Adoption of Information and Communication Technologies among Farmers in the Region of West Macedonia

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Abstract. Knowledge is an increasingly significant production factor in modern agriculture. Information and Communication Technologies (ICTs) can accelerate agricultural development by facilitating knowledge management. Landholders in rural areas keep expanding the use of ICTs and specifically Internet. This is mainly due to the increased availability of hardware, software and communications infrastructure at reasonable cost. However, it is unclear if the benefits of adopting ICTs relate just to cost reduction or to production gains and improvements in marketing opportunities. The study aims to evaluate the adoption of ICTs among farmers in the region of Northern Greece.

Keywords: Information; Communication; Agriculture; Adoption; Precision Farming; Categorical Regression Model

1 Introduction

During the last decade, despite problems, a range of opportunities provided by scientific research and technological advances emerged (Baily and Lawrence, 2001; Jorgenson, 2001; Litan and Rivlin, 2001; Oliner and Sichel, 2000). Advances have occurred based on improved productivity and changes in the labour and capital markets. Such advances are partly due to the integration of computing hardware and software into production processes, the development of new services and products (including the Internet), and the improved linkages between businesses and consumers (including e-commerce).

Furthermore, novel ways of applying mounting information in decision making in agriculture and the extension of the ability to control operations automatically emerge. These techniques can be grouped under the general heading of Precision Agriculture (or Precision Farming) which includes livestock production as well as the spatially-variable field operations using the Global Positioning System (Cox, 2002).

In the United States, the proportion of farmers with access to ICTs had risen from 13% in 1997 to 29% in 1999 (Just and Just, 2001). By June 2000, 58% of Australian farms had computer access and 34% had Internet access (Australian Bureau of Statistics, 2000). The high

rates of technology adoption indicate that farmers are gaining real benefits from using ICTs and that they judge the benefits to be greater than the costs of time, money and frustration involved in adopting new technology (Rolfe *et al.*, 2003). However, there has been little work to identify and quantify these benefits and costs.

Two reasons can be identified as to why farmers take up ICTs. Firstly, ICTs can lead to improved productivity and therefore this might be important in achieving further growth in agriculture (Rolfe *et al.*, 2003). Second are the farmers' expectations of the net benefits. These goals are not easily achievable. It is difficult to identify transactions that occurred electronically, or to apportion actions and transactions that have an electronic component (Fraumeni, 2001). Besides, many of the benefits and costs relating to information technology are not priced in markets. Non-priced benefits range from free products available on the Internet to the social benefits in isolated areas due to e-mail access. Non-priced costs include the additional time spent on solving problems, and the potential for harmful events like virus infections or data loss (Rolfe *et al.*, 2003).

The aim of this study is to examine to what extent farmers have been adopting ICTs in the Region of Western Macedonia. In particular, technologies which have already been adopted by farmers are explored. In addition, particular attention is given to the farmers' interest in precision agriculture such as global positioning systems (GPS) and their preferences for extension services for the years to come.

This paper initially reviews the diffusion theory. It then moves on to present the methodological background and data acquisition details. Finally, results are discussed and policy implications are deduced.

2 Adoption of ICTs in agriculture

The basic notion which underlines the adoption theory is that potential adopters do not adopt the innovation independently, but instead influence each others' adoption decisions. In a farming context, the more farmers have adopted the innovation, the higher the likelihood that the remaining farmers will also do so. The influence of early adopters (innovators) on later adopters (laggards) is often called "word of mouth communication" (Rogers, 1995). This term refers to a much broader set of phenomena than farmers simply talking to each other. For instance, a farmer might be influenced by another farmer simply by observing his/her behaviour (Kibwana *et al*., 2001). Similarly, for firms, the uncertainty surrounding a firm's adoption of a technological innovation may be reduced when observing other firms' experiences (Ganesh and Kumar, 1996).

One of the first large-scale studies exploring structural implications of the telecommunication age on agriculture was the Office of Technology Assessment report (O.T.A., 1989), predicting major shifts in information sources and channels. According to the study, biotechnology coupled with information-intensive technology would vastly restructure farming, leading to fewer and larger farms that would be vertically linked throughout the food chain. Farmers would be vertically linked within a commodity chain and receive all inputs, including information, within the chain system, reducing or eliminating outside suppliers, such as extension services. Farming in today's information-intensive world can be supported by obtaining information via an array of electronic communication technologies, personal computers, GPS, internet, fiber optics etc. Hence, "new age" technology may improve farm families' access to diverse information and result in better coordination between food processors and marketers.

Lasley *et al.* (2001) have sought to discern farmers' opinions about new technologies. In their study, nearly 2,400 Iowa farmers voiced opposition to such technologies. Also, 40% of the farmers expressed opposition to robotics (defined as computer-assisted

machinery for on-farm use); 30% and 20% of them oppose to confinement livestock facilities and to the use of personal computers respectively.

Several other researches have probed the acceptance of ICTs (Rivera, 2000; Rogers, 1995). Audirac and Beaulieu (1986) explored the adoption and diffusion of microcomputers in farming identifying a large number of personal and institutional constraints. Hoban *et al.* (1992) examined the adoption of ICTs by farmers and their impacts on the traditional extension information delivery approaches.

3 Methodological and Data Background

The West Macedonian Region (Figure 1) is located in the northwest part of the Greek state and represents the natural gate of Greece to the northwest borders and especially to Albania and to the Former Yugoslavian Republic of Macedonia (FYROM). The landscape of the region, accounting for 7.2% of the country's surface, mainly consists of highlands (69.2%), forest areas (26.0%), rangelands (43.0%) and cultivations or fallow lands (24.0%).

Fig. 1. A map of West Macedonian Region

The purpose of this research is to identify the extent to which farmers have been adopting ICTs and to determine the importance of agricultural extension as an information source in the study area. In particular, ICTs that farmers have already adopted in their farming practices are explored. In addition, particular attention is given on farmers' interest in precision agriculture methods.

The collected data relate to the farmers use of ICTs and the nature of their enterprise. Demographic and attitudinal information was also collected. The key questions concern the value of ICTs use in their business according to a number of factors including the use of accountancy records as well as the use of online banking. To encourage participation and

minimise the cognitive burden on respondents, most questions were framed with *Likert* scale intervals.

The list of potential respondents was compiled from several sources. These comprised lists of members of cooperatives and lists of beef producers obtained by the regional authorities including producers with more than 20 heads. Participants were selected at random from the compiled lists

Data were collected through a mail-out/telephone response format. All surveys were mailed out in batches of 30 per week from January to March 2007. Respondents were contacted by telephone in the following week and asked if they would like to participate. Respondents could either complete the forms in their own time and return them by post, or respond over the telephone. By June 2007, 160 responses had been received from 500 questionnaires issued. There were another 34% of respondents who indicated that they did not use ICTs and that the survey was not relevant to them, giving an overall response rate of 66.0%.

Statistical analyses were performed using S.P.S.S. for Windows version 14.0 (Statistical Package for Social Sciences, 2005). The focus of the analysis was on producing overall descriptive statistics as well as correlating the usage of ICTs with the characteristics of the respondents. The Categorical regression model was also used to handle optimally transformed the categorical variables and to predict future use of ICTs.

4 Results

Reliability analysis (Bohrnsedt, 1977; Statistical Package for Social Sciences, 2005) for the twenty ICTs items was firstly performed to determine the extent to which these items are related to each other to get an overall index of the internal consistency of the scale as a whole and to identify items that had to be excluded from the scale. In fact, only two items (wireless connection system and pager) were excluded consequently from the total number of fourteen items. Table 1 shows the presence of available ICTs in farms.

Table 1. ICTs on farms

	Responding "Yes"
Television	*96.87% (155 respondents)*
Tone telephone	*88.75% (142 respondents)*
Cellular telephone	*82.50% (132 respondents)*
Personal Computer	*45.62% (73 respondents)*
Printer	*30.62% (49 respondents)*
Answering machine	*22.50% (36 respondents)*
Internet or e-mail capacity	*13.75% (22 respondents)*
FAX machine	*10.00% (16 respondents)*
Cable television	*7.50% (12 respondents)*
DSL Internet	*5.00% (8 respondents)*
Satellite TV dish	*2.50% (4 respondents)*
Global positioning system (GPS)	*1.25% (2 respondents)*

The value of Cronbach's alpha (α) reliability coefficient was found equal to 0.88, indicating that the ICTs scale is reliable to accept. Friedman two-way analysis of variance, with x^2=2,631.69 (α=0.00) and Hotelling's T^2=1,069.29 (F=36.48 and α=0.00), indicated the significance in differences of item means.

Having accepted the consistence of the twenty items, the average rankings for each respondent were used as numerical values of the dependent variable "ICTs" along with categories of nine independent variables shown in Table 2.

Table 2. Selected independent variables

Independent variables	Type	Categories
Classification of farmers	Ordinal	1=no tech, 2=low tech, 3=medium tech, 4=high tech, 5=very high tech
Familiarity with precision farming	Ordinal	1=not familiar, 2=somewhat familiar, 3=very familiar
Interest of precision farming	Ordinal	1=not interested, 2=somewhat interested, 3=very interested
Use of precision farming	Ordinal	1=no plans to adopt, 2=plans to adopt within 5 years, 3=have already adopt
Gender	Nominal	1=male, 2=female
Age	Ordinal	1=under 35, 2=over 35
Years of Education	Ordinal	1=none, 2=two or less, 3= from three to four, 4=from five to six, 5=seven or more
Annual income	Ordinal	1=less than 10,000€, 2=10,001€-15,000€, 3=15,001€-20,000€, 4=20,001€-25,000€, 5=more than 25,001€
Farming time	Ordinal	1=full time, 2=part time

Categorical regression (Kooij and Meulman, 1997) was used to handle optimally the transformed categorical variables. It yielded an R of 0.92 indicating moderate relation between the "ICTs" and the group of selective predictors. However, since R^2=0.8464, it is indicated that 84.64% of the variance in the transformed "ICTs" rankings is explained by the regression of the optimally transformed variables used. The F statistic value of 7.42 with corresponding α=0.00 indicates that the model is performing well.

Standardized coefficients (Table 3) indicate that the transformed variables "classification of farmers", "annual income" and "gender" aresignificant in pointing out possible effects on "ICTs". In fact, from the zero order correlation coefficients between transformed predictors and the transformed response we get a better understanding of how these predictors are doing.

Table 3. Categorical regression coefficients and other statistics

Independent variables	Standardized Coefficients		F	Correlations			Importance	Tolerance	
	Beta	St. Error		Zero-order	Partial	Part		After	Before
Classification of farmers	**-0.29**	0.05	22.80	-0.39	**-0.27**	**-0.25**	**0.12**	0.87	0.85
Familiarity with precision farming	0.10	0.07	2.20	0.36	0.08	0.07	**0.10**	0.66	0.64
Interest of precision farming	0.01	0.05	0.09	0.21	0.01	0.01	0.01	0.94	1.00
Use of precision farming	0.02	0.06	0.31	0.07	0.02	0.02	0.01	1.04	1.11
Gender	**0.14**	0.06	2.40	0.28	0.08	0.08	**0.09**	0.89	0.96
Age	0.05	0.06	1.47	0.10	0.07	0.05	0.02	1.13	1.22
Years of Education	0.04	0.07	0.05	0.24	0.00	0.13	**0.23**	0.68	0.72
Annual income	**0.21**	0.08	8.86	0.38	0.19	0.16	**0.27**	0.82	0.88
Farming time	-0.03	0.06	0.62	-0.13	-0.03	-0.03	0.01	1.12	1.19

Partial correlation coefficients indicate that, removing the effects of other variables, "classification of farmers" explains about 7.29 percent [or $(-0.27)^2$] of the variation in the "ICTs" factor. The rest of the variables explain smaller portion of variance if the effects of the other variables are removed. Moreover, by removing the effects of other variables from "classification of farmers" the remaining part of this variable becomes smaller, about 6.25 percent [or $(-0.25)^2$].

However, the relative importance measures (Pratt, 1987) of the independent variables show that the largest importance to predict "ICTs" corresponds to "annual income" accounting for 27%, followed by "years of education" (23%), "classification of farmers" (12%), "familiarity with precision farming" (10%) and "gender" (9%). The five variables' additive importance accounts for about 81%. Finally, the tolerances of all variables are high enough to assure exclusion of the multicollinearity problem (Table 3).

According to the descriptive statistics analysis the use of e-mail and social and recreational uses are rated highly by farmers, followed by weather, education and online banking (Table 4).

Table 4. Different categories of ICTs use

	None (1)	*Low (2)*	*Medium (3)*	*High (4)*	*Very high (5)*	*Median score*
E-mail	2	1	3	6	10	**3.95**
Weather	8	2	2	4	6	**2.91**
Technical	12	3	4	1	2	2.00
Market info	10	4	3	2	3	2.27
Education	5	8	2	3	4	**2.68**
Online banking	9	5	3	2	3	**2.32**
Social and recreation	2	2	3	8	7	**3.73**
Buying	12	2	5	3	0	1.95
Selling	18	0	0	2	2	1.64
Own web site	20	0	0	1	1	1.32

Respondents were also asked to rate the advantages of ICTs use. The results (Table 5) show that the majority of respondents viewed the ICTs as being of low value to them. Among the reasons that ranked higher in the perceived advantage in ICTs use were "better information decision-making" and "greater clerical efficiency" (less paperwork)

Table 5. Perceived advantage in ICTs use

	None (1)	*Low (2)*	*Medium (3)*	*High (4)*	*Very high (5)*	*Median score*
Better information	30	14	52	45	19	**3.06**
Less paperwork	67	24	38	17	14	**2.29**
Improved customer	80	48	21	5	6	1.81
Faster supply of goods in	107	29	17	5	2	1.54
Better inventory control	128	14	18	0	0	1.31
Reduced costs	103	27	19	8	3	1.63
Service differentiation	71	45	21	19	4	2.00
Competitive advantage	112	24	10	12	2	1.55

The survey also included the following description of precision farming. *"Precision farming, or site-specific farming, is a way of looking at farms, fields, or specific areas within fields through use of information management systems."* Farmers were asked about their familiarity with precision farming, their level of interest in it, their intention to adopt it within the next years and potential benefits of precision farming. It was thus found (Table 6) that 30% of the farmers are very familiar and 56.25% of them are somewhat familiar with precision farming. Likewise, their level of interest in precision farming is reflected in their level of familiarity with technology. More than one-third (33.75%) of the farmers indicated an interest in the technology and about one-fourth of the farmers (25.62%) have already adopted precision farming.

Table 6. Farmer's familiarity with precision farming

	Percent	frequencies
Level of familiarity		
Not familiar	13.75	22
Somewhat familiar	56.25	90
Very familiar	30.00	48
Level of interest		
Not interested	22.50	36
Somewhat interested	43.75	70
Very interested	33.75	54
Level of use		
No plans to adopt	54.37	87
Plan to adopt within next years	20.00	32
Have already adopted	25.62	41

Furthermore, farmers were asked to indicate whether agricultural extension services should place "less emphasis", "the same amount of emphasis" or "more emphasis" on fourteen ICTs delivery approaches (Table 7). Farmers are slightly more likely to prefer local educational meetings or seminars (56.88%). In addition, farmers are also likely to place emphasis on: involvement on applied research 55.63%, printed bulletins 44.38% and phone help lines 41.88%.

Table 7. Preferred educational delivery methods for farmers (indicating "more")

	percent	frequencies
One-to-one consultations	48	30,00%
On farms demonstrations	62	38,75%
Local educational meetings or seminars	91	**56,88%**
Prefectural educational meetings or seminars	28	17,50%
Regional educational meetings or seminars	44	27,50%
Farmer involvement on applied research	89	**55,63%**
News and reports via the farm media	43	26,88%
Phone help lines	67	**41,88%**
Printed bulletins	71	**44,38%**
Training with farm supply dealers	58	36,25%
Video tapes	11	6,88%
Computer assisted instructions	36	22,50%
Interactive video conferences	16	10,00%

5 Conclusions

ICTs have helped to transform the non agricultural sectors of developed economies and drive real productivity gains. In recent years, agricultural enterprises and farms have adopted ICTs, suggesting that farmers are gaining real benefits from employing those technologies in their farms. However, these benefits have been difficult to identify and quantify.

In this paper, survey information has been analyzed using categorical regression models and descriptive statistics. Neither cost and time savings nor production gains, resulting from access, are able to be identified by the farmers. However, the statistical analysis identified that high value rating for ICTs appeared to be associated with the use of e-mail, electronic banking, education, weather and social and recreational uses. There are also examples of individual producers who use ICTs in innovative ways to reduce paperwork and to obtain access to better information.

This paper aims at contributing to a better understanding of the impact of adopting ICTs in farming. Findings support that farmers, though very apt at adopting new technologies, desire to maintain at their disposal a wide range of information delivery channels. However, farmers are reluctant to abandon any of the delivery methods provided by the extension services. Instead, it seems that their ability to receive information via ICTs may further enhance desire to enrich current delivery approaches.

Furthermore, findings suggest that regardless of the number of sophisticated ICTs available, there is a strong preference for personal communication. The preferred emphasis for local educational meetings and farmer involvement in applied research underscores the importance of personal communication. The proliferation of information channels could add to or complement personalized delivery approaches.

The analysis presented focuses on the examination of the extent to which farmers have been adopting ICTs in a specific Greek mountain region but has not included cross-region differences. Future cross-region or cross-country research on this issue would be a useful complement to the results presented here.

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