Adopting ICT Tools by Farms in Lucania Region

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Abstract. This study aims at investigating how Lucania' farms cluster according to the level of innovation adopted. It was used a questionnaire for asking if farms adopts ICTs tools and, in case, what type they involved in managing and/or production processes. It has been done a cluster analysis on collected data. Results show that, using k-means clustering method, appear two clusters: innovators, remaining groups. While, using boxplot representation, clustered three groups: innovators, early adopters and laggards. Results will be exploited for identifying good practices in terms of smart devices adopted, within the H2020 project "Short Supply Chain Knowledge and Innovation Network - SKIN".

Keywords: ICT, Clustering Analysis, Lucania, Farms

1 Introduction

Agriculture is a field very suffering low efficiency in carrying out its core activities due to many reasons coming from quick scenery changes. Such changes have been fostered by new digital technologies. They appear in integrated system named Farm Management Information System (FMIS). Nowadays, the general addresses to lead the growth in Europe come from European Commission (EC). In fact, being able to cope daily problems means to be able to engage synergies among tangible and intangible resources inspired by arisen studies on such issues. They set out that smart growth can be put in practice sharing knowledge and adopting innovations (Contò et al., 2015). Reducing distances among the available resources and accelerate the access to them. In addition, it has been stated that is necessary to be in conformity with ecosystem needs (Debackere et al., 2014). To this end, Information and Communication Technologies (ICTs) tools play an important role for achieving mentioned goals. Since ecosystem is quite a lot dynamic and changes frequently occur, it is complex to manage all data emerging by daily activities and to take under control the scenario evolutions. Such problems are much more evident in small medium enterprises (SMEs) where information flows are often stressed by the lack of capabilities to access to ICT innovations (Contò et al., 2015). These tools allow farmers reducing asymmetric information, being the main cause of moral hazard and adverse selection mostly affecting firms operating in international markets. The information management, in turn, influences internal and external actions (Bian et al.,

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2016). Hence, the highest concern has to be that of making accessible tools useful to reduce the information gap. The benefits will affect transactional costs. In fact, it is possible to find many farms that got economic improvements adopting such technologies (Deichmann et al., 2016). The demonstration of such claims comes from developing countries that show high level of growth. To this end, the World Bank arose data in his yearly report dating back to 2016. The report shows that firms in poor countries adopt digital technologies getting to be much more competitiveness, whilst maintaining a low profile in international markets due to the lack of appropriate skillful and infrastructures as well (World Bank, 2016). On the other hand, scholars have been arising complex management systems that bring together all elements making farms up. The hardest challenge is to guarantee a right resources coordination and employment in long period, in order to attain the general goal of adding sustainable value to the stakeholders.

This article is structured in different sections, they are organized as follows: the second section (ii) proposes a literature review; the third section (iii) shows the outline of the questionnaire used for collecting data farms; the fourth section (iv) explains the analysis method used for processing data for extracting information. Finally, there are summarized the results and provided their discussion before the conclusions.

2 Literature Review

Over the years, many changes have been occurring with the advent of ICTs technologies, affecting, in particular, the farms efficiency. Scholars have taken this opportunity to study deepen the impacts of such extraordinary evolutions. The first step to better understand following consideration on ICTs farms tools, is related to the reason making necessary to implement innovation processes and knowledge uptake. It is based on the pace of the cost level showed by farms so far. Nowadays, European and national policies address organizations to realize a cost reduction through the adoption of smart devices, being in line with the industry 4.0 topics. To this extent, world organizations as the World Bank pursues in broadcasting analysed data showing how costs decrease (World Bank, 2016) by introducing ICT tools for managing the growing complexity activities, due to the complicated competition and vice versa (Jain et al., 2011; Chen et al., 2012; Lee and Yang, 2013). Deichmann et al. (2016) explain what type of problems preventing the digital devices adoption in developing countries. Obviously, there are many countries divided in different areas, several ones are into prominent growing processes, and others suffer the absence of capabilities to acting growth. It depends on many factors. The significant ones concerns the slowness in reforming business regulations and the skills development system. They stress the idea that building efficient information system is the key for triggering sustainable growth in long period. A signal of farms (and more in general firms) efficiency is related to the impact of smart tools on the amount of the production, which measure the total factor productivity growth (OECD, 2013). Within the farms dynamisms, Diedern et al. (2003) distinguished between innovators, early adopters and laggards. These three categories can represent the farmers profile appearing in European areas. Measuring innovation level within the farm has taken to different assessing methods. Another classification can be carried out with a matrix that makes differentiation between innovations as major, intermediate or minor based on their technological advancement. The matrix shows an innovation numerical index standing for the innovation level of each farm (Ariza et al., 2013). Many others studies have explained the agricultural innovations through the agricultural technologies uses (Dimara and Skuras, 2003; Sauer and Zberman, 2012; Stefanides and Tauer, 1999). On the other hand, their study issued that structural characteristics, such as farm size, utilized agricultural areas and age of the farmer, reflect the attitude and the willing to choose to undertake and pursue innovating processes. According to these assumptions, they distinguish between innovators and remaining groups. The literature breakdown also involves a study using more complex index. This index not considers the adoption of a single technology. Conversely, it focuses on combined factors defining the innovations. The complexity comes due to the variables taken into account not only focalize on tools and equipment (Chen et al., 2014; Esmeijer at al., 2015) for carrying out farms activities (e.g. ICT tools, tractors, etc.), but also on primary productive factors (e.g. seeds). Therefore, it brings together different elements combining the effects on the farm results and showing the benefits from emerging synergies. However, the latter is not the case of this paper. This study used several of those simple methods for evaluating the results in terms of innovation level. The first stage identifies the groups through a clustering analysis and such analysis reveals to exist two main groups (as Dimara and Skuras, 2003; Sauer and Zberman, 2012; Stefanides and Tauer, 1999 conclusions revealed): innovators and remaining groups. The next step sheds a light on four variables mined from the dataset and organized in a boxplot. This examination highlights that the groups are three groups, complying with the insights coming from Diedern (2013).

3 Data Collection Method

The questionnaire is composed by twenty-two Questions (Qs) in total. The survey is divided in two parts: i) *General Information*, starting from the Q1 to the Q7, regarding the general aspects of the farms involved in the survey. Based on the Q7 reply, regarding the use of ICT tools, the questionnaire foresees the second section dedicated to the ii) *Farms using ICT* (from Q8 to Q22), or it ends in case of negative answer. In the second section there are set of Qs dedicated to analyse what are the most used ICT tools applied to the farm management and the impact that these technologies could have on the decrement of agronomic input and manpower employed and on the production increasing.

Following the Qs are described:

Q1) Legal status: possible answers (*partnership*; *capital company*; *others*).

Q2) Time of Constitution: possible answers (*less than five years; between five and ten years; more than ten years*).

Q3) Farmer's Age: possible answers (*less than thirty-five years; between thirty-five and fifty years; more than fifty years*).

Q4) Utilized Agriculture Area (UAA): possible answers (*less than ten hectares; between ten and fifty hectares; more than fifty hectares*).

Q5) Crop Type: possible answers (*Tree crops, herbaceous crops, mixture crops*).

Q6) Income: possible answers (*between 0 and 50000€; between 50001 and 120000€; between 120001 and 250000€; between 250001 and 500000€; between 500001 and 1000000€; more than 1000000€*).

Q7) Do you use ICT tools? Possible answers (*yes or no*). If the reply is positive, the farmer answers the demands from Q8 to Q22, in contrary the questionnaire ends.

Q8) What type of Management Tools do you use? Possible answers (*none; tools for Farm's notebook; tools for warehouses' management; tools for management of balance sheet; tools for management of invoicing; Enterprise Resource Management; others*). Multiple answers are allowed.

Q9) What type of Software for Data Management do you use? Possible answers (*none; software for data storing; software for market analysis; Decision Support System software; software to analyse the costs; others*). Multiple answers are allowed.

Q10) Do you use tools for Precision Agriculture? Possible answers (*yes or no*). If the reply is positive, the farmer answers the demand Q11, in contrary the Q17.

Q11) Do you use environmental sensors? Possible answers (*yes or no*). If the reply is positive, the farmer answers the demand Q12, in contrary the Q13.

Q12) Why do you use environmental sensors? Possible answers (*Fertilization, Phytosanitary treatments, Weeding, Irrigation, Sowing, Soil management*). Multiple answers are allowed.

Q13) Do you use Unmanned Aerial Vehicle (UAV or drones)? Possible answers (*yes or no*). If the reply is positive, the farmer answers the demand Q14, in contrary the Q15.

Q14) Why do you use UAV? Possible answers (*Fertilization, Phytosanitary treatments, Weeding, Irrigation, Sowing, Soil management*). Multiple answers are allowed.

Q15) Do you use Satellite Data? Possible answers (*yes or no*). If the reply is positive, the farmer answers the demand Q16, in contrary the Q17.

Q16) Why do you use Satellite Data? Possible answers (*Fertilization, Phytosanitary treatments, Weeding, Irrigation, Sowing, Soil management*). Multiple answers are allowed.

Q17) Do you use External Data Sources? Possible answers (*yes or no*). If the reply is positive, the farmer answers the demand Q18, in contrary the Q19.

Q18) What types of Data do you research? Possible answers (*Agro-Meteorological, Market, Legal aspects, Phytosanitary bulletin, Others*). Multiple answers are allowed.

Q19) What type of tools do you think is the most useful? Possible answers (*External Data Sources, Enterprise Resource Planning, Software for Data Management, Precision Agriculture tools*).

Q20) Since you started to use ICT tools, do you have detected a reduction in the use of agronomic inputs (pesticides, fertilizers, water, etc.)? To what extent? Possible answers (*None; between 0 and 5%; between 6 and 10%; between 11 and 20%; more than 20%*).

Q21) Since you started to use ICT tools, do you have detected a reduction of employed manpower? To what extent? Possible answers (*None; between 0 and 5%; between 6 and 10%; between 11 and 20%; more than 20%*).

Q22) Since you started to use ICT tools, do you have detected an increment of production? To what extent? Possible answers (*None; between 0 and 5%; between 6 and 10%; between 11 and 20%; more than 20%*).

For the cluster analysis presented in the next section a subset of the total variables was taking into account (Table 1).

Table 1. Variables used in the cluster analysis. The code is associated to a single answer in the cluster analysis.

Question	Name and abbreviation	Answers	Code
Q1	Legal Status	*Partnership*	1
		Capital company	2
Q3	Farmer's Age (Age)	*Less than thirty-five years*	1
		Between thirty-five and fifty years	2
		More than fifty years	3
Q4	Utilized Agriculture Area (UAA)	*Less than ten hectares*	1
		Between ten and fifty hectares	2
		More than fifty hectares	3
Q5	Crop Type	*Tree crops*	1
		Herbaceous crops	2
		Mixture crops	3
Q6	Income	*Between 0 and 50000€*	1
		Between 50001 and 120000€	2
		Between 120001 and 250000€	3
		Between 250001 and 500000€	4
		Between 500001 and 1000000€	5
Q7	Do you use ICT tools? (ICT)	*Yes*	1
		No	2

4 Data Analysis Methods

In this paper, collected data have been analysed using clustering analysis. For obtaining groups featured by homogeneous parameters, it has been resorted to considering k-means cluster method. The analysis returned acceptable results setting two clusters. The choice of selecting two clusters it was possible due to:

- the k-means clustering method can be applied with both supervised and un-supervised methodology (Wagstaff et al., 2001);
- three clusters not returned acceptable results.

In general, k-means is a method that born as un-supervised. Therefore, processing machine automatically calculates the least distances, respecting the set threshold between features (Zhang et al., 1996). The goal aims to evaluate if the distances are such to consider the minimum sum of the squared error (SSE) within each groups (Likas et al., 2003). The formula of the SSE is the following:

$$SSE = \sum_{k=1}^{K} \sum_{\forall x_i \in C_k} \left\| x_i - \mu_k \right\|^2 \quad \textbf{(1)}$$

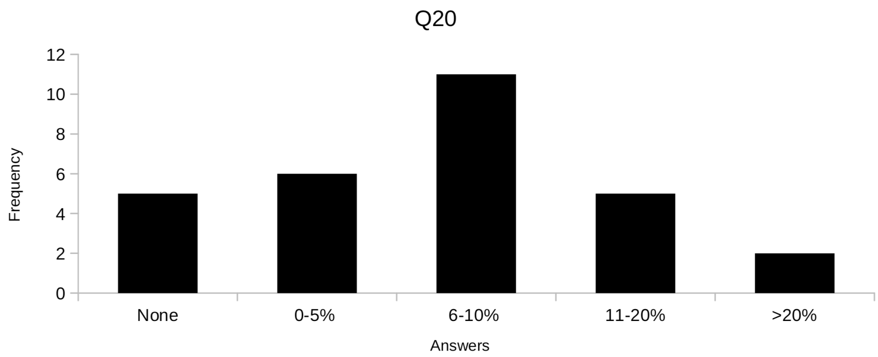
where C_k is the set of grouped data in cluster k; μ_k is the vector mean of cluster k. Using un-supervised method, it was found that the clusters were two. Nevertheless, for being in line with Diedern et al. (2003), the scope was to find three groups to be labelled as innovators, early adopters and laggards. The test not achieved the goal and it was tried with a supervised method setting three clusters. In turn, the test not succeeded due to the cluster two and three presented identical features (the reason why un-supervised method returned two clusters). Hence, it has been chosen to apply a supervised method selecting two clusters. At this stage, the test succeeded and results were accepted to fulfill the two groups theory (innovators and remaining groups) issued by Dimara and Skuras (2003), Sauer and Zberman (2012), Stefanides and Tauer (1999).

Then again, it has been attempted to go through the data, analyzing data through a boxplot to summarize the frequencies. The analysis comes from intersection of selected variables. It has chosen to fix variables for creating groups and, to this extent, UAA and age have been selected. Within each group, it has been investigated how the presence of ICT tools is bridged to the incomes and legal status.

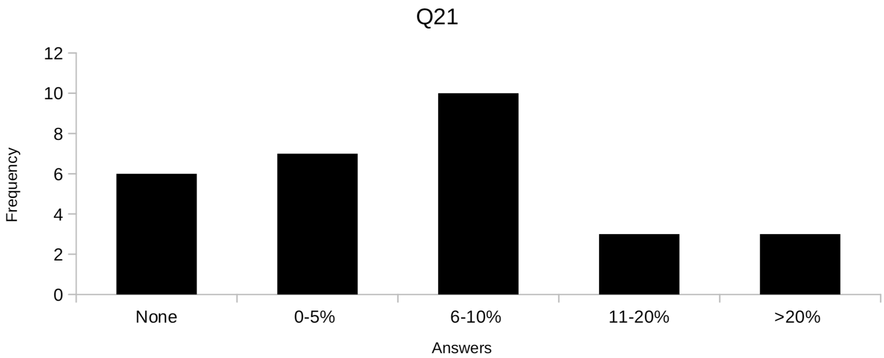
5 Results and Discussion

The questionnaire shows answering from a sample within a producer organization (PO) in Lucania region. The respondents are 59. They represent the image of the region in terms of the typology of farms and, in scale, the farm population composition in Lucania region.

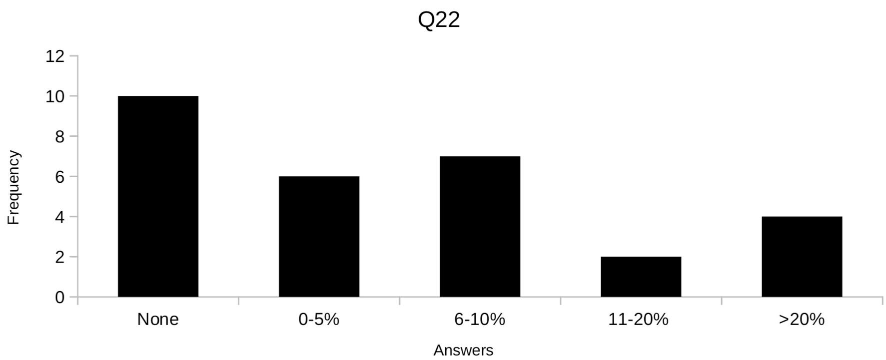
In this section are exposed the results from the frequency distribution of Q20, Q21 and Q22, and the cluster analysis and the boxplot. The paragraph concludes with discussion from results, emphasizing the differences of the marks basing insights on the literature provided in section (ii). The reader finds the frequencies of relevant selected variables and relative comments as well. The discussion provides insights for explaining potential barriers, obstructing the ICT tools adoption, to be investigated with further studies. There are delivered considerations on what the farmers not ICTs skilled and, in consequence, not adopter, while oriented and inclined to adopting.



a)



b)



c)

Fig. 1. Frequency distribution of answers related to: a) Q20 (Since you started to use ICT tools, do you have detected a reduction in the use of agronomic inputs (pesticides, fertilizers, water, etc.)? To what extent?); b) Q21 (Since you started to use ICT tools, do you have detected a reduction of employed manpower? To what extent?); c) Q22 (Since you started to use ICT tools, do you have detected an increment of production? To what extent?). None = None; 0-5% = between 0 and 5%; 6-10% = between 6 and 10%; 11-20% = between 11 and 20%; >20% = more than 20%.

In Fig. 1 there are the frequency distributions related to Q20 (a), Q21 (b) and Q22 (c), regarding the 29 farms that use ICT tools. The Q20 and Q21 concerning, respectively, the reduction of agronomic input, such as fertilizers, pesticides, water, etc. and employed manpower, recorded by the farmers since they started to adopt ICT tools. Analysing the Q20 answers, the 17,2% (5 replies) did not notice difference in the application of the agronomic input, while a little reduction (0-5%) was detected in the 20,7% (6 replies). The modal value with 11 replies (37,9%) is the range 6-10%, and the last two intervals, 11-20% and >20%, have collected 5 (17,2%) and 2 (6,9) replies, respectively. Taking into account the Q21 answer, 6 farmers (20,7%) did not notice any reduction in the employed manpower related to the use of ICT tools, while a light decreasing (0-5%) was perceived by 7 farmers (24,1%). Even in this case, the range 6-10% represents the modal value, with 10 answers representing the 34,5% of the total, with the last two intervals, 11-20% and >20%, have collected both 3 replies (10,3%). Finally, the modal value of the frequency distribution of the Q22 is represented by the first class, with 10 (34,5%) farmers that did not notice any production increment associated to use of ICT tools. Then the others range, 0-5%, 6-10%, 11-20% and >20% have collected respectively 6 (20,7%), 7 (24,1%), 2 (6,9%) and 4 (13,8%) answers.

As indicated in the section (iii), the queries aimed to evaluate the number of farms that adopt ICTs tools and associated evidences from the farm structure and the age of the farmers. The cluster analysis shows two main clusters characterize as follows (Table 2):

Table 2. Two emerging clusters after processing data. The result concerns a selected number of variables from the survey.

	CLUSTER	
	1	2
Legal status	1	1
Crop type	2	3
Age	2	2
UAA	2	2
incomes	2	4
ICT	0	1

The resulting clusters present different features, only concerning three variables: crop type, incomes and ICT. In general, both clusters appear to consist of farms established as partnership, with farmers being medium age ranking old (35-50); farming between 10 and 50 hectares. Differences come from:

- Crop type: the cluster 1 is featured by herbaceous crop, while the cluster 2 is featured by mixed crop (herbaceous and tree crop);
- Incomes: the cluster 1 gains to the extent between 50.000,00 and 120.000,00 euros, instead the cluster 2 lines up between 250.000,00 and 500.000,00 euros;
- ICT: the cluster 1 is represented by farms not adopting ICT tools, the cluster 2 is featured by farms adopting ICT.

Table 3 shows the frequencies within each cluster. There appear the 38 clustered in the first (1) group and the 21 grouped in the second (2) cluster.

Table 3. Number of cases of each cluster.

Cluster	
1	38,000
2	21,000
Valid	59,000
Missing	,000

The major number of farms is concentrated in the first cluster. Although the last evidence, the cluster analysis points out that, in accordance with Dimara and Skuras, (2003), Sauer and Zberman (2012), Stefanides and Tauer (1999) asserted, come up two groups: innovators and remaining groups. The cluster 2, populated by innovators, registers revenues much more relevant than the 1. The measure corresponds to the range between 250.000,00 and 500.000,00 euros against the cluster 1 featuring incomes between 50.000,00 and 120.000,00 euros. Furthermore, it results that the cluster adopting ICT is characterized by mixed crop. In this regards, the crop diversification is associated to higher incomes (Di Falco and Zoupanidou, 2017). Taking into consideration that the ones encompassed in the cluster 2 adopt ICT tools, the result in terms of incomes is significant. When farms adopt ICTs seem to improve the performance. On the other hand, there is a dependency between those two variables, though it is not defined the direction: at this stage is not clear what kind of factors push farms in innovating with ICT. In fact, it can depend on the achievement of excessive dimension and, due to the increasingly complexity, farms need to improve the data collection and management phases; otherwise, it can depend on the need to improve the revenue performance and so, the adoption of ICT tools cause the incomes increasing. For making clearer the explained point, it has been done another analysis. Assuming that the variable type of crop is excluded due to it has been chosen to conduct the analysis not considering such qualitative agronomic variable. The focus remains on the economic aspects, exploring relations with economic parameters.

Fig. 2 shows the boxplot where are intersected four different variables, looking for stratum where farms adopt ICT. Outputs put in evidence that there are three main groups classified by UAA and age. Firstly, results seem to be in comply with the conclusions of Diedern et al. (2003). Indeed, the picture features three different relevant groups that can be summarized as follows:

- Innovators, characterized by age between 18 and 35 and UAA no more 10 hectares;
- Early adopter, mainly featured by age between 35 and 50 and UAA between 11 and 50 hectares;
- Laggards, principally classified by age over 50 and UAA between 35 and 50 hectares.

It has been assumed that if the age and the UAA present low value, hence the ICT adoption positively affects the productivity and, in consequence, the incomes. The picture displays that the major concentration of the ICT matches with the square corresponding to age level 1 (18-35) and UAA level 1 (0-10 hectares). This consideration confirm that younger farmers are much more incentivized and motivated to resort to ICT tools for managing farming activities (Plechowski, K. 2015). The innovators label is due to the age of the farmers, who, even though the low profile in terms of utilized lands, got medium-high level of incomes. The data is also confirmed by the legal status. In fact, the corporations are concentrated within the innovators group. In this regard, this type of legal status costs more than the one for partnership, and for sustaining the effort farms need to account sufficient resources in terms of revenues. This consideration allow answering the question coming from the previous analysis: in this innovators group ICT seem to push the incomes. Early adopters are characterized farmers aged between 35 and 50 and farming lands between 11 and 50 hectares. In that case, the growing of the farm dimension seems to pull ICT tools for managing the growing data complexity. Conversely, the group where age corresponds to the level 2 and the UAA to the level 3, even though is represented by a niche of respondents, it is another cluster of innovators. Therefore, the boxplot clustering analysis goes through the data catching more details than the first one. As a result, the innovators' cluster is morphologically more various than the one emerged from Table 2. Finally, laggards (or not innovators) are featured by the oldest classified farmers, not interested in introducing ICT devices in farm processes.

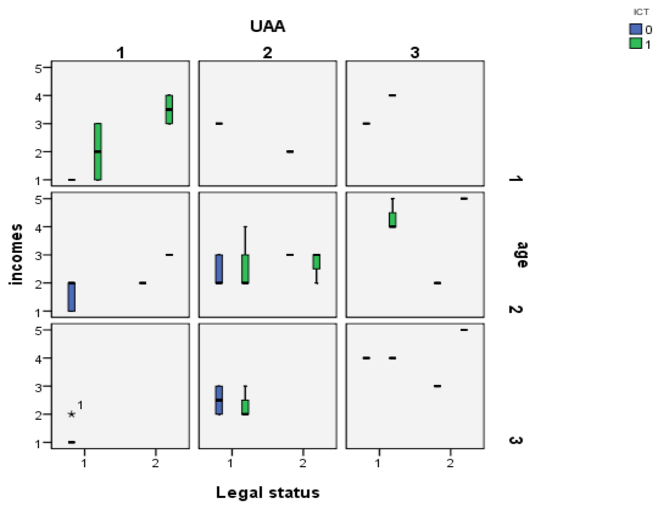


Fig. 2. Boxplot grouping clusters according to age and UAA.

6 Conclusions

This article mapped the profile of farms in Lucania region, putting in the spotlight good practices in terms of smart devices used for improving the efficacy and efficiency of the farms decisions and daily actions. Practitioners can optimize processes rising to be considered good practices when they reduce the inputs and improve the outputs, becoming increasingly revenues. In addition to previous reasons inspiring this study, the survey was also aimed to show good practices adopted by Lucania farmers. The goal fits with the objectives of the H2020 (EC, 2015) project Shot Supply Chain Knowledge Innovation Network (SKIN), granted by European Commission and started on the 1st November 2016. The project consists in collecting good practices operating in short food supply chain and involving them in European building network in order to boost and facilitate knowledge transfer and real innovation uptake. The metrics indicators referenced within the project activities for collecting good practices, points out that farms raise to be good practice also if adopt smart tools, such as ICT tools, for improving the economic, environmental and/or social sustainability. Grouping collected data in clusters allows identifying the most significant features qualifying smart organizations. The innovators and early innovators are ready to get into the network providing their experiences and gaining from other farms experiences. On the other hand, laggards can benefits after network will be built and synergies will be engaged. They can align their profile to the smarter ones. Innovators in terms of ICT adoption are mentioned like the ones able to promptly fit farm' activities to the environmental complexity and thence the ICT tool play an important role in moving to that category due to they return efficiency and efficacy (if they are rightly implemented). By contrast, laggards, even though the growing environmental complexity (external factors deflecting the right activities implementation if not correctly managed) do not adopt solution to make simple processes. However, innovations come up to be needed in rural and agro-food transition to allow farms becoming economically sustainable. Such necessity is implied in the farm size that is mainly medium-small and it reduces the competitiveness in findings profitable markets. The agricultural shocks are going to increasingly be frequent due to the market uncertain. ICTs facilitate the information management and the shock control.

Finally, this study considered a small sample of farms from Metaponto' area where are mostly concentrated agricultural activities. It appears, obviously, as weakness. Nevertheless, it has been tried to look at the composition of the sample interviewing three different types of farms according to the Crop Type (tree crops, herbaceous and mixed).

Going back through the study, Lucania region presents different profile according to the ICT devices uses within farm activities. Looking beyond the simple technology adoption or not adoption, there appear barriers preventing the innovation access and/or not enabling a real uptake and opportunities exploitation.

The next step of this work consists in:

- checking the results with a bigger sample;
- going through the barriers and investigating detailed reasons limiting and constraining ICT adoption.

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