complexity of innovation pathways assessment.

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