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It is all about the risk – how can an enabling environment for agricultural innovation be created within the Common Agricultural Policy?

Abstract: *When creating an enabling environment for agricultural innovation adoption, it is not only the financial risk that has to be taken into account but also other aspects of risk and their behavioural determinants. The paper applies a systematic review approach to present the recent findings on behavioural factors that determine farmers' participation in different policy schemes that should be taken into account when shaping innovation support instruments within the European Union's Common Agricultural Policy (CAP). The aim of the paper is to present what should be the next steps in developing an enabling environment for innovation adoption within the CAP and in which direction future research on adoption of innovations by farmers should go.*

Keywords: *Common Agricultural Policy, innovation, risk, behavioural economics.*

Introduction

Agriculture in the European Union (EU) faces numerous challenges. The most important of them relate to two issues – competitiveness and the environment. With the strive to enter the path of sustainable development, sustainable intensification, climate-smart agriculture, bio-based economy or circular economy, it is of key importance that European agriculture absorbs innovations balancing economic and environmental goals related to agricultural activity. Also looking from a strictly economic perspective, the high costs of labour and other factors of productions in EU agriculture makes innovation the only potential solution for increasing the competitiveness. Therefore, the Common Agricultural Policy (CAP) should encourage innovations in agriculture. The most recent reform of the CAP introduced measures to support innovation, but it is too early to assess their impact. However, we can suppose that there is still much room for improvement as the financial incentives seem not to be sufficiently accompanied by mechanisms to tackle other than financial barriers to implementing innovations at a farm level.

In relation to innovations there are two separate, although closely related, issues that need to be tackled. The first of them is the creation of truly innovative, new technologies and practices. The second one is the implementation of both brand-new innovative technologies and of already-established technologies that have not been implemented so far by a given farmer. Although both creation and implementation of innovations are important, a visible impact on the competitiveness and environmental footprint of agriculture has the implementation of innovations as only spreading innovations can make a noticeable difference. Therefore, it should be a priority for the CAP, while innovation creation should be a shared responsibility of the EU research policy and the CAP.

Innovations offer benefits both at social and private level (Moreddu, 2016). Therefore, there is a rationale to support them using public funds via a well-planned and targeted policy to ensure efficiency and effectiveness. The key barrier that should be addressed by public policy is risk, which is commonly known to slow the pace of adapting new technologies (Marra et al., 2003). Yet, risk is not only related to financial aspects. As stated by Grolleau et al. (2015), taking into account the non-economic factors when shaping agricultural policy can lead to higher efficiency and effectiveness. In order to benefit from behavioural economics in agricultural policy design, carefully prepared experiments must be conducted to study determinants of farmers' decisions. There is already a wide range of studies on conducting experiments in agriculture (Greiner et al., 2014), so there is a basis for more in-depth assessment of factors triggering specific behaviours.

Several very common non-economic factors that should be accounted for when designing policy instruments can be named. They all seem to be especially important when trying to encourage farmers to implement innovations.

The best-known behavioural factor biasing farmers' decisions is loss aversion (Grolleau et al., 2015). The other key elements that have to be taken into account are: risk aversion, ambiguity aversion, status quo bias/default bias and choice overload (Colen et al., 2015). Moreover, policy makers must also bear in mind that there is a certain time inconsistency between their decisions and actions undertaken by other stakeholders.

In this paper, agricultural innovations are understood broadly as introducing both farming practices and any other organisational and managerial practices that are new to a given farm. Thus, as innovations are seen both transformation from a conventional to an organic farm and making use of leasing as a way to acquire a new agricultural equipment.

The aim of the paper is to present what should be the next steps in developing an enabling environment for innovation adoption within the CAP and in which direction future research on adoption of innovations by farmers should go. The paper presents a literature review of the behavioural barriers to innovation adoption in the farming sector.

Methodology

The paper applies a systematic review approach. The databased used for the study was ISI™ Web of Knowledge™ and the search was conducted across the whole period covered by this database. The study was conducted in the following steps based on the research problem 'Creating enabling environment for agricultural innovation'. Firstly, the concept of agricultural innovations was defined for the purposes of this research. Based on this definition, the literature review concentrated on the issue of the characteristics of an enabling environment for agricultural innovations, especially in the context of public policy instruments. Following the results of this literature review, the key research question was: What are the shortcomings of the current CAP in supporting the scaling up and out of agricultural innovations?

A further research step was the literature review concentrating on the barriers to adoption of innovations in agriculture. The review results served as an assessment questionnaire for identifying the flaws of the current design of the CAP. Given the paper limitations, the paper focuses on presenting the results related to the last step of the systemic literature review conducted – identified barriers to effective CAP support of scaling-up and out agricultural innovations.

The systematic literature review was not a goal in itself and it was not intended to identify the most popular topics and issues related to the enabling environment, but rather to identify the most novel ideas that can give the CAP a cutting edge in scaling agricultural innovations. Therefore, the details of the procedure

conducted at each step are not presented in this paper[1]. The systematic literature review stems from medical research where it is applied to identify dispersed research results concerning one issue. In the case of medical research or any other research question requiring precision the procedure conducted within the systemic literature review must be carefully followed and recorded to make it verifiable by other research groups[2]. Yet, in this paper the actual setting of the research review or the number of participants are irrelevant as the review is conducted to identify a set of potentially relevant issues that need to be accounted for in order to create an innovation enabling environment.

It is important to look for new policy tools and the specific details of designing them that could increase the creation of innovations and their uptake among EU farmers as the limitations of environmental resources and cost of labour are not the factors through which the global competitiveness of EU farming could be boosted. An overview of the research relating to non-economic barriers to innovation presented in this paper provides a broad-spectrum summary of the potential directions for altering the CAP policy tools aimed at increasing diffusion of innovations in the EU agricultural sector.

Results

The innovation process is interlinked not only with market but also with political and institutional support (Figure 1). In the case of agriculture, it is the support policy that can tip the scales for creation and adoption of innovations.

Different roles of public policy in the innovation process can distinguish Wieliczko (2016), namely a direct role of public policy in the development and adoption of innovations (this includes different kinds of incentives such as tax allowances or preferential credits), and an indirect role of public policy in the development and application of environmental innovations that focuses on education and popularisation of innovations.

The enabling environment for agricultural growth and competitiveness has already been defined. An illustrative index created by Diaz-Bonilla et al. (2014) shows which key elements create a basis for agricultural growth and competitiveness. It presents the so-called systems-oriented approach, thus it is not limited to technology and includes, inter alia, social and institutional aspects (Schut et al., 2014). The Agricultural Growth Enabling Index (AGEI) consists of following elements:

[1] The keywords used related to farmers' behaviour and innovation process, including, among others: farmers' risk aversion, agricultural innovation, farmers' ambiguity aversion, farmers' loss aversion, information overload in innovation process. It must be stated that the number of records for most of the search phrases was not satisfactory. Therefore, the study also included a number of papers cited by the authors of publications found on the ISI Web of Knowledge. The study was limited to publications in English.

[2] See, among others, Higgins and Green (2008) for details concerning the application of systematic literature review focused on numerical findings.

I. Governance (20 per cent weight; equal shares on each subcomponent): macro, institutions and political stability affecting food security;

II. Capital (20 per cent weight; equal shares on each subcomponent): health/education, presence of food safety nets and infrastructure;

III. Markets (20 per cent weight; equal shares on each subcomponent): goods market operations, labour market operations and financial market operations;

IV Agriculture/rural areas (20 per cent weight on each pillar; equal shares on each subcomponent within a pillar with the exception of double weight on public agricultural R&D expenditures):

4.1. Pillar A: access to financing for farmers, public agricultural R&D expenditure as a per cent of agricultural GDP and land market rights and access.

4.2. Pillar B: agricultural infrastructure, index of intensification and index of availability of land and water.

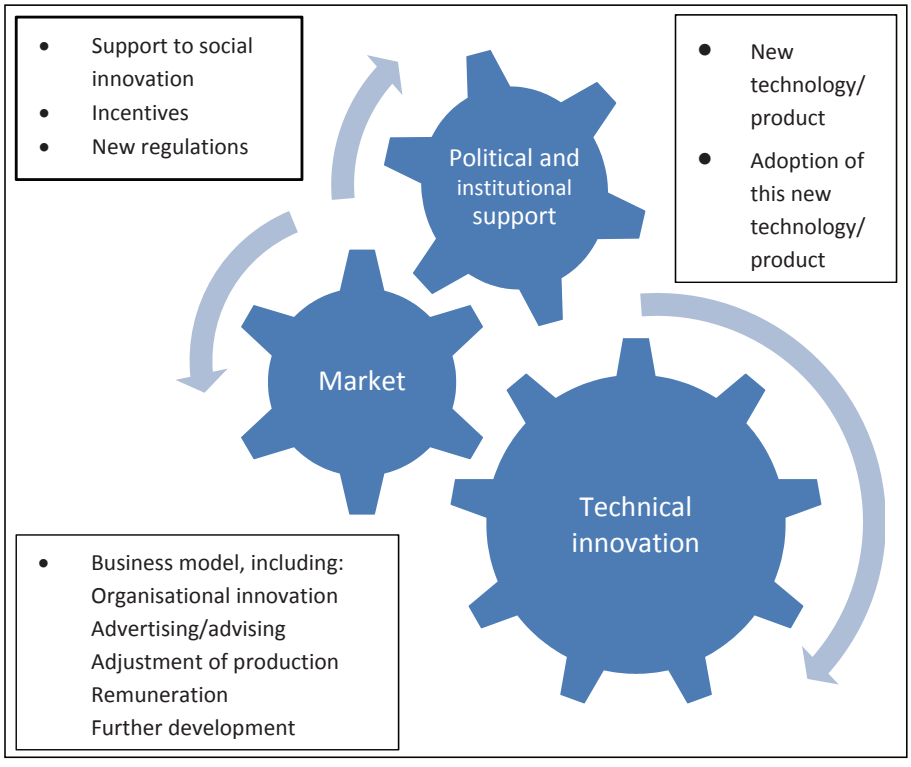

Figure 1. Links between innovation process and institutional, market and technical sphere

Source: Impresa (2016).

This index shows that R&D is part of the environment enabling agricultural growth. Yet, the index was based on the experiences of developing countries and thus it seems that it can show the factors enabling the growth path to be reached rather than keeping to it. In the case of developed countries, the role of innovations is probably even more profound.

Ward and Sight (2014) stated that "when studying technology adoption, failing to account for risk preferences potentially introduces bias in the estimated effects of other determinants of adoption". This is an important hint for improving the CAP, as the actual role of public policy in implementation of innovations is the so-called scaling of the adoption of innovations. We can distinguish between scaling up and scaling out (Millar and Connell, 2010). Scaling up relates to an increase in number of adopters of an innovation, while scaling out concerns expansion in terms of geographical area where an innovation is used. As regards the role of the CAP in the process of innovation implementation, we can state that there is need for policy action in these both dimensions. Yet, as mentioned by Wigboldus et al. (2016), scaling agricultural innovations to be beneficial for the agricultural sector and other stakeholders must take into account the complexity of links between environmental, social, economic and institutional factors, and to anticipate the potential consequences of scaling.

Moreover, it must identify the barriers to adopting innovations. There is a vast literature on the factors determining adoption of agricultural innovations (Ward and Singh, 2014). As might be expected. the economic factors prevail and the key barriers are generally the lack of funds or credit constraints. The unwillingness for changes is also a result of the asset structure already possessed (Latruffe et al., 2013). Yet, there are other factors relating to personal characteristics of a farmer such as the age or the level of education. As shown by the innovation diffusion literature, human and social capital, the agricultural knowledge system, socio-cultural norms, a close relationship with farming industry and specific macroeconomic factors are decisive for adopting innovation (Hansen, 2015).

However, there is also a growing literature on behavioural aspects shaping the decision making process related to adoption of innovations. The differences in farmers' behaviour prove also to be crucial for policy effectiveness. As shown by Läpple and van Rensburg (2011) there are significant differences between early, medium and late adopters of an innovation in their response to encountered economic and non-economic factors.

The key behavioural factors hindering farmers from undertaking innovations are: risk aversion, loss aversion, ambiguity aversion, status quo bias/default bias and choice overload[3]. Thus, a list of factors influencing adoption decisions is lengthy and includes different categories of variables (Table 1).

3 These terms are defined further in the text.

Table 1. Variables that may influence adoption decisions

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

Source: Borges et al. (2015).

It is also necessary to look into the adoption process. It is a complex issue. The innovations do not necessarily lead to a fundamental change in the functioning of a farm – they do not change the regime within it operates, but they are adapted to the already established operation mode (Figure 2). Therefore, the attitude towards innovations and willingness to adopt them are strongly related to the types of innovations and their potential impact on the current functioning of a farm.

Risk aversion is manifested by avoiding choosing the option viewed as a riskier one despite its potential higher returns. In the case of loss aversion, a higher sensitivity to a potential loss is observed than to a potential gain. Ambiguity aversion relates to a situation of incomplete information which leads farmers to choose known risks instead of the unknown ones. Status quo or default bias is a preference to avoid changes and to choose an option that results in keeping everything unchanged. Choice overload is the situation where too many similar choices are available, thus making the decision difficult.

The studies on behavioural factors influencing decisions on adopting innovations commonly tackle two of the most often cited factors: risk aversion and either loss aversion or ambiguity aversion. The theoretical background used in the studies on risk and loss aversion is commonly based on expected utility theory, theory of planned behaviour or cumulative prospect theory. Yet, the prospect theory seems to be more useful as it tackles the problem of probability weighting and reference dependence (Bocqueho et al. 2014).

There are numerous studies concerning the link between individual's attitudes and technology adoption (Ahsanuzzaman and Norton, 2015). As stated by Knight et al. (2003), risk aversion is associated with lower probabilities of technology adoption. Also, Ghadim et al. (2005) and Takahashi (2013) showed that risk aversion tended to reduce adoption of innovations.

Liu (2013) concludes that higher risk aversion or higher loss aversion impede the adoption of new plant varieties. This is also shown by Brick and Visser (2015), who concluded that risk aversion leads farmers to opt for traditional farming. Yet, Engle-Warnick et al. (2007) found no correlation between risk aversion and adoption of new technologies, while Barham et al. (2014) stated that risk aversion had small impact on timing of innovation (in their study, innovation was an adoption of genetically modified soy). This shows the need for further research.

However, we also must take into account the type of innovation. An important group of innovations are those related to other than agricultural practices. They include financial management. With the growing risks related to conducting farming activity, risk management increases in importance. In the case of insurance, farmers' risk aversion is the factor significantly increasing the probability of buying an agricultural weather index insurance as showed by Jin et al. (2016). The authors also stated that among other factors leading to higher probability of buying an insurance was farmers' subjective beliefs concerning the probability of crop losses, that is farmers' loss aversion. Similar results were shown by Lyu and Barré (2017) in relation to crop insurance.

As stated by Klibanoff et al. (2005), ambiguity aversion is interlinked with risk aversion. Ambiguity aversion can have a positive impact on adoption of innovations speeding this process. This was shown by Barham et al. (2014), who suggest that their finding is a result of the fact that GM soy is insect

resistant. Yet, as stated by Ross et al. (2012), ambiguity aversion limits the adoption of new technologies, despite the high level of expected profits. Also Alpizar et al. (2011) observed that both risk aversion and ambiguity aversion led to farmers deciding not to adopt innovations.

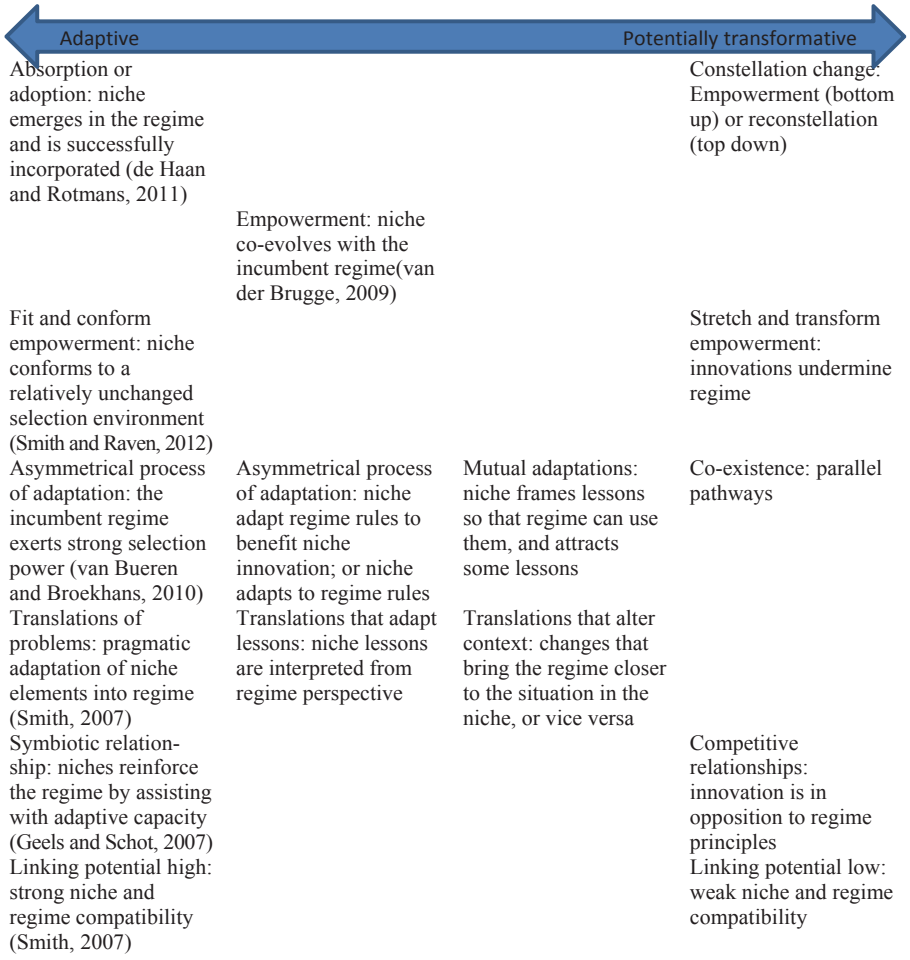

Figure 2. Extent of adoption process vs. the current regime
Source: Ingram (2015).

The presence of loss aversion among farmers was showed, inter alia, by Barnes et al. (2016) and, as presented by Bocqueho et al. (2014), farmers are twice as sensitive to losses as to gains. Loss aversion can support adopting innovations as indicated by the findings of Liu and Huang (2013). Their study showed that Chinese farmers characterised by higher loss aversion used smaller quantities of pesticides, while those with higher risk aversion used excessive amounts of pesticides.

It seems that the next step in research on innovation adoption should be the analysis of behavioural aspects of the decision making process in the context of characteristics of innovations that affect adoption identified by diffusion innovation theory.

There are five characteristics of innovations that affect their adoption: relative advantage, compatibility, triability, observability and complexity (Rogers, 2003). The relative advantage is the perception of a potential adopter of an innovation of its advantages. Compatibility relates to the assessment of compatibility between an innovation and needs of potential adopter. Triability is understood as the degree to which a potential adopter may experiment with the innovation, while observability relates to the visibility of results of the innovation and the complexity is the perception of difficulty in becoming familiar with the way innovation is to be used. Yet, as stated by Feola et al. (2015) understanding farmers' behaviour requires the knowledge concerning three aspects: (a) decision making model; (b) cross-scale and cross-level pressures; and (c) temporal dynamics. These three aspects must be simultaneously studied, which calls for the application of various research methods.

Discussion

The CAP is constantly evolving. In the recent reform of the CAP, 'Fostering knowledge transfer and innovation in agriculture, forestry, and rural areas' was named as one of the priorities of rural development. This is the next step in the process of extending the CAP's involvement in supporting innovation process. Apart from support for farmers to make use of extension services, the CAP offers support for launching cooperation between different stakeholders thus it plays a role of 'super-broker' of innovations.

The CAP has encompassed the concept of Agricultural Innovation Systems (AIS) and has an active role in supporting the establishment of multi-actor innovation platforms. It is also clear that the CAP is increasingly involved in so-called 'innovation brokering', involving not only agriculture as such but also of other sectors. This implies seeing innovation "as a process that is shaped by interactions between actors and institutions inside and outside the agricultural sector" (Schut et al., 2014, p.99).

As stated by Elabed and Carter (2015, p. 150) "policy reliance on these behavioural insights has been modest". This also applies to the CAP, which at this stage of its development should explore the decision-making process of the farmers and take into account the uncertainty they face. Intrinsic motivation and human responses, especially risk perception and its tolerance, are vital for policy effectiveness and innovation implementation. When designing specific policy measures, policy makers have to take into account not only of economic but also social and personal rewards expected by farmers.

It must be also underlined that the development of policy must be followed by changes in research focus. In relation to agri-environment policy the changes in policy priorities lead to changes in research priorities and this applies also to innovation policy (Table 2).

Table 2. Innovation policy and research priorities

Phase	Innovation policy priorities	Research priorities
Pilot/immediate	Maximising value of schemes; participation rates; payment vs. participation	Quantification of number of participants; uptake levels
Consolidation/ driving forces	Maximising environmental value for money; barrier to entry removal & additionality	Profiles of adopters/non-adopters; identifying barriers
Mature/ underlying processes	Innovation benefits; innovation mentality	Motives adoption/non-adoption; underlying processes; attitudinal shifts

Source: own elaboration based on Beedell and Rehman (2000).

Based on the presentation of key non-financial barriers related to implementing innovations, it can be argued that they are all related to different types of risk. Aversion to different types of risk is an important factor discouraging farmers from implementing innovations. Therefore, it is recommended that more attention is paid to insights from behavioural economics during the formulation of the post-2020 CAP as this may offer useful advice on the designing of an enabling environment for agricultural innovation. The results of the studies cited in this paper show that the assumption widely present in economic studies that farmers are expected utility maximisers may not be valid and that in fact farmers' behaviour should be looked at from the perspective of cumulative prospective theory (Babcock, 2015).

Making use of behavioural economics means conducting experiments to verify farmers' attitudes towards different forms of policy design. Such experiments serve not only to answer the question of the farmers' preferences towards different forms of policy measures but they also offer guidance on the ways of helping to alter farmers' attitudes towards implementing innovations. Moreover, it must be also borne in mind that some of the technological innovations can reduce farmers' exposure to risk and thus they can influence farmers' attitudes towards future implementation of innovations.

Notwithstanding the progress made in research on behavioural aspects of adopting innovations, there is still much to be done to make the research more useful for policy makers. The first item on the agenda for further research improvement is taking into account subjective probabilities as suggested by Hardaker and Lien (2010), who state that in the decision making process farmers use not objective probabilities but subjective ones.

As suggested by Liu (2013), the problems of risk aversion and loss aversion can be decreased by applying insurance measures within the agricultural policy. Yet, this requires not only additional financial resources but also handling the problem of moral hazard and adverse selection. Clot et al. (2014) emphasise that unintended behavioural responses to policy tools must be one of the key issues to be tackled in the design of new policy instruments.

To summarise, the first step to creating an enabling environment of agricultural innovations is to explore the farmers' decision making process concerning risk management. This can be done by applying tools of behavioural economics, taking into account the characteristics of innovations that affect adoption named by the innovation diffusion theory.

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