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What Drives Farmers' Decisions to Invest? The Role of Research Engagement, Information Collection and Type of Farm

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ABSTRACT

The present paper develops a framework for modeling and explaining the decisions of farmers for realizing investments aimed at improving the operation of their holdings. The empirical analysis is conducted in Greece on 777 farmers of arable and orchard crops. The results prioritize the significance of farmers' research engagement and information collection and show that there is a systematic difference between the realized investments between arable crops and orchard farmers, as the latter seem to invest more in their holdings. Finally, the paper ends up with a clustering exercise, in order to distinguish three groups of farmers which could be used as a means for shaping more tailored policy initiatives.

***Keywords**: Investment; decision-making; arable; tree; farmers; ordinal regression*

1 Introduction

Among the most important policy targets for global agriculture are the shift to more productive, sustainable and environmentally friendly farm practices and the wide use of technological achievements such as "precision farming" and "smart farming". However, their achievement requires the active involvement of farmers and the realization of relevant investments by their side (Edwards-Jones, 2006; Borchers and Bewley, 2015). Therefore, understanding the way that farmers make decisions for whether to follow or not a policy recommendation and realize or not a technological upgrade in their farm's capital is critical for driving policy making in global agriculture (Burton, 2004; Mills et al. 2017).

Farmers' propensity for change is influenced by their understanding of the various implications that these changes will have both for their personal and professional life. This understanding is enhanced through the interrelations of farmers with knowledge transferring actors such as agronomists, extension services providers and universities (Ingram, 2008; Mittal and Mehar, 2016). Information gathering activities may take the form of simple participation in education or information programs, or to a more active enrolment in participatory research programs. The latter case usually calls for a more active participation of farmers in terms of time and financial resources investment (Pratiwi and Suzuki. 2017; Knook et al. 2020). The literature has shown that a well-informed farmer may become more innovative and improve his/her capability to better assess the cost and benefits of a change and make wiser choices (Ali and Kumar, 2011; Ambrosius, Hofstede, Bock, Bokkers and Beulens, 2015). Apparently, the capacity of farmers becomes more enhanced when farmers take part in participatory research programs, because these entail the notions of co-development and co-production (Pohl et al. 2010; Hauser, Lindtner, Prehsler and Probst, 2016).

Despite this theoretical establishment of the relationship between information gathering activities and knowledge capacity of farmers, there is still little and contradicting empirical evidence for whether better farmers' knowledge capacity is actually translated to behavioral shifts from the farmers' side (Bartkowski and Bartke, 2018). Moreover, as the analysis of Methods and variables section shows, the up to now incorporation of knowledge capacity in explanatory frameworks of Farmers' Decision-Making (FDM) process has not disentangled the one stemming from participatory research projects. On the contrary, knowledge capacity was constructed based on all types of information gaining activities. Therefore, what is yet to be revealed is how the behavior of farmers is affected by their engagement in the simplest types of information gathering, but also in the most commitment-demanding participatory research projects.

The present paper seeks to address these questions by focusing on a specific type of farmers decisions; this of realizing investments for farms modernization. Understanding the relation of knowledge and information with farmers' investment decisions is critical for policy makers so as to steer efforts in the most effective direction and mobilize the least prone to invest farmers. In order to examine the relationship between farmers' information capacity and investments, one should consider that farmers' decision making is affected from a series of other factors (Ingram, 2008). Consequently, the effect of a single factor, such as information capacity, should be incorporated into more holistic methods of FDM modeling (Feeney, Accursi and Mac Clay, 2019).

The need for modeling FDM process has been long realized by researchers worldwide and for this reason the relevant literature is rich and diverse (Feeney, et al. 2019; Konrad, Nielsen, Pedersen and Elofsson, 2019). Decision-making studies share some common characteristic in a sense that they incorporate quantitative methods to model the behavior of farmers considering psychological constructs and other relevant information about holdings and farmers (Morris and Potter, 1995; Burton, 2004). Bartkowski and Bartke (2018) recognize more than 80 variables used by various scholars to explain twenty different types of decisions in Europe, with the greatest attention to be given in participation or not in Agricultural Environmental Measures (AEMs) and choice of management.

The past research on FDM has revealed that the effect of various factors on the decisions of farmers is context dependent and subject to the type of decision considered by each study (Siebert, Toogood and Knierim, 2006; Bartkowski and Bartke, 2018). In addition, a potential source of heterogeneity in FDM, is the type of crops cultivated by the farmers. As far as decisions for investing are concerned, this heterogeneity was highlighted by a recent study of Lefebvre et al. (2014) who found that arable crop farmers were more prone to invest in farm modernization than farmers of livestock, perennial crops and mixed farms. So, studies on investment behavior that failed to account for this kind of heterogeneity may have produced misleading results for policy making.

These remarks render clear, that in order to test the effect of knowledge capacity on investment behavior of farmers, an explanatory framework incorporating also additional factors with a potential effect on investment behavior should be developed and empirically tested. In addition, analysis should also incorporate the different types of farming as a potential source of heterogeneity. Considering the aforementioned, this paper seeks to answer the following research questions:

1) Is there any difference in the investment realization rates between arable crop and orchard famers?

2) Does better knowledge capacity promote investments' realization from the farmers' side?

3) Does the effect of simple information gathering on investment realization differ from this of Participatory Research Programs (PRPs)?

Together with providing answers to these questions, the paper examines the effect of other variables found to having a role in shaping FDM, according to the relevant literature. In addition, at a final step, it combines the farmers' scores in relevant key variables in order to build clusters of farmers with common characteristics that could be used for formulating tailor-made policies toward the enhancement of farms modernization. The empirical part of the paper is based on a survey conducted on Greek farmers. More precisely, a structured questionnaire was filled up by 802 farmers (777 valid) in the Thessaly region which lies at the central part of Greece. The survey was implemented during October 2019 and was targeted on both arable crops and orchard farmers. More precisely, the selection of the general explanatory framework that will facilitate the elaboration of the research questions is presented and discussed in the Methods and variables section. Moreover, the variables incorporated into the analysis together with a brief literature review on past findings, regarding their effect on farmers decision making, is also given. In the Results and discussion section, the main findings are discussed and the answers to the research questions are presented. The paper ends up with the conclusions where some policy implications for enhancing investment at the farm level are presented, together with some comments regarding the generalization of the results and the limitations of the present study.

2 Methods and variables

The multidisciplinary approach to FDM has led to the adoption of a variety of conceptual models which are also widely used in domains outside agriculture. To this end, the behavior of farmers has been mostly modelled with the use of 'Theory of Planned Behavior' which considers the attitudes of farmers and their societal interactions as drivers of FDM (Edwards-Jones, 2006). In addition, when technology adoption is at the spotlight of research, many authors have relied on the Technology Acceptance Model (TAM) which asserts that farmers' intention to use a new technology is affected by their perceived usefulness and ease of use of this technology (Flett et al. 2004).

The conceptual models of most studies are complemented with various socioeconomic and demographic factors which provide a more holistic representation of the FDM. In Table 1 some widely used conceptual models for understanding the determinants of FDM are presented. As can be seen, the papers of Table 1 provide conceptual explanatory frameworks for various types of decisions. Edward Jones (2006) concentrate on technology adoption decisions while Siebert et al. (2006), Defrancesco, Gatto, Runge and Trestini (2008) and Riley (2011) focus on the environmental management. Finally, Bartkowski and Bartke (2018) adopt a wider perspective, covering a wide range of decision types. As for the factors, the paper of Siebert et al. (2006) adopts a three-categories scheme, while Bartkowski and Bartke (2018) extend the factor categories to the number of six. The other papers, organize the explanatory variables in five categories of factors. The conceptual models share a lot of common factors such as the characteristics of farm, business and farmers as well as the situational and social factors. On the other side, Siebert et al. (2006), Defrancesco et al. (2008) and Bartkowski and Bartke (2018) pay additional attention to the farmers behavior and attitudes, while all frameworks with the exception of this of Defrancesco et al. (2008) distinguish a category where the individual characteristics of the alternative choices of the decision at stake (scheme, technology etc) are modelled.

Table 1.
Conceptual explanatory frameworks on farmers decision making

Authors	Edwards-Jones (2006)	Siebert et al. (2006)	Defrancesco, Gatto, Runge and Trestini (2008)	Riley (2011)	Bartkowski and Bartke (2018)
Scope	FDM on technology adoption	FDM on following biodiversity policies	FDM on participation in Agri-Environmental Measures	FDM on participation in Agri-Environmental Schemes	Review on the determinants of farmers' behavior and decision-making
Factors	Personal characteristics	Farmers' willingness	Farm structural factors	Physical farm factors	Objective characteristics of farm
	Households' characteristics	Direct and wider social influences	Farmer characteristics,	Farmer characteristics	Objective characteristics of farmer
	Farm holding structure	Farmers' ability	Business factors	Farm business factors	Behavioral characteristics
	Social environment		Situational factors	Situational factors	Social-institutional environment
	Characteristics of the innovation to be adopted		Farmers' individual behavior and perceptions	Scheme factors	Economic constraints
					Decision characteristics

The present study, apart from the knowledge acquisition and farm type variables, has also considered a number of other factors that might have an effect on the investment realized by farmers. The incorporation of the variables is done in order to capture any heterogeneity among farmers with respect to other affecting factors. Additionally, it makes the results of the present more easily comparable to future similar studies. Considering the frameworks presented in Table 1 we followed the framework of Defrancesco et al. (2008). This is because, their framework does not include any category where the explicit characteristics of the decision itself are modelled as factors of FDM. This characteristic makes the framework more suitable for being implemented in various types of decisions, apart from the participation in environmental schemes.

The basic information regarding the formation of the variables is presented in Table 2. The realized investments of farmers are captured with the use of the variable Total Investments (Tot_Inv). In order to build the variable, farmers were asked to indicate how many technological improvement investments they had implemented in the last five years. Then, their responses were used to build three ordinal categories of low, medium and high investment activity. In addition, the first category of explanatory variables is labelled as farmers' characteristics, and includes three socio-demographic variables, namely Sex, Age and Education (Educ). Demographic variables have been used with many variations in many relevant studies (Bartkowski and Bartke, 2018). Considering the relevant literature, *Sex* has remained understudied and has an ambiguous effect on FDM regarding the technical and environmental improvement of farms (Bartkowski and Bartke, 2018). In addition, *Age* seems to have a negative relationship with farmers propensity to take action toward the implementation of a change in their farms (Bertoni, Cavicchioli, Pretolani and Olper, 2011; Chacón-Cascante and Kastens, 2012; Riley, 2011). Nevertheless, being the goal of this study to check if linearity stands true for the relationship between Age and FDM for investment, we will also test some higher order terms before we end up with the final specification of the model. Moreover, *Educ* seems to promote change in farms, especially on the environmental dimension of operation (Riley, 2011). Bartkowski and Bartke (2018) claim that no clear relationship between education and

decision-making can be established when considering the relevant literature. *Educ* here is measured with an ordinal variable, measuring four grades of attainment, starting from primary school and ending at university studies.

Table 2.
The variables of study

Variable Category	Variable (Abbr)/Question	Type of variable	Measurement
Dependent	Total Investment (TotInv) / In the last five years have you realized any investment for improving •Plowing - Tillage •Irrigation •Lubrication •Harvest •Environmental protection •Monitoring •Management support	Ordinal	Three ordinal categories are shaped according to the number of investments implemented by each farmer 1. 0-1 2. 2-4 3. 5-7
Farmers' characteristics	Sex/ Please Indicate your gender	Dummy	0. Male 1. Female
	Age / Please indicate your age	Discrete	Years
	Education (Educ) / Please indicate the highest level of education you have achieved 1) Primary School 2) Secondary School 3) High School 4) University	Ordinal	1-4
Business factors	Income (Inc) / Please indicate in which of the following categories your annual income lies in 1) 0-5000 € 2) 5001-10000 € 3) 10.001-20000 € 4) 20.000 €	Ordinal	1-4
	Farmer / Please indicate if farming is your only occupation	Dummy	0. No 1. Yes
	Cooperative (Coop)/ Please Indicate if you are a member of a cooperative	Dummy	0. No 1. Yes
Farm structural factors	Area/ Please indicate the total are (in Thousand m2) of your farm.	Discrete	Thousand m^2
	CropType (Crop)/ Please indicate your farm type	Dummy	0. Arable Crop 1. Tree
Situational factors	Info_Engagemnt (Info) / In the last five years have you been engaged in any of the following activities? • Attended a training seminar • Attended a workshop • Attended a cooperative meeting • Attended an online seminar • Attended a meeting with other colleagues • Formed an inquiry to an agricultural consultant. • Formed an inquiry to university	Ordinal	0-7/The sum of the activities that each farmer has undertaken
	Research Engagement (Res) / In the last five years have you taken part in any research program?	Dummy	0. No 1. Yes

Variable Category	Variable (Abbr)/Question	Type of variable	Measurement
Individual behavior and perceptions	Future View (FutVw) / The future of the agricultural sector is bright	Ordinal	5-points Likert scale ranging between fully disagree to fully agree
	Commitment (Comm) / 1) I would easily shift to another crop if it saved me money 2) I would easily shift to another crop if it saved me time	Discrete	The average value of the responses of farmers to the two questions. Both questions came up with answers of a 5-points Likert scale ranging between fully disagree to fully agree
	Motivation (Mtv) / 1) I enjoy farming activities 2) I would hardly abandon farming for another job with the same income	Discrete	The average value of the responses of farmers to the two questions. Both questions came up with answers of a 5-points Likert scale ranging between fully disagree to fully agree
	Trust / How much you trust the following organizations 1) Ministry 2) University 3) Agricultural Advisors 4) Suppliers 5) Local Authorities 6) Internet 7) Other Farmers 8) Cooperatives 9) European Union	Discrete	The average value of the responses of farmers to the 9 actors. All questions came up with answers of a 5-points Likert scale ranging between No trust to Absolute trust

Considering the business factors, income variable is divided in four relevant ordered categories. In general, the disposable income may be considered as a driving factor of investment realization and modernization of farms. Nevertheless, the results of the relevant literature are contradictory. For instance, Bishop, Shumway and Wandschneider (2010) found no statistical relationship between financial capacity of dairy farmers and their intention to adopt a newly developed anaerobic digestion technology. On the other side, Bertoni et al. (2011) showed that income had a significant positive impact on farmers' decision for improving the environmental performance of their farms. The Farmer variable denotes if farming is the only occupation of the respondent. Defrancesco et al (2008) have found that as the proportion of farming income on respondents' total income decreases, their propensity to invest in the environmental improvement of their farms follows the same trend. The opposite result was found by Nielsen (2001), as they showed that farmers who gain a large proportion of their income from activities other than farming are more prone to innovate. Finally, Konrad et al. (2019) found that part-time farmers where less likely to adopt new nutrient abatement technologies. It should be noted that other economic variables such as the liquidity or the access to finance could also affect relevant investment decisions. For this study, the assumption made is that liquidity is directly related to available income and thus it is not modelled separately. Moreover, access to finance is also considered as varying with farmers' income as banks in Greece remain nearly the only funding source for farmers and loans provision is very limited to farmers with very high collaterals, with this status to be met in countries with similar economic structural characteristics (European Investment Bank, 2018: pp. 87-88).

Coop variable is used in order to test the effect of participating in cooperative schemes to the investment intention of farmers. The variable is included in order to test the hypothesis that cooperatives' members enjoy some benefits such as better information, guidance and income stability, which could help them to plan and realize changes in their farms' operation more easily (Wollni and Zeller, 2007; Nwankwo, Peters and Bokelmann, 2009). Nevertheless, the prior empirical knowledge regarding the impact of this parameter is not satisfactory,

since the variable has not been included in many studies of FDM (Bartkowski and Bartke, 2018). As for the studies that this variable has been considered, Peterson, Barkley, Chacón-Cascante and Kastens (2012) found no statistically significant relationship between farmers' involvement in cooperatives and their intention to shift to organic farming. On the other hand, in an Ethiopian context, Abebaw and Haile (2013) found that cooperatives' members were more prone to adopt agricultural technologies than non-members.

The study also incorporates two variables under the category of farm structural factors. The first variable (*Area*) captures the size of the holdings in terms of total thousand m^2. The size could be considered as one of the most frequently tested factors on FDM with strong indications that could be considered as a positive factor of change at the farm level (Bartkowski and Bartke, 2018). There are though some studies that fail to find a significant causal relationship between farm size and FDM, with others findings to support the existence of a negative relationship (Riley, 2011; Bartkowski and Bartke, 2018). In addition, the farm type variable (*Crop*) seeks to capture any differences in the FDM for investments between the arable crops and orchard farms and thus provides answer to the 1st Research Question. To better illustrate the previous findings, we present in Table 3 the most important findings of relevant studies. As can be seen from the figures of Table 3, the studies cover mainly the European and US markets. In addition, they focus on a variety of different decisions types and use different criteria to distinguish farm types. The potential effect of different farm type on FDM was tested on various sets of farm types, such as crop vs livestock (Koesling, M., Flaten and Lien, 2008) and conventional vs organic (Boerngen and Bullock, 2004; Flaten, Lien, Koesling, Valle and Ebbesvik, 2005). Additionally, we present in the last three rows the more disaggregated crop type distinction into explanatory frameworks of the surveys. More precisely, Bertoni et al. (2011) spot a difference between farmers of annual and perennial crops regarding their intentions to participate in AEMs. Best (2009) has shown that cash crop farmers tend to enroll in organic farming less than farmers of fodder crops. In addition, as it was shown in the Introduction, Lefebvre et al. (2014) have detected a notable difference on investment intentions between arable crops farmers and those of livestock, perennial crops and mixed farms. The present conceptualization of farm type extents the ones developed by the above-mentioned papers and therefore provides more insights on the role of crop types in shaping FDM.

Table 3.
Studies on FDM accounting for farm type in the explanatory framework

Authors	Country	Farm type distinction	Type of decision
Boerngen and Bullock (2004)	Illinois, USA	• Conventional • Organic	Investment in improving human capital
Flaten, Lien, Koesling, Valle and Ebbesvik, 2005	Norway	• Conventional • Organic	Risk management
Koesling, Flaten and Lien, 2008	Norway	• Crop • Livestock	Conversion to organic farming
Hermann, Mußhoff and Agethen, 2016	Germany	• Conventional • Organic	Investment behavior
Best (2009)	Germany	• Cash crops • Fodder crops • Finishing pigs / poultry • Mixed	Shift to organic farming
Bertoni et al. (2011)	Italy	• Arable crops • Permanent crops • Dairy farms	Participate in AEMs
Lefebvre et al. (2014)	Six EU countries (Czech Republic, Germany, Spain, France, Italy and Poland)	• Arable crops • Livestock • Perennial crops • Mixed farms	Investment intention

As for the situational factors' category, this incorporates the variables aimed at answering Research Questions 2 and 3. Table 4 provides some codified information regarding the scope of analysis, the way that the related

variables have been incorporated in past relevant studies, the type of decision considered and the extracted results. The studies on the effect of information on FDM have a wide geographical coverage, as the existence of any effect was tested on countries of Asia, Europe, Africa and the USA. In general, all studies have incorporated a single information variable which captures different characteristics such as the effect of farmers' interaction with agronomists, the amount of information received, the quality of information and the access to extension services. Most of these studies considered decisions regarding farmers' shift on more environmentally friendly types of management, excepting Ingram (2008) who considered FDM on more general management issues and Ambrosius et al. (2015) who modelled farmers' decision for shifting product market orientation. The majority of studies found a positive effect of information gathering activities on the considered as desirable direction of decision, but there where also studies who failed to establish a significant relationship between information gathering and FDM. More precisely, Ingram (2008) showed that the effect of agronomists on FDM is only visible on farmers who are open to information reception, while Tey et al. (2014) showed that the quality of information was a critical parameter effecting the FDM of farmers only for the half of the considered types of sustainable agricultural practices.

The present study differentiates from such research approaches in a sense that it disentangles information activities in two distinct categories and respective variables. The Info Engagement (*Info*) variable measures the overall activity of farmers in collecting information to guide their interventions. Multiple sources of information have been given as options to the respondents and the expectation is to extract a positive relationship between information activities and investment realization. This variable is more similar to the ones used in previous studies. On the other hand, the second variable of Research Engagement (*Res*) explicitly targets at capturing the participation of farmers in research projects and its role in promoting investment action-taking. The research activity differs from the other forms of knowledge gaining as it is more interactive and requisites the active participation of farmers, the exchange of knowledge with scientists and researchers, and in many cases it is accompanied with a certain investment by their side (Hoffmann, Probst and Christinck, 2007; Lundström and Lindblom, 2018). Participation in research projects, especially when it is associated with a notion of co-production of research outputs, is expected to come up with an endogenous commitment of farmers toward the constant improvement of their farm practices (Brunori et al. 2013).

Table 4.
Studies on FDM accounting for information acquisition in the explanatory framework

Authors	Country	Type	Type of decision	Type of effect
Damianos and Giannakopoulos (2002)	Greece	Farmers' agricultural training (short-courses, seminar etc.)	Farmers' willingness to participate in agri-environmental schemes	Positive
Ingram (2008)	England	Role of agronomists	Best management practices adoption by farmers	Uncertain
Tey et al. (2014)	Malaysia	Quality of gathered information	Farmers' adoption of six types of sustainable agricultural practices	Positive/Uncertain
Ambrosius et al. (2015)	Netherlands	Role of agronomists	Farmers decision to adoption of added-value markets.	Positive
Garbach and Long (2017)	California, USA	Amount of information sources used by farmers	Farmers' adoption of field edge plantings	Positive
Zamasiya, Nyikahadzoi and Mukamuri (2017)	Zimbabwe	Farmers' access to extension services	Behavior regarding climate change adaptation	Positive

Finally, the category of individual behavior and perceptions includes four variables. The first one captures the personal view of farmers regarding the future of agriculture, incorporating in this way both their expectations on the need and the risk of investing to remain active. Perception of future prospects is very important for taking action, as farmers who are more optimistic about the future of agriculture are expected to invest more than those with the more pessimistic view. Undoubtedly, a thriving agricultural sector is associated with expectations for higher return on investment as well as less risk of investments. On the other hand, pessimistic views may also push farmers for investing in order to be more competitive during hard times that they expect, or in order to shift to other forms of farming which may be more resilient. The different perceptions entail various risk levels and the final decision of them is affected by their stance against this risk (Bocquého, Jacquet, and Reynaud, 2014; Meraner and Finger, 2019). The exact relationship between farmers' perception about the future of agriculture and their realized investments could be considered as ambiguous as it heavily depends on their risk perceptions.

The second variable captures the commitment of farmers on their selected type of farms, measuring how easy they could shift to other production systems for realizing profit gains and time savings. The variable is computed as the average farmers' response to the two questions presented in Table 1 using a 5-points Likert scale. There is not a clear expectation regarding the type of relationship of commitment and investment decisions. This is because, more committed farmers may put an extra effort in investing so as to support their choice for growing the same type of crop, but at the same time more free farmers may come up with a more powerful sense of entrepreneurship which can lead them to invest more.

The third variable captures the motivation behind respondents' engagement in farming. Higher values of the variable express a pleasure driven engagement with farming, while lower values correspond to farmers which are driven by profits. Motives are critical factors for driving FDM, as farmers may proceed to different choices according to whether they seek to maximize their profit or a more diverse welfare function (Edwards-Jones, 2006; Bartkowski and Bartke, 2018; Konrad et al. 2019). Finally, the fourth variable of the category is this of trust. Up to now, it has been extensively modelled as a factor affecting FDM under various types of decisions and on various types of actors on whom trust is measured (Hunecke, Engler, Jara-Rojas and Poortvliet, 2017; Bartkowski and Bartke, 2018). The results regarding the type of relationship between trust and FDM is context dependent. More precisely, Hunecke et al. (2017) on their study regarding their willingness to adopt new irrigation technologies, have shown that trust to different types of actors had a varying effect on farmers' decision. Moreover, Jayashankar, Nilakanta, Johnston, Gill and Burres (2018) have shown that trust in the technology has a positive impact on perceived value and negative on the perceived risk of farmers regarding the adoption of Internet of Things (IoT) in farming practices. Finally, Li, Zeng, Mei, Li and Li (2019) found that trust to the government or the organization which promoted a green fertilization technology has no direct effect on the willingness of farmers to adopt the technique and it is only indirectly related with it through the improvement of farmers' operational ability.

Regarding the method to be used in order to test the effect of the variables on the investment decisions of farmers, it should be noted that there exists a plethora of available options consisting of simple correlation analyses (Greiner et al., 2009) to multivariate regression models (Defrancesco et al., 2008; Bishop et al., 2010, Bertoni et al., 2011, Konrad et al. 2019) and Structural Equation Models (Jayashankar et al., 2018; Li et al. 2019; Wang, Tian, Liu and Foley, 2020). Considering the ordinal type of the dependent variable and following the practice of past relevant papers (Bishop et al., 2010; Peterson et al., 2012) the present analysis will be based on an ordered regression model. The final model is the following:

$$
\begin{aligned}
link(\theta_j) = a_j - \begin{pmatrix}\beta_{SEX-0}\\ \beta_{SEX-1}\end{pmatrix} * \begin{pmatrix}SEX-0\\ SEX-1\end{pmatrix} - \beta_{Age} * Age - \beta_{Age^2} * Age^2 - \beta_{Age^3} * Age^3 \\
- \beta_{Educ} * Educ - \beta_{Inc} * Inc - \begin{pmatrix}\beta_{Farm-0}\\ \beta_{Farm-1}\end{pmatrix} * \begin{pmatrix}Farm-0\\ Farm-1\end{pmatrix} - \begin{pmatrix}\beta_{Coop-0}\\ \beta_{Coop-1}\end{pmatrix} * \begin{pmatrix}Coop-0\\ Coop-1\end{pmatrix} \\
-\beta_{Area} * Area - \begin{pmatrix}\beta_{Crop-0}\\ \beta_{Crop-1}\end{pmatrix} * \begin{pmatrix}Crop-0\\ Crop-1\end{pmatrix} - \beta_{Info} * Inf - \begin{pmatrix}\beta_{Res-0}\\ \beta_{Res\ -1}\end{pmatrix} * \begin{pmatrix}Res-0\\ Res-1\end{pmatrix} \\
-\beta_{FutVw} * FutVw - \beta_{Comm} * Comm - \beta_{Mtv} * Mtv - \beta_{Trust} * Trust \quad j=1,2
\end{aligned}
\tag{1}
$$

Where,

$link$ = The link function

θ_j = The cumulative probability for the *j*th category

a_j = The threshold for the *j*th category

β = The regression parameters to be estimated

A basic requisite for running an ordinal regression is the specification of the link function. The link function selection depends on the escalation of the response variable's cumulative probability. The examination of the frequencies of responses for the three categories shows that the distribution looks like a normal one since the first class of Total Investment accounts for the 24.5% of the cases, the second category for the 49.9% and the third for the 25.6%. When the distribution of the dependent variable has these characteristics, it is advisable to use the Probit link function and thus this type of link is selected for the present study (Norusis, 2004).

3 Results and discussion

The survey was implemented during October 2019 in the region of Thessaly which lies at the central part of Greece. In total, 802 questionnaires were filled up by local farmers, resulting in 777 valid responses based on whether respondents replied to all the questions which used for shaping the variables of the present study. We applied random stratified sampling on the basis of the regional ratio of the total arable crop to orchard farmers which hovers around 1.65 in the period 2009-2016 (Hellenic Statistical Authority, 2018). Region of Thessaly is heavily specialized in the primary sector, as the proportion of the sectoral workforce to the total regional workforce is on average 11.2% when the national figure lies at only 4.2% (Hellenic Statistical Authority, 2020). The descriptive statistics of the variables are presented in Table 5. As can be seen from the mean value of the Sex variable, only 13% of the sample is women. The values of the age variable range between 18 and 83 with the mean age of the respondents estimated at 47 years.

Table 5.
The descriptive statistics of the model variables

Variables	Minimum	Maximum	Mean	Std. Deviation	Coefficient of variation
Sex	0	1	0.13		
Age	18	83	47.39	12.97	0.27
Education	1	4	2.79	0.88	0.32
Income	1	4	2.59	1.13	0.44
Farmer	0	1	0.66		
Cooperative	0	1	0.23		
Area	1	2500	88.90	166.78	1.88
Crop	0	1	0.39		
Info Engagement	0	7	2.94	1.52	0.52
Research Engagement	0	1	0.15		
Future View	1	3	1.81	0.77	0.43
Commitment	1	5	3.76	0.89	0.24
Motive	1	5	3.67	1.07	0.29
Trust	1.22	4.75	2.85	0.70	0.24

Source: Own elaboration based on survey responses

The mean of the Education variable is estimated at 2.79, a tally that shows that the average farmer of the region has at least finished the secondary school. Considering the Income variable, for which the estimated mean value

is 2.59, it is concluded that the average farmer earns about 10 to 20 thousand € per annum. The mean value of the Farmer (0.66) and Cooperative (0.23) variables show that two to three respondents are full-time farmers while only about one to four farmers are members of a cooperative. The mean size of the farms is estimated at 89 thousand m^2 while orchard farmers account for the 39% of the total sample. Farmers have on average undertook three information activities out of the seven-total offered, while only 15% have been engaged in a research project. Considering the view of farmers on the future of agriculture, it is really impressive how low the average value of responses is, while indicative of their generally pessimistic stance is the fact that no farmer chose any score above three, which corresponds to a subjective neutral view of the future.

In addition, the mean value of Commitment variable (3.76) indicates that, on average, the farmers of the region are prone to shift to other types of crops if it is to achieve more profits or time savings. This attribute can be considered as the outcome of the new European Union's (EU) subsidy scheme. The decoupled payments administrative framework fully supports the restructuring of agricultural holdings and the most important motive toward this direction is the increased degrees of freedom farmers have, under the new framework, to decide what to cultivate and produce according to market powers and consumer demands. The average value of 3.67 denotes that the majority of farmers weigh more the joy and self-fulfillment that they get from farming activities, than the profit factor. Finally, Trust could be considered as rather mediocre as its mean value lies under the 3, which was the choice of medium trust to the provided institutions at the 5-points Likert scale.

In Table 6, the results of two goodness of fit tests for the model are presented. The first test has the null assumption that the location coefficients for all of the predictor variables in the model are zero. The significance level of the estimation which is lower than ($p<0.01$) leads us to the rejection of the null hypothesis that the intercept-only model performs better than the model with the predictors. The second test checks if the regression coefficients are equal for all corresponding outcome categories and is called the test of parallel lines. As can be seen from the statistical significance of the Chi-Square estimation, the null hypothesis cannot be rejected and thus the model is suitable for being executed on the sample data (Norusis, 2004). Additionally, the Pesudo-R^2 Nagelkerke is estimated at 0.314 and the Cox and Snell at 0.275. Although these estimations seem to be rather low when compared to the respective of the Ordinary Least Squares method, this should not be considered as a serious problem for the present analysis as this is nearly always the case when comparing these alternative R^2 measures with the standard R^2 of OLS (Norusis, 2004). Finally, in order to check for the existence of collinearity, an OLS regression with the same variables was executed and all the Variance Inflation Factors (VIF) were found well below the threshold of 10 (the maximum VIF value was 1.446). It should be noted that during the collinearity testing only the first order term of the Age variable was incorporated into the estimations.

Table 6.
Results of the Diagnostic tests of the Ordinal Regression Model

Model Fitting Information				
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	1,609,318			
Final	1,360,943	248,374	16	0.001
Test of Parallel Lines				
Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	1,360.943			
General	1,340.254	20.690	16	0.191

Link function: Probit

The estimated coefficients and the respective statistical significance for each variable are presented in Table 7. The positive and statistically significant (<0.05) estimation of the Sex coefficient denotes that women invest more than men. The Age variable seems to be related with the probability of farmers to invest with an N-shaped link as the all three terms are statistically significant and their signs change alternately. More precisely, considering that the sign of the linear curve is negative, it is extracted that at their early engagement, farmers don't invest so much, maybe due to the lack of funds and knowledge capacity. As time passes, their investment rate is altered as they start to implement all the necessary investments, in order to realize their business plans. Finally, after a certain point and as they getting older their inclination to invest slows down. The coefficient of the Education variable is positive and statistically significant, suggesting that more educated farmers are more likely to invest in their farms. The same holds also for the Income variable, as the positive and statistically significant estimation of the respective coefficient denotes that as the income of farmers increase, they tend to invest more on their capital improvement. As for the type of occupation, the negative estimation of the relevant

coefficient indicates that part-time farmers are investing more than the full-time ones. Nevertheless, the estimation acquires marginal statistical significance only at the (<0.10) level and hence it should be treated with caution. As for the third variable of the business factor, the participation in a cooperative does not seem to affect the investment rate of farmers.

Table 7.
Results of the Ordinal Regression Model

Variable Categories	Variable	Estimate	Std. Error	Wald	Sig.
Dependent	TotInv (1)	-4.305	1.287	11.195	0.001
	TotInv (2)	-2.656	1.282	4.291	0.038
Farmers' characteristics	Sex	0.321	0.129	6.176	0.013
	Age	-0.263	0.081	10.538	0.001
	Age^2	0.005	0.002	9.336	0.002
	Age^3	-0.000	0.000	8.010	0.005
	Educ	0.170	0.057	9.092	0.003
Business factors	Income	0.138	0.045	9.405	0.002
	Farmer	-0.166	0.101	2.724	0.099
	Coop	0.151	0.106	2.048	0.152
Farm structural factors	Area	0.001	0.000	11.135	0.001
	Crop	0.307	0.096	10.330	0.001
Situational factors	Info	0.240	0.032	56.992	0.000
	Res	0.639	0.129	24.626	0.000
Individual behavior and perceptions	FutVw	-0.116	0.058	3.944	0.047
	Comm	-0.067	0.050	1.806	0.179
	Mtv	-0.032	0.042	0.597	0.440
	Trust	0.203	0.064	10.147	0.001

The estimations of the farm structural characteristics variables' coefficients are both positive and statistically significant at the (<0.01) level. This result signifies that the farm size push farmers to invest more. In addition, the estimated coefficient of the Crop variable indicates that orchard farmers are more likely to invest that those of arable crops. Hence, responding to the Research Question 1 it could be said that there seems to be a path dependency on the investment rate of farmers which can be attributed on the type of farm that they select to hold. Therefore, it is testified that orchard farming is more demanding in investment terms. This result is in contrast with the respective findings of Lefebvre et al. (2014) who reported that European arable crop farmers were more prone to invest in the period 2014-2020 than the orchard ones. This contradiction should be treated with caution because the present paper used a different sample of farmers and measured investment realization in quantitative and not in monetary terms which was the case in the study of Lefebvre et al. (2014).

At the situational factors, both variables are positive and statistically significant at the (<0.01) level. Therefore, responding to the 2nd and 3rd Research Questions, the results show that the engagement of farmers with institutions that promote change in agriculture, either just for gathering information or for cooperating on a research project enhance the willingness of farmers to invest, thus improving the agricultural sector as a whole. It could be said that both types of information gathering enhance the investments propensity of farmers. Finally, the estimations for the variables of individual behavior and attitudes present some variations in signs and levels of statistical significance. The negative estimation of the variable FutVw denotes that the more pessimistic a farmer is, the higher the likelihood that he/she invests on his/her farm. Maybe, this behavior could be attributed to the importance that farmers place on the improvement of their farm conditions as a means to stay competitive in a sector that, according to their view, is constantly providing less opportunities for profit-making. Moreover, the commitment of farmers to the cultivation of their existing crops does not seem to play a role in

their investment decisions, since no statistical significance was found for the estimated coefficient. The same stands true for the effect of farming motivation on farmers' investment decision, as no statistically significant relationship was found for the two measures. Finally, trust seems to play a positive role in enhancing investment in agriculture, as the estimation of the respective coefficient was found positive and statistically significant at the (<0.01) level.

The varying effect of the different variables on the FDM has remarkable policy implications, as policy makers should take into account how farmers' characteristics and attitudes drive their intention to modernize their farms. Digging further to the scores of each individual on the variables used in the present study, these can be used as a means for distinguishing some farmer groups with common characteristics. This clustering could facilitate policy making in the sense that this will be drafted on larger farmers' segments rather on just individuals. To provide an example of how this could be achieved with the results of this or other similar studies, a clustering exercise is conducted. Clustering is an effective way to categorize farmers on the basis of common characteristics (Paustian, Wellner, Theuvsen, 2015). More precisely, seven variables capturing the attitudes and the behavior of farmers are used in order to perform a K-Means clustering analysis and extract some distinct groups of farmers which come up with different policy challenges (Jain, 2010). The present analysis distinguishes three groups considering that all variables' means present a statistically significant difference among the groups according to a relevant ANOVA analysis (Norusis, 2004). The mean values of the seven variables per group are presented in Figure 1.

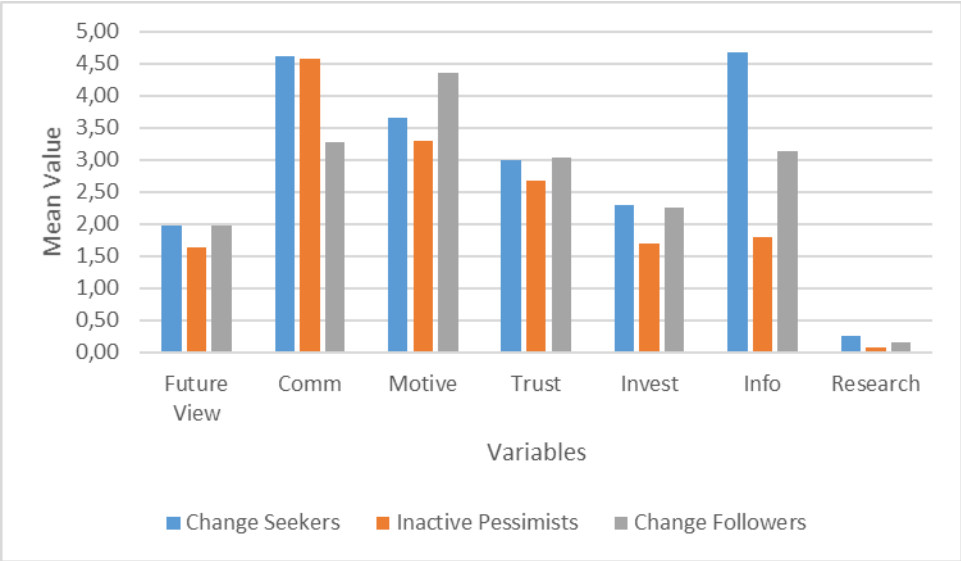

Figure 1. The mean scores per variable of the three farmers' clusters

The first group is highly involved in activities of info gathering (>4.50), while presenting the higher rates of participation in research projects and quite high investment activity. As for their attitudes, farmers of the group are optimistic and are driven by both economic and more altruistic motives, as they stand in the middle of the two other groups in the variable Motive. Finally, they present the weakest tie with their past farming practices, as they can easily change to more profitable and time saving crop types. The overall flexibility of the group and its propensity to learn and test in practice the outcomes of research are the main reasons for assigning them the label of "Change Seekers". Policy makers could consider this group as a good basis for testing new ideas and promoting more radical changes toward the achievement of more sustainable farming practices.

The second group, is the less active in information gathering actions, research projects and investments. It's mainly driven by profit motives and has a very pessimistic view regarding the future of farming. Considering that the farmers of the group present also the lowest levels of trust to the other actors of the sector, it could be said that these form an inactive segment of farmers which embodies a negative and pessimistic view for all developments around the sector. Therefore, the label "Inactive Pessimists" denotes that in the policy level, a lot of effort should be given, in order to mobilize these farmers in becoming more engaged in various sectoral processes and thus undertake activities that could bring essential improvements in farming practices.

Finally, the third group, lies somewhere between the other two in terms of its engagement and its potential to initiate any major changes in agricultural practices. This is because the group presents a satisfactory engagement in information and research activities, as well as in investment realization. The farmers of the group put a premium on joy over profit as driver of their engagement with agriculture and this fact seems to make them be closely connected with their crops (lowest score in Commitment variable). Considering that they also present the highest level of trust on various institutions and they have an optimistic view on the future of the sector, these farmers could easily adopt new practices and implement the necessary investments, provided that they will help them extract more joy from agriculture. The policy makers should not see this group as a fertile ground for experiments but as willing adopters of already tested practices and this is why the group is labeled as "Change Followers".

4 Conclusions

The paper provided a framework for understanding the driving forces of farmers' inclination to realize investments. The methodological framework focused on the role of information gathering and type of farm but also considering a quite large sample of farmers specialized in arable crops or orchards. Among the most important results of the study is that engagement in information gathering activities, as well as the participation in research projects, have a significant positive effect on the investment propensity of farmers. It should be also stressed that farmers' education and their trust to various organizations which are directly or indirectly involved in research around the agricultural sector, have also been found to be significant drivers of investments. Therefore, it is extracted that the overall education, research and information interplay between farmers and institutions can acquire a very significant role in promoting the desired change in agriculture. Indeed, there is a capable portion of the literature examining the conditions under which this interplay is developed (Ingram, 2008) but more evidence is definitely welcomed, in order to examine how this interplay promote the shift of farmers to more sustainable practices.

In addition, the results showed that there is a significant difference in the investment rates of farmers when their farm type is concerned. There seems to be a higher inclination for realizing investments in farmers that cultivate fruit and nuts trees than in arable crop ones. This finding has remarkable methodological implications since most of the previous studies did not incorporate this distinction in the models of FDM. Therefore, a number of previous findings regarding the role of various factors on the behavior of farmers, and especially when investment is at stake, may be questioned due to the potential existence of a selection bias (Angrist and Pischke, 2014). Of particular importance are also the findings regarding the demographic variables. The fact that female farmers were found to invest more than their male colleagues is very promising for the future role of women in agriculture, but it should be furtherly tested as the proportion of women in the sample was rather small. Regarding age, the paper has shown that it is rather risky to impose a linear relationship between farmers' age and their behavior in many aspects, as in the case of investment propensity there seems to be phases in the life of farmers in which they present different rates of investment.

Moreover, the fact that wealthier farmers and those with off-farm earnings seem to invest more, signifies that both the size and source of income affect the propensity of farmers to invest. Therefore, the lack of the ability to realize savings may impede any initiative for farms modernization. Finally, the subjective opinions and attitudes of farmers, regarding a series of issues seems to have a lower impact on FDM, when considering the statistical significance of the estimations of the relevant variables. Apart from trust, only the future view of agriculture seems to impact farmers' choices for investing, as the motives and their ties with the crops that they cultivate does not seem to have an effect on investment records. The finding of the impact of future view should be examined more thoroughly, as it signals that farmers undertake more initiatives for modernizing their farms when they operate under pressure sourced by their external environment and under their negative perceived prospects for future growth.

The aforementioned findings come up with important insights for policy makers, too. Initially, the study has revealed that some objective socioeconomic, business and demographic factors as well as the actual information and research engagement of farmers have a role in shaping their investment decision. Therefore, the findings can help policy makers to draw well targeted policies that will seek to alter these objective characteristics in a favorable direction. Considering the estimations of individual coefficients, it is extracted that engaging middle-aged farmers in research projects will have a substantial effect in investment enhancement, as both factors have been found to act as investment drivers. But it is also on the greatest benefit of the sector as a whole to make the less prone to invest age categories to participate in research projects, so as to eliminate the negative effect of given and unchanged characteristic of farmers, such as their age, with the empowerment of other attributes which are surely able to be altered. This finding also prioritizes the need for a wider dissemination of the projects' results.

A targeted policy with various farmers' segments being defined beforehand could be essential for triggering investment activity. The segmentation could be based on individual objective criteria such as the type of farm. In this case, policies should pay more attention to the less prone to invest category of arable crop farmers. On the other hand, the grouping could be more general considering both objective and subjective factors. To this end, the exercise of clustering conducted in the present paper, can be a good example for developing tailor-made policy interventions. The clustering should not only be seen as useful for driving policy measures, but also for identifying the particular role of different farmers' group in a more general and long-term development strategy formulation context. That is, farmers prone to change could be used at the initial stages of a policy implementation as a means for disseminating the results and engaging the less active farmers in the whole process.

As it was shown in the literature review, the majority of studies on FDM draw evidence form surveys implemented on individual countries. Therefore, the generalization of the results becomes more difficult. To overcome this barrier, studies incorporate a range of socioeconomic and contextual variables capturing the heterogeneity of the different samples and therefore rendering the extracted results comparable at an international context (Ambrosius et al. 2015). The same strategy was followed also by the present study and therefore the results could be regarded as a valuable contribution toward the better understanding of FDM.

As this all holds true for all the similar studies on FDM, the present analysis could be improved and complemented in a series of aspects. The formulation of the model employed by the present does not allow for accounting any indirect effects among the variables. Therefore, the relationship between key variables of the present, such as the information and research activities, as well as the types of farms could be tested on a Structural Equation Modelling framework. Moreover, given that research engagement has a role in improving the structure of farms, it is critical to examine which particular factors motivate farmers to participate in research projects, so as to steer policy measures at this direction, too. In addition, some other variables as the liquidity or the access to finance may be relevant to be checked as factors affecting investment decisions, especially in international case studies. Finally, a more thorough study on the particular characteristics that may have a role in making arable crops farmers less prone to invest, compared with their orchard farmers, should follow in order to shed more light on the causes of this imbalance.

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