University doctoral (PhD) dissertation abstract

THE DIFFUSION OF ICT INNOVATIONS IN SMALL FARMS

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1. THE ANTECEDENTS AND OBJECTIVES OF THE RESEARCH PROJECT; HYPOTHESES OF THE RESEARCH

My first experience of the internet dates back to 1997, when I was a freshman at the agricultural university in Gödöllő. From the very start I had taken an interest in the impact new information and communication technologies (ICT) exert upon society, so after I graduated, I did not hesitate to take the opportunity to become acquainted with the research conducted in this field and to master the fundamentals of sociology in a social science-oriented organisation (BME-ITTK; the Information Society and Trend Research Institute of the Budapest University of Technology and Economics), opening up a world that was quite distant from my agricultural studies. From the second half of the 2000s it was my ambition to bring these two worlds closer together, all the more so since the impacts of the information society had steadily increased during this period, and today's development projects confirm that they have led to significant changes in the agricultural sphere too. By now ICT has apparently penetrated the agricultural production processes and farm management tasks.

The diffusion of ICT is taking place as we speak; however, it is necessary to understand the characteristics of these processes in order to effectively exploit the potential inherent in infocommunication devices (this potential primarily aimed at increasing efficiency). This is especially true in the case of small farms that do not and cannot maintain a separate apparatus that would carry out management tasks. The Hungarian agricultural strategy clearly set itself the objective of strengthening small family farms, and informatics is indispensible in realising this aim. The importance of ICT is also emphasised by the National Infocommunication Strategy; hence, the development of agricultural informatics (providing solutions to small farms) is at the cross-section of several national economy priorities.

In light of the above, the study of ICT innovations gaining ground and their possible introduction into daily management practices is justified in several respects. One of these is the highlighted role agriculture plays in the Hungarian national economy as well as in the shaping of rural society. Also, by exploiting the use of ICT solutions can be given to problems that have been burdening the agricultural sector for a long time, these including the need to increase efficiency and information deficits observable at several levels. Researching this theme is also necessitated by the fact that while we have an increasing

amount of data at our disposal in regard to the computer and internet use of Hungarian households and businesses, as well as to its quality, frequency and the role it plays in the daily management of life or in the success of a business, studies conducted about the computer and internet use of Hungarian farmers as well as about their openness to ICT use and their user habits are rather sporadic: the existing studies only address narrow segments of the area and recent, general data can basically only be gained from the reports of a few pages published by market research companies. It is especially important to study those small-sized farms whose daily sustenance, or a significant part of it, is provided by farming (the number of such farms is in the tens of thousands); however, since these are typically family run farms, their analysis cannot be based merely on an economic basis as the person who runs the farm is of at least the same importance.

1. Based on the above, my first objective is to explore the attitude farmers have to generally used ICT innovations (computers, internet, smart phones). I start from the premise that Hungarian farmers are no different to the general Hungarian population in regard to their acceptance and willingness to start using these so-called general purpose technologies that can be utilised in several areas of life. Hence, in this context the personal qualities of farmers play a more important part in adaptation than the agricultural activity they pursue.
2. My second objective, closely linked to the first one, is the examination of the information environment of farmers. The exact role of ICT means can only be fully assessed if we are familiar with the information processes in farms and the sources of information available to farmers. New technologies and solutions must be integrated into the already existing processes, thus it is crucial to know what sources are preferred by a farmer in attaining information concerning farming, and it must also be explored if distinct groups with clearly delineable attributes can be identified within the farming society based on preferred sources.
3. My third objective is to explore factors that determine and influence the diffusion of innovations; that is, to examine what primary and latent influences shape farmers' decisions in regard to using ICT-based innovations. During my analysis I strove to make a distinction between the already mentioned general purpose technologies and

those used with an agricultural purpose (I studied the latter primarily through the use of agricultural software).

4. My fourth, and last, objective is to establish the causal relations between the influencing factors I found, i.e. to construct and test a model that can lead to a deeper understanding of the further interpretation of the diffusion of ICT-based innovations in agriculture. Here I make the presumption that general purpose ICT use acts as a kind of gateway to agricultural ICT use, and that intensive ICT accompanied by an increasing compatibility between ICT-based information management and farming practices will result in a more intensive agricultural ICT use.

I have formulated four hypotheses based on the four objectives:

H1: In the case of general purpose information technologies the adaptation pattern of farmers and the diffusion of these technologies follows/complies with the values for the entire Hungarian population, not differing from it to a significant extent.

H2: Based on their preferred sources of information farmers can be divided into distinct groups, each having specific attributes (**H2.1**), and these groups take a different approach to the use of information technology (**H2.2**).

H3: Factors impacting the diffusion of ICT innovations can be separated into those dependent on farmers and farms, and other, latent influencing factors that differ in agricultural and general purpose ICT use.

H3.1: The personal attributes of the farmer (age (-), qualifications (+), agricultural qualifications (+)) impact the diffusion of ICT innovations

H3.2: The parameters of the farm (size (+), location (-), complexity (+), revenue (+), profitability (+), service provision activity (+)) impact the diffusion of ICT innovations.

H3.3: The openness of farmers and some latent innovation-related factors may accelerate ICT diffusion (openness to innovation (+), perceived usefulness (+), self-confidence/ease of use (+), observability (+), compatibility with agricultural practice (+)).

H4: The latent factors included in H3.3 form a structure which, supplemented by the intensity of general purpose information technology use, impact the agricultural use of ICT and its intensity in a certain kind of 'accumulation' structure.

Important conclusions can be drawn in regard to the design, introduction and operation of information services provided to farmers by answering the above hypotheses and by examining the spreading of innovation as well as the fundamental relations of information management. The results of this and other, similar research projects may be utilised on several levels: they can contribute to the strengthening of the already mentioned strategic approach, while they can also be helpful for the agricultural administration and for those providing information technology-based services to farmers in the provision of new information services and in enhancing the efficiency of existing services.

2. THE DATABASE AND THE METHODS APPLIED

During my research I used qualitative (focus group interviews) and quantitative (with questionnaires) methods in the various phases of the research project.

2.1. The qualitative (exploratory) research method

Using focus groups is a form of exploratory qualitative research and I chose the method to validate my findings from the literature review. In this method a group of generally 8-10 (but 6 at minimum) people from a selected target group is invited for a joint discussion of 1 to 2 hours. The main advantage and the objective of this kind of research is for the participants to form attitudes during the joint discussion of their individual experience – ones they would not necessarily do under other circumstances – thus enabling a more in-depth understanding of attitudes and behavioural intention and a more efficient exploration of their motivation. In my research three groups were organised; the members were recruited during the mandatory training courses held by the colleagues of the GAK Non-profit Ltd. about the funds for the New Hungary Rural Development Plan (ÚMVT). The discussions took place in March and April 2011, i.e. after the training: one in Jászkarajenő and two on the premises of GAK in Gödöllő with a total of 19 participants (14 men and 5 women). The participants of the three groups took part in the training because they applied for various types of support under the Common Agriculture Policy (participants in the Natura 2000 Agricultural Environmental Management (AKG) programme, and applying for support for irrigation/meliorisation investment), so they had different characteristics, which was one of the objectives when I organised the focus groups to gain data about as wide a circle as possible. The first group comprised mostly of owners of small farms with an area falling under the scope of the Natura 2000 ecological network; that is why they had to enrol in the training, while the members of the other two groups were owners of farms that applied for development or environmental support. The majority of the farmers in the second group owned 30-110 hectares with ploughland, grassland and animals. The irrigation investment was used by seed manufacturing companies, as well as fructicultural businesses and larger family farms. In regard to their age the participants were evenly distributed: there was an approximately similar number of young and middle-aged people and those over sixty in the three groups. In regard to education, however, the overwhelming majority of the participants

held higher education degrees, apart from the first group, where only two members held such a degree.

The discussions were not exclusively centred on ICT use but sought to identify the various channels based on the flow of information. It also compared the scope and source of information required by farming with those available to farmers, and explored the potentials in the internet and other ICT tools, while measuring the efficient use of ICT and validating the domestic presence of factors proposed in literature as having an impact on innovation.

2.2. The quantitative (with questionnaires) research method

I analysed a database based on a questionnaire survey conducted in May and June 2015 in Hajdú-Bihar county with the cooperation of the county directorate of the Hungarian Chamber of Agriculture (NAK). The delivery and filling in of the questionnaires by the farmers was assisted by the experts of NAK's agriculture extension network ('Falugazdász' in Hungarian). According to my previous knowledge, each extension worker has an approximately similar number of clients, so every officer distributed the same number of questionnaires and they were instructed to have the clients arriving at their next consultation fill them in (and if there are not enough clients, then have the rest filled in during the next consultation session). Hence, the surveyed population was the circle of farmers registered in Hajdú-Bihar county, and the method used a quota-based sampling combined with accidental factors.

The questionnaire had 45 questions seeking to cover all the factors considered as relevant by literature. The first section contained questions about ICT tools and internet use (also asking about the functions used and the frequency of their use in the case of mobile phones). The second section was aimed at examining the attributes of internet and computer users (the beginning of the use of the technology, accumulated experience, the evaluation of their own IT skills, the extent of support) as well as the form and frequency of use, also focusing on various agricultural software programmes and agriculture-related applications. In the case of the latter I devoted special attention to communication, information and transaction services. In this same section those who do not use the internet were asked why they opted for non-use. The third section started with questions about the sources of information necessary for farming, followed by questions in regard to the various factors impacting

innovation, i.e. questions about one's social network and approach to innovation, the reliability of online content, and the perceived usefulness, the ease of usage, observability and compatibility. The last two sections of the questionnaire were devoted to the given farmer's socio-demographic and farming-related attributes and asked for the description of the farm he or she owned.

2.3. Methods used to analyse the database, and the research model

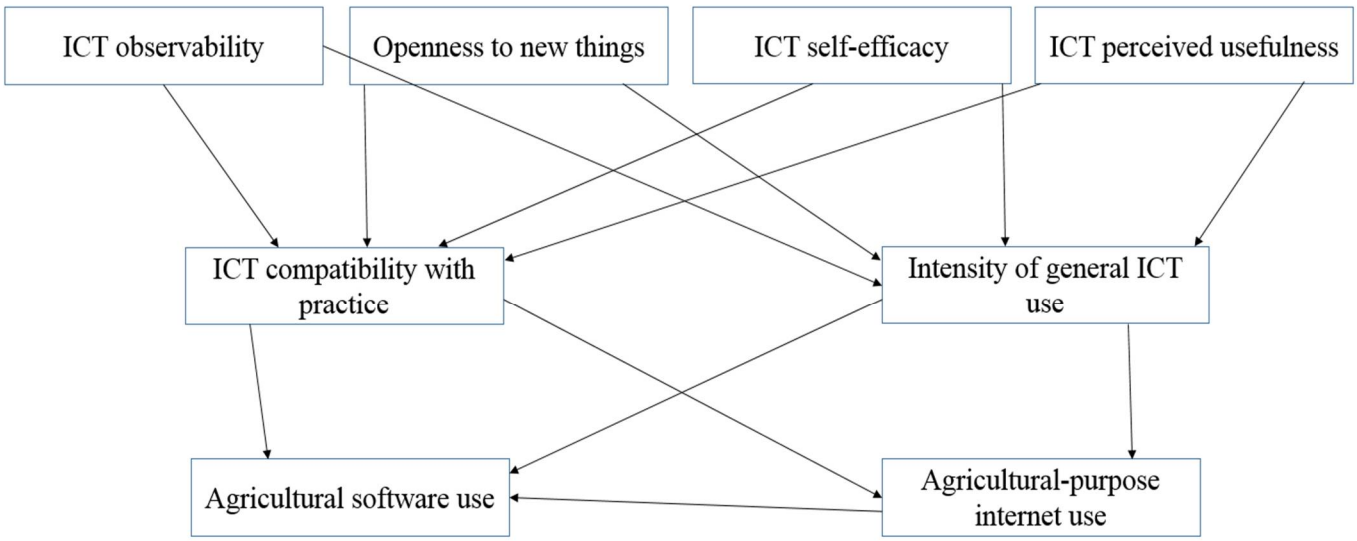
Out of the 200 questionnaires that were handed over, a total of 148 were suitable to be evaluated. I recorded the information included in the questionnaire electronically, and ran a consistency check. I then converted the records into the SPSS statistical programme, where I completed the required data cleaning tasks along with the filtering out missing/contradictory data, while altering the existing variables (necessary for logical and/or distributional reasons) into ones that can be better used in the analysis. I used version 23 of AMOS to run examinations in relation to the model of structural equations.

I used several methods to analyse the primary research data. I did a correlation calculation to establish the correlation between the selected variables (Pearson's chi-squared test for nominal variables, and a t-test for interval scale variables). I used a special case of factor analysis, called main component analysis, to produce factors used for the necessary data reduction, dimension reduction, and structural equations model. Based on the results I gained during the principal component analysis of preferred media, I divided the farmers into groups with the help of cluster analysis using hierarchical clustering, which is aimed at gradually decreasing the number of groups by merging at every stage of the process those two groups that are in the closest proximity to each other and show the greatest similarity. I applied the squared Euclidean distance to determine the distance between the objects, and I chose Ward's method aimed at minimising the total within-cluster variance.

I used path analysis, a special case of Structural Equation Modelling (SEM), to explore the correlation between influencing factors. With this method, widely applied in the social sciences, the latent correlations between variables created from the observed variables are identified, while the direct and indirect impact of different variables are also established. According to my research model (fig. 1), constructed based on literature and my focus group exploratory research, the diffusion of ICT innovations can be understood as an accumulative

process: the basic openness of farmers, their approach to innovation, and the factors that influence the diffusion of innovations (ICT observability, ICT self-efficacy/perceived ease of use, perceived usefulness) determine what ICT tools farmers will use. However, in the agricultural use of ICT, ICT compatibility (with farming) and the intensity of general ICT use (measured in the model by an indicator index containing mainly the frequency of cell phone use and various internet-related activities) play a key role, since these variables exert a strong influence on the aforementioned factors: the more compatible computer/ICT use is with the everyday practice of farming and the more intensively these tools are integrated into a farmer's daily information management practice, the greater the chance that these tools will also be used in the given farmer's daily management activities. Thus, the model contains two dependent variables: the level of agricultural computer software use, and the agricultural purpose internet activities, from which I created an index. The assumption in the model is that agricultural purpose internet use (mainly for gathering information) also influences agricultural purpose computer use, i.e. thee is a causal relation between these two dependent variables too.

Fig. 1. The path model for the diffusion of agricultural ICT innovations



Source: own research

3. THE MAIN STATEMENTS OF THE DISSERTATION

3.1. The findings of the focus group research

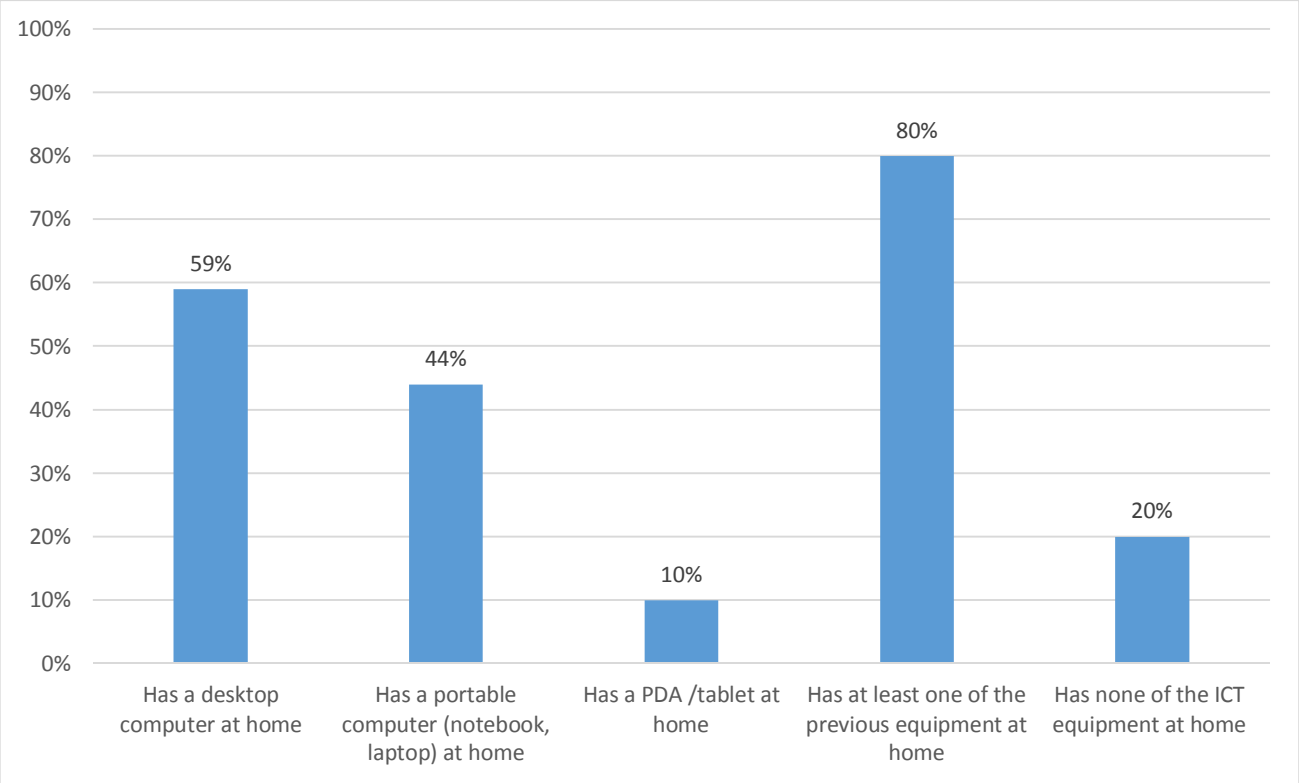
It became clear during the focus group interviews that the results contained in professional literature about the diffusion of ICT in agriculture hold strong relevance to the Hungarian situation too. There are differences in regard to ICT use, and thus in information strategies depending on the attributes of a farmer and a farm (mainly the level of education, the size of the farm and the objective of farming). An unexpected finding was the impact exerted on ICT use by other workplaces; this element, along with the level of education, significantly counterbalanced the role played by age, at least in the focus groups. The key attributes laid down in theories on the diffusion of innovations are confirmed by my research too and are mainly applicable to the following: compatibility with existing practices, relative advantage, usability, trialability, and the degree of support. Similarly to international literature, my research unambiguously shows that the potential inherent in ICT is not fully exploited in Hungarian agriculture either, in which all stakeholders play a part. Some areas are in an especially critical situation from the perspective of farming; this could be significantly improved by the targeted and appropriate use of information technologies. Another obvious finding is that general purpose and specific ICT use and, eventually, technologies supporting management and production, must be distinguished.

3.2. The main findings of the questionnaire research

3.2.1. The penetration of ICT, applications and the internet

Fifty-nine percent of respondents have a desktop in their homes, while for 44 percent of them a notebook or a laptop is a more accessible solution, and tablets are used by 10 percent (fig. 2). A total of 80 percent of those asked have access to some kind of computer in their homes, and the proportion of those with internet access is the same. The majority subscribed to wired broadband internet (this connection is found in the homes of two-thirds (68%) of those asked).

Fig. 2. Home access to computers (%)



Source: own research

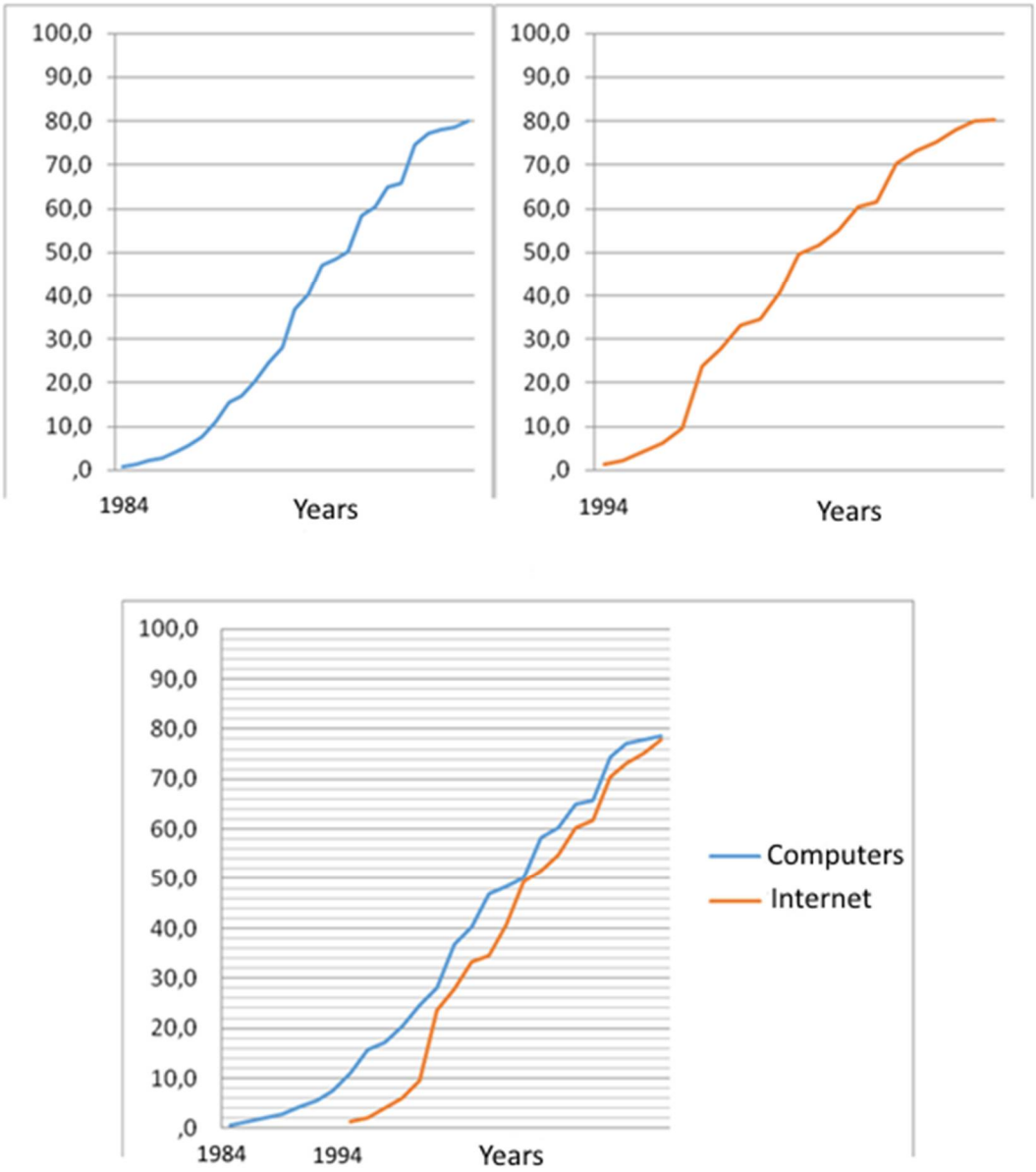
Almost all (95%) of the farmers included in my research have a mobile phone, and the majority use smartphones rather than traditional mobiles (49% of all farmers, of which 4% also have a traditional mobile). This roughly accords with the nationwide data for the Hungarian population. 64% of mobile-owners have a subscription, while one third (31%) use the pre-paid scheme of telephone use, and a small group (5%) has both. The data listed here significantly overlap with KSH (Hungarian Central Statistical Office) data (households with desktop computers: 53%; households with laptops: 45%; households with internet access: 73%; households with mobile phones: 95%), which indicates that the same diffusion process is taking place among farmers as in the rest of the Hungarian population in regard to general-purpose ICT use.

As regards internet use, half of the respondents use the internet on a daily basis, one fifth use it several times a week, and some ten percent use it less frequently than that. These data also accord with the 2014 KSH figures measuring regular internet users (those using the internet in the past one year: 78%, those using it in the past three months: 76%).

As part of the research internet users were asked how long they had been using this technology; the usage curve drawn based on the responses can be seen in fig. 3, with a

clearly visible S curve. The growth of internet use started in earnest in 2000, with the majority of people encountering the world wide web for the first time in the first years of the new millennium; the rise continued at approximately the same pace in 2005-2010, while today the basis for further increase is exhausted, as illustrated by the flattening, i.e. saturation, at the end of the curves. The presented data and the S curve suggest that general ICT solutions among Hungarian farmers follow the same pattern as that observable in Hungarian society, which confirms **hypothesis H1**.

Fig. 3. The uptake of computers and the internet among farmers (%)

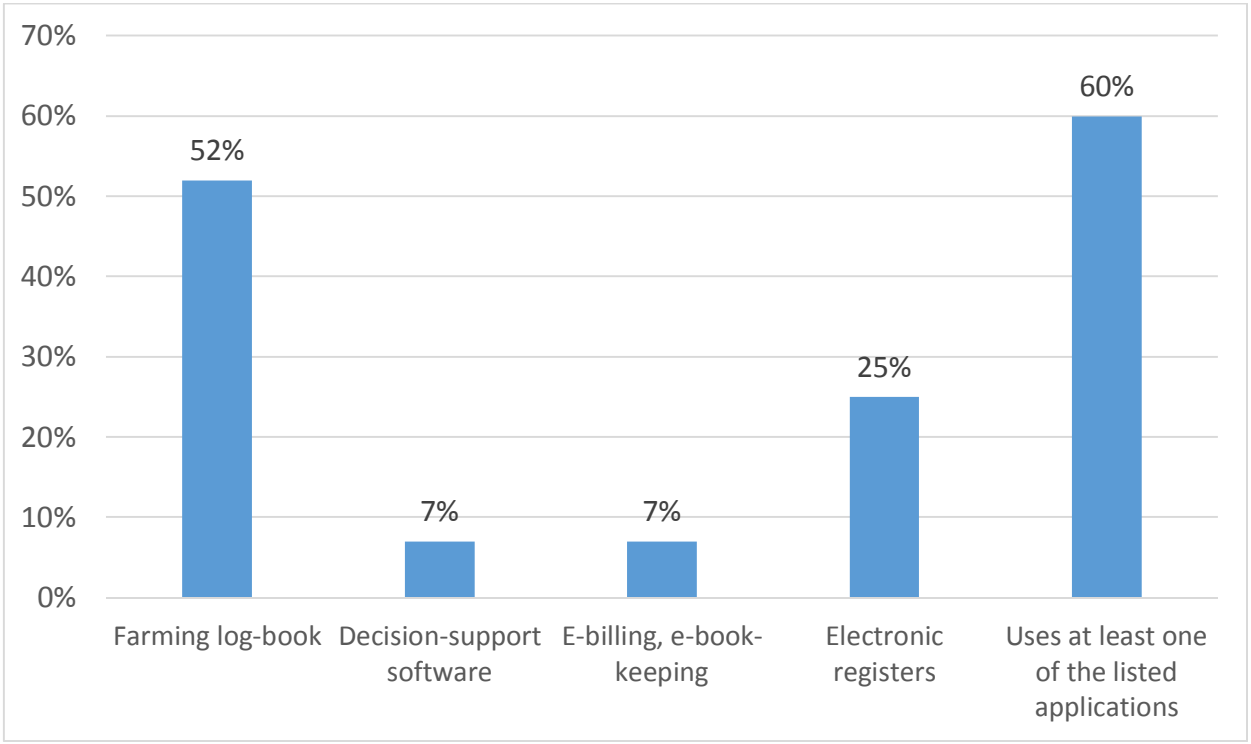


Source: own research

Those who do not use the internet were asked (30 people) during the research why they opted to not use this technology. Every respondent was able to mark the three of the listed

choices that they found as the most important reason. Most of them picked the lack of computer/internet skills (23), and some (9) quoted the lack of a computer/smartphone as a reason. The rest of the answers concerned the usefulness of the internet and negative attitudes to this technology, such as "I do not like computer technology" (12), "I am not interested in the internet" (9), "It is not my way of managing my tasks" (18). In other words, besides relative advantage, complexity and compatibility appear as the reasons non-use (this is referred to as cognitive obstacles in Hungarian internet research, in contrast to financial factors. Only one respondent gave an answer indicating the latter ("too expensive")).

Fig. 4. Agricultural software use (as a percentage of farmers using the internet)



Source: own research

In regard to directly applied agricultural solutions it can be stated that the use of various software programmes supporting the management of farming is also clearly present in a certain group of farmers: half of internet-user farmers use farming log-book software, while a quarter of them keep some kind of electronic register. The wide use of the farming log-book (FL) is somewhat overshadowed by the fact that keeping a log-book is mandatory to apply for certain forms of financial support. However, since these support schemes are not tied to the use of an online FL, it is primarily farmers with a basic openness to ICT who tend to chose this software. The support of e-management and decision-support systems are not yet widespread (fig. 4). To sum up, some form of agricultural software is used by 60% of

computer-user farmers, and 46% of the whole sample (out of this 28%, 14% and 4% of the respondents use one, two or three applications, respectively).

3.2.2. Sources of agricultural information and the personal information space of farmers

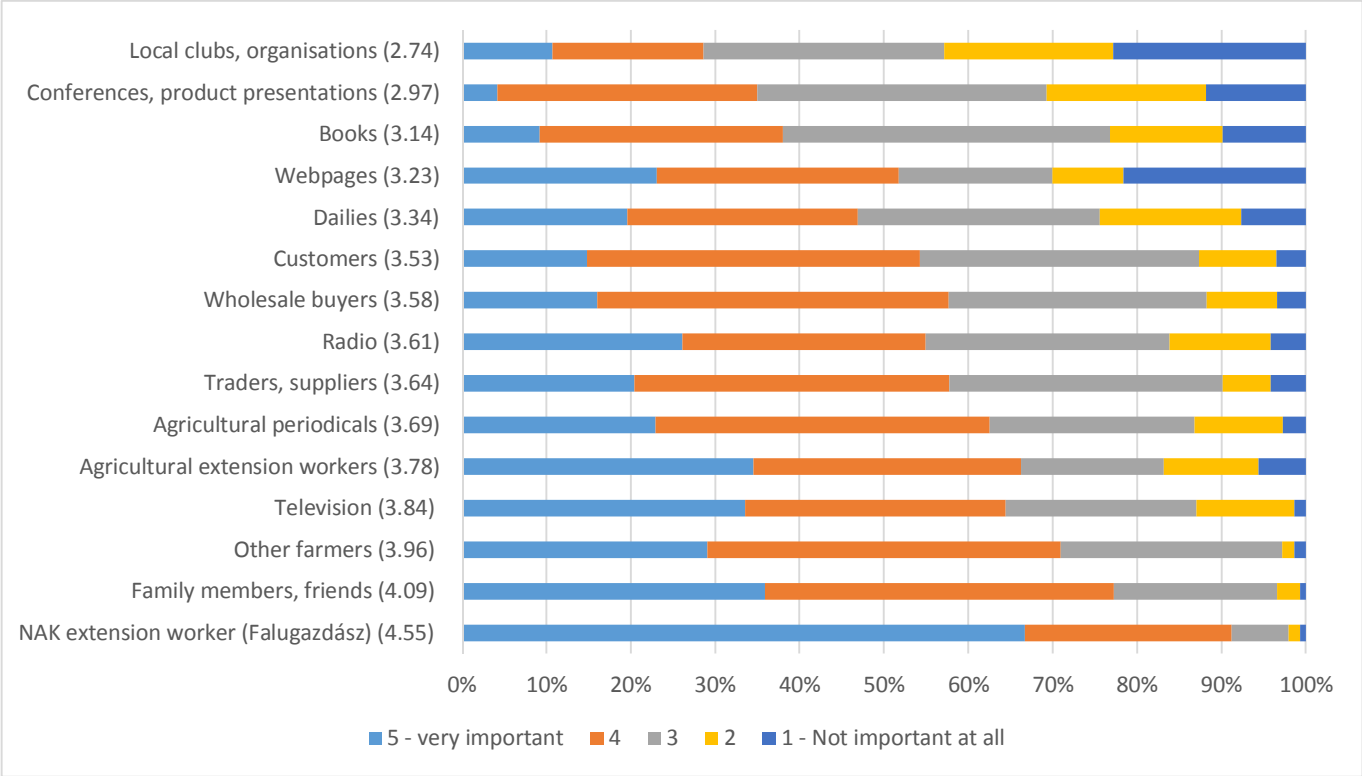
I asked the farmers to evaluate the sources of information they can potentially access, and rate their importance in farming management. Fig. 5 shows the distribution of answers provided; the numbers in brackets after the sources are the average values for the given source. The role of NAK extension workers (Falugazdász) (4.55) as sources of information outweighed all other alternatives, although it might partly result from the sampling method, since the questionnaires were filled in with the help of the extension workers, and even if some of the farmers who went to the rural consultancy office for the questionnaire research are not regular visitors to the office, it is likely that it was those farmers who ranked the role of extension workers in their personal information network in a prominent place who were included in the sample. It could be observed in the focus group research too that extension workers are actually well equipped to provide personalised information to farmers; moreover they render assistance in transaction services and are able to synthesise the benefits of other sources. Television (as mass media, from where general information can be gained about important issues first) is still in the top five choices among preferred and important sources of information in addition to other personal sources of information. Agricultural periodicals also occupy a prestigious place in this regard, while books and other sources providing knowledge transfer in groups are lower in the ranking.

Websites lagging behind came as a surprise, however, it must be noted that this question was also answered by non-internet-users, which negatively impacts the average of this source. After filtering out non-internet-user farmers the average for the internet in this question rises to 3.73, i.e. almost comes on a par with that of agricultural extension workers and specialist periodicals. Based on the answers given, it seems plausible that television continues to be the primary source of gaining information about farms and farming.

As could be seen in the review of the professional literature, several authors claim that there is a difference between the decision-making techniques of farmers, and it is reflected in their media use. In order to confirm this, I conducted an explorative factor analysis in order to

decrease the dimensions of the listed and then divide the farmers into groups based on their preferred media, or preferred categories of media.

Fig. 5. Assessing the importance of various sources of professional information



Source: own research

The analysis revealed the existence of three factors representing clearly distinguishable communication activities:

Component 1: 'Personal professional sources', in which the personal, face-to-face dialogue plays the central role, primarily conducted with professional players (other farmers, traders, suppliers) and to a lesser extent with family members, agricultural consultants and perhaps in the framework of professional events.

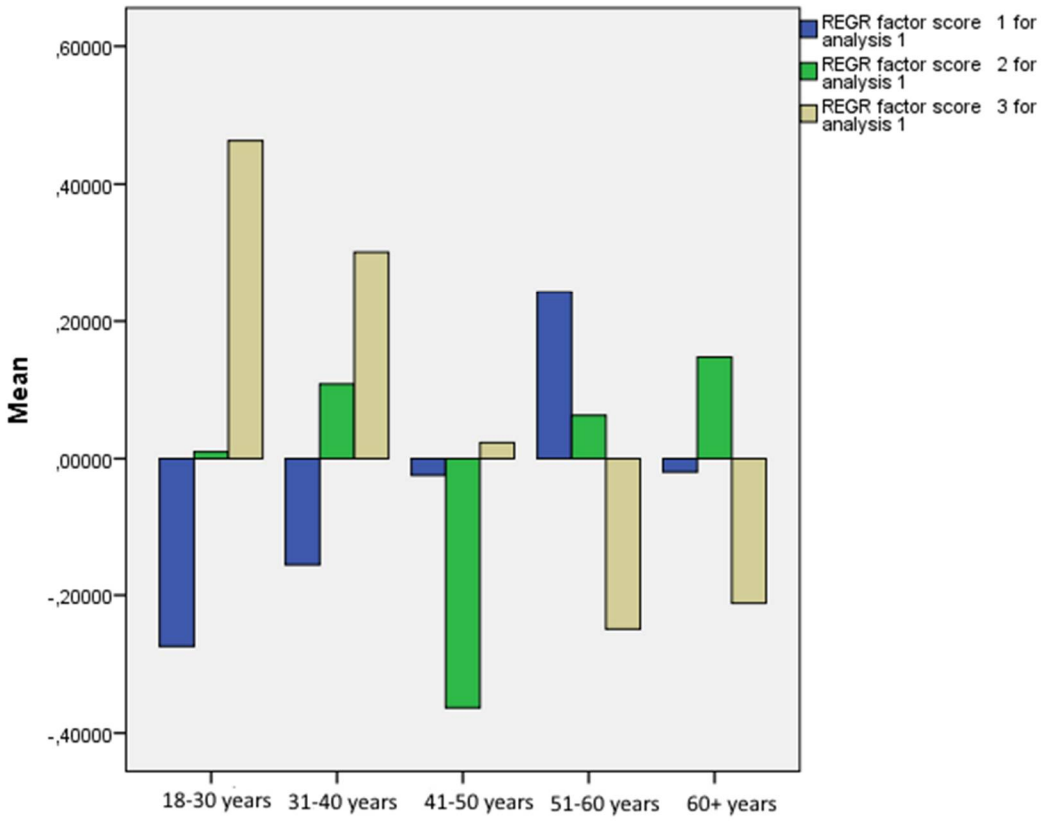
Component 2: 'General sources', with the key role played by traditional mass media (TV, radio, dailies (agricultural periodicals to a lesser extent) and everyday communication with family and friends relations.

Component 3: 'Analytical sources', featuring agricultural mass media (agricultural periodicals and books) and group activities (local clubs, conferences, product presentations).

When the different factor scores are represented according to the age groups of the farmers (fig. 6), a turning point can be observed at 40-50 years, since while the third factor dominates

in younger age groups (i.e. a kind of analytical approach, which correlates with the higher level of education in the case of younger farmers), it has a negative factor score in older age groups. The middle age groups tend to avoid the middle component, i.e. general sources. The role of personal professional relations steadily increases up to age 60 (these relationships become more extensive with time), but for pensioner age farmers the dominance of general sources can be seen.

Fig. 6. Distribution of media use factor scores according to age



Source: own research

I conducted a cluster analysis with the factor scores, and based on the result I created three groups, the first two of which comprise ICT-active, while the third one non-ICT-active famers.

Group 1 ('the information accumulators', 26%): in most of the cases they are average ICT technology users; almost half of them have agricultural qualifications. Both the general sources and the analytical information factors are significant here, as the members of this group gather information from various sources.

Group 2 (‘the analytically-minded’, 38%): the most active group with a marked proportion of the middle-aged (41-50) and a significantly higher number of those with agricultural qualifications (¾ of the group has such qualifications). We can see the dominance of the analytical information factor in this group, while the use of general sources is not at all characteristic.

Group 3 (‘the isolated ones’, 36%): a significantly smaller part of this group went to computer courses; the proportion of the older age groups is some 15-20 percent higher. Only a small proportion (10%) in this group have degrees in tertiary education, and less than half of them have agricultural qualifications (45%). One fifth do not regularly discuss matters relating to their farms with anyone and almost exclusively use general sources of information, but not to a great extent.

It is important to note that there is no significant difference between the groups in regard to whether the farmers in it do their activity full-time, i.e. the fact whether agriculture is a main source of income or not does not have an influence on their management methods and information management. Group 2 is a kind of ‘farmer elite’. A high number of them have agricultural degrees, and, thus, a more analytical way of thinking, and they own larger and more successful farms; these factors are clearly interrelated. This group is the most efficient in integrating ICT solutions in their management practices, as will be detailed below.

In regard to internet use, almost all the members (91%) of group 2 are internet-users, while this percentage is approximately the same for the other two groups (79% for group 1 and 71% for group 3, the latter being almost 10% lower than the average); the difference between the groups is significant. Group 3, the one less open to ICT, is significantly lagging behind in regard to mobile phone use (the percentage of mobile phone use is 61% and 66% for groups 1 and 2, respectively, while it is only 37%- for group 3).

A clearly visible and significant difference can be seen in the area of agricultural software use (Table 1): groups 1 and 2, which resembled each other in many other respects, are clearly dissimilar in this regard. While two thirds in group 2 use agricultural software, the proportions are reversed in groups 1 and 3, which is reflected by the number of accessible computers, where the distribution is similar in the latter two groups: while almost all the

farmers in group 2 have a computer at home, 30% do not have one in both of the other two groups.

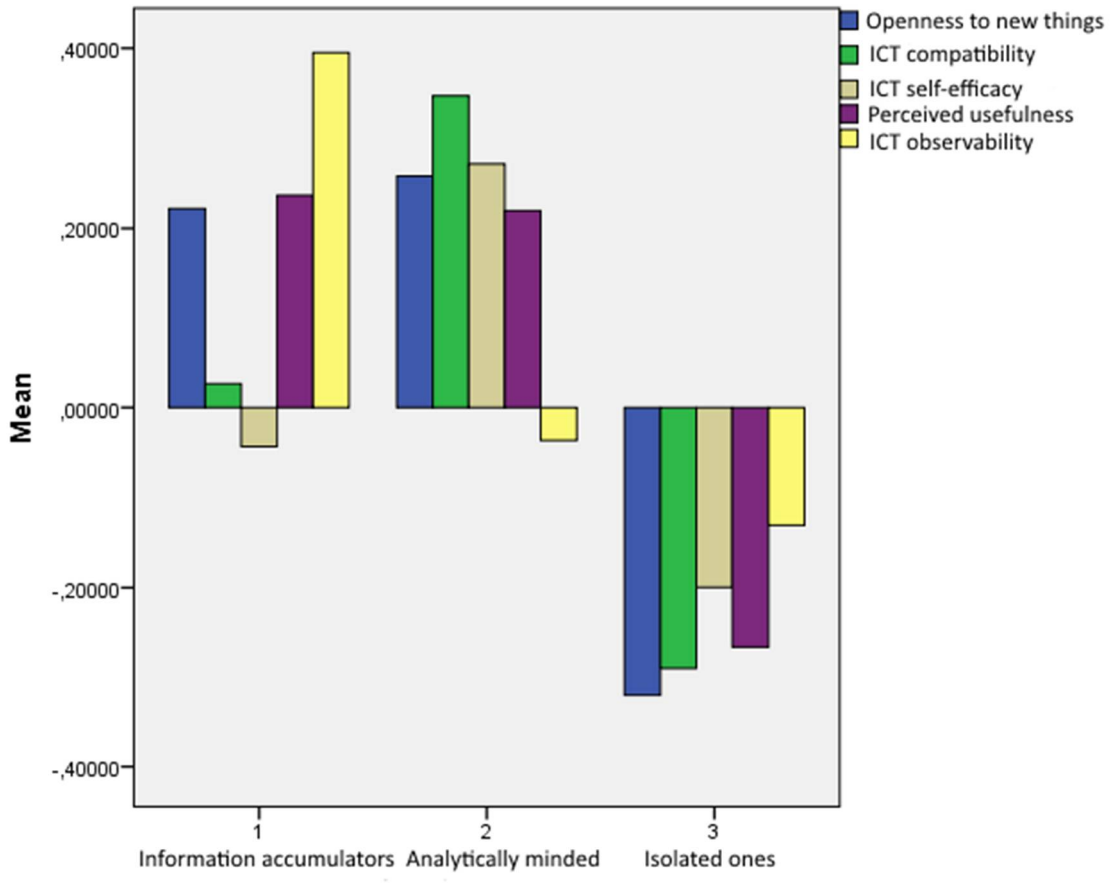
Table 1. Agricultural software use by groups

Agricultural software use	Group 1 ('information accumulators')	Group 2 ('analytically-minded')	Group 3 ('isolated ones')
Yes	33%	66%	37%
No	67%	34%	63%

Source: own research

This can partly be explained by the influence of latent factors (fig. 7). Groups 2 and 3 are almost dire opposites to each other: the analytics are open to new things and there is a perfect harmony between their agricultural use of ICT and their management style; they also have good computer skills and understand the benefits ICT delivers. In contrast, most of the members of group 3 are averse to new things, have rather poor computer skills, and do not see the benefits of ICT; therefore, ICT does not match their management style.

Fig. 7. Latent variables within the clusters of farmers



Source: own research

Group 1 holds special interest: its members are innovative and open people who understand the benefits of ICT and the internet, frequently experiencing the beneficial effect of these in their surroundings; at the same time, they have poor ICT skills and little self-confidence in regard to ICT, which are likely to stop them from using ICT in agricultural activities, even though they have the opportunity to do so (since the proportion of those with small farms is the highest in this group, an increase in self-confidence would probably not automatically result in a sudden rise of software use). Based on the data regarding the various farmer groups, **hypothesis H2** is proven.

3.3. Factors influencing the diffusion of ICT innovation

I examined the influencing factors on three levels: those of the attributes of the given farmer and the given farm, and based on latent factors. As it could be expected based on literature, the age and education of farmers exert a marked impact on the use of all forms of ICT (Table 2). These two variables are closely interrelated and influence other personal attributes, giving rise to such a closely interconnected system of mutual that almost determines the diffusion of ICT innovations. Going on IT training courses also exerts a great influence in this regard; moreover, it is linked with the aforementioned two factors. On the one hand, the higher level education one has, the greater his or her opportunity to have met ICT solutions and come across IT training programmes (thus he or she can gain positive inputs in regard to trialability, usefulness, usability and compatibility); on the other hand, the influence exerted by age is made stronger by the fact that IT education had become widespread in schools in the past twenty or so years (the effect of this can be seen in fig. 6). Another factor that has an influence on the diffusion of ICT innovation among farmers is having an agricultural degree, which is also linked to the previous factors, as it is generally true that the proportion of those with agricultural qualification is greater among those with higher level degrees. The influence exerted by management experience (the number of years spent farming) and experience in computer use is an interesting case in point. It can be clearly seen in the latter that late adaptors and those who only started using computers for the last 5-10 years are generally slower at adapting to other ICT devices too. It is noteworthy to examine the role of farm management experience on the use of agricultural software: when linked with age, its influence is obvious in the case of internet and smartphone use, i.e. general-purpose ICT, while its influence only manifests in agricultural software use only

among those with enormous farming experience; besides age, this might be because these farmers insist on using the processes they are accustomed to.

Table 2. Farmers' attributes influencing the diffusion of ICT innovations (with the strength of the association indicated in the line of the factor's name)

Influencing factors	Internet users	Internet non-users	Agr. software users	Agr. software non-users	Smart phone users	Smart phone-non-users
Age	**,000**		**,000**		**,000**	
Ages 18-30	100%	0%	54%	46%	92%	8%
Ages 31-40	100%	0%	73%	27%	83%	17%
Ages 41-50	93%	7%	43%	57%	68%	32%
Ages 51-60	78%	22%	42%	58%	37%	63%
Aged over 60	47%	53%	19%	81%	6%	94%
Education	**,000**		**,000**		**,000**	
8 or fewer years of primary education	27%	73%	0%	100%	0%	100%
Vocational school	58%	42%	26%	74%	26%	75%
Secondary vocational school	81%	19%	39%	61%	39%	61%
Secondary school	96%	4%	46%	54%	50%	50%
College, university	98%	2%	23%	77%	83%	17%
Previous ICT education	**,000**		**,000**		**,000**	
Yes	98%	2%	28%	72%	76%	24%
No	63%	36%	75%	25%	26%	74%
Agriculture qualification	**,000**		**,000**		**,001**	
Yes	90%	10%	65%	35%	61%	39%
No	64%	36%	19%	81%	32%	68%
Began to use computers			**,001**		**,002**	
before 1995	-	-	83%	17%	70%	30%
1996-2000	-	-	61%	39%	77%	23%
2001-2005	-	-	62%	38%	69%	31%

2005-2010	-	-	45%	54%	33%	67%
after 2011	-	-	0%	100%	25%	75%

Source: own research

The data also show that those who assess their own skills higher are significantly more active users of these technologies. This factor does not exert such an influence on agricultural software use: it only appears as a severe obstacle in those who assess their skills as very poor, so the root cause here is probably fear of using ICT. I will analyse the role of self-confidence in regard to ICT use in more detail later on. In any case, those who are active users of the internet have far greater confidence in internet content. Based on the data in table 2., **hypothesis H3.1** is proven since age has a negative influence, while education (including IT and agricultural qualifications) exert a significantly positive influence on ICT use.

The findings were interesting in regard to the impact of the attributes of farms. These attributes (size of the land, return from sales, complexity, size of labour, possible service activities) practically have no influence on internet and smart phone use, and this is especially obvious in the case of smart phones: it can be seen that the diffusion of this device is only and exclusively influenced by the personal attributes of the farmers, as well as by their computer skills and previous experience in computer use. however, some attributes of the farm (table 3) strongly influence agricultural software use (the most noticeable exception to this being the distance of the farm from the county seat, which, in contrast to some literature sources, did not affect adaptation, although it must be seen that 'distance' might be interpreted differently in Hungary, in other European countries and in the USA. The influence of the amount of the livestock also seems to be non-existent).

Table 3. Attributes of the farm affecting the diffusion of ICT innovations

Influencing factors	Internet users	Internet non-users	Agr. software user	Agr. software non-user	Smart phone users	Smart phone non-users
Size of cultivated land	,100		**,000**		,911	
0-5 hectares	74%	26%	26%	74%	49%	51%
5-20 hectares	75%	25%	41%	59%	46%	54%

20-100 hectares	83%	17%	63%	37%	51%	49%
More than 100 hectares	100%	0%	78%	22%	56%	44%
Amount of livestock	,165		,114		,743	
None, or fewer than 2 animals units	81%	19%	41%	59%	51%	49%
2-10 animals units	68%	32%	50%	50%	43%	57%
More than 10 animals units	88%	12%	64%	36%	52%	48%
Perceived profitability	**,001**		**,000**		**,001**	
Constant struggle	71%	29%	21%	79%	50%	50%
Break-even	58%	42%	27%	73%	21%	79%
Positive balance	85%	15%	48%	52%	54%	46%
Money left over for development	100%	0%	86%	14%	73%	27%
Return from sales	**,003**		**,000**		,310	
up op 600,000 HUF	75%	25%	25%	75%	43%	57%
600,000 – 4 million HUF	65%	35%	33%	67%	44%	56%
4-10 million HUF	91%	9%	52%	48%	49%	51%
More than 10 million HUF	94%	6%	80%	20%	63%	37%
Distance from the country seat	,244		,620		,251	
Less than 20 km	91%	9%	50%	50%	56%	44%
21-35 km	77%	23%	46%	54%	52%	48%
36-49 km	81%	19%	51%	49%	51%	49%
over 50 km	70%	30%	35%	65%	30%	70%
Complexity	,187		**,009**		,268	
One activity	84%	16%	36%	64%	53%	47%
Two activities	78%	22%	64%	36%	50%	50%
Three or more activities	67%	33%	43%	57%	67%	33%
Employees	,322		**,008**		,979	

No permanent employees	79%	21%	29%	71%	50%	50%
1-2 employees	77%	23%	54%	47%	50%	50%
2-5 employees	91%	9%	59%	41%	50%	50%
More than 5 employees	100%	0%	80%	20%	40%	60%
Services provided	,133		**,004**		,453	
Yes	91%	9%	74%	26%	57%	43%
No	78%	22%	42%	58%	48%	52%

Source: own research

In the case of the complexity variable the level of agricultural software use was low in farms engaged in a single activity, this possibly being a reflection of the factor also referred to by literature that the simplification of the farm structure can lead to a reduction in the number of management tasks. However, only two factors – revenue from sales and perceived success – exerted an influence on the adoption of general purpose technologies, which means that in regard to the components pertaining to **hypothesis H3.2.** So a distinction must be made between agricultural and general ICT solutions. One more thing is important in regard to "size". While the size of the land and the number of employees influence agriculture software use, the size of the animal stock does not (this might be explained by the lack of software in Hungary targeting small and medium animal livestock farmers). The impact of revenue from sales, perceived profitability, complexity and service provision is also confirmed, but not that of location (in our case the impact of the farm's distance from the county seat could not be proven). In the case of general purpose ICT only perceived /profitability and revenue from sales exerted a significant impact (the influence of the latter only being felt in the area of internet use), with their influence being exerted only in correlation with other, personal variables, i.e. the nature of ICT innovations and their compatibility with management practices are important factors forming a layer 'deposited' on that of the diffusion of general ICT innovations.

It is a noteworthy finding that the various factors pertaining to farms have no impact on smartphone adaptation: smartphones seem to be such personal devices that their use is only influenced by the personal attributes of their owners, as well as by revenue from sales and perceived profitability, which, however, are closely linked to the attributes of farmers: this

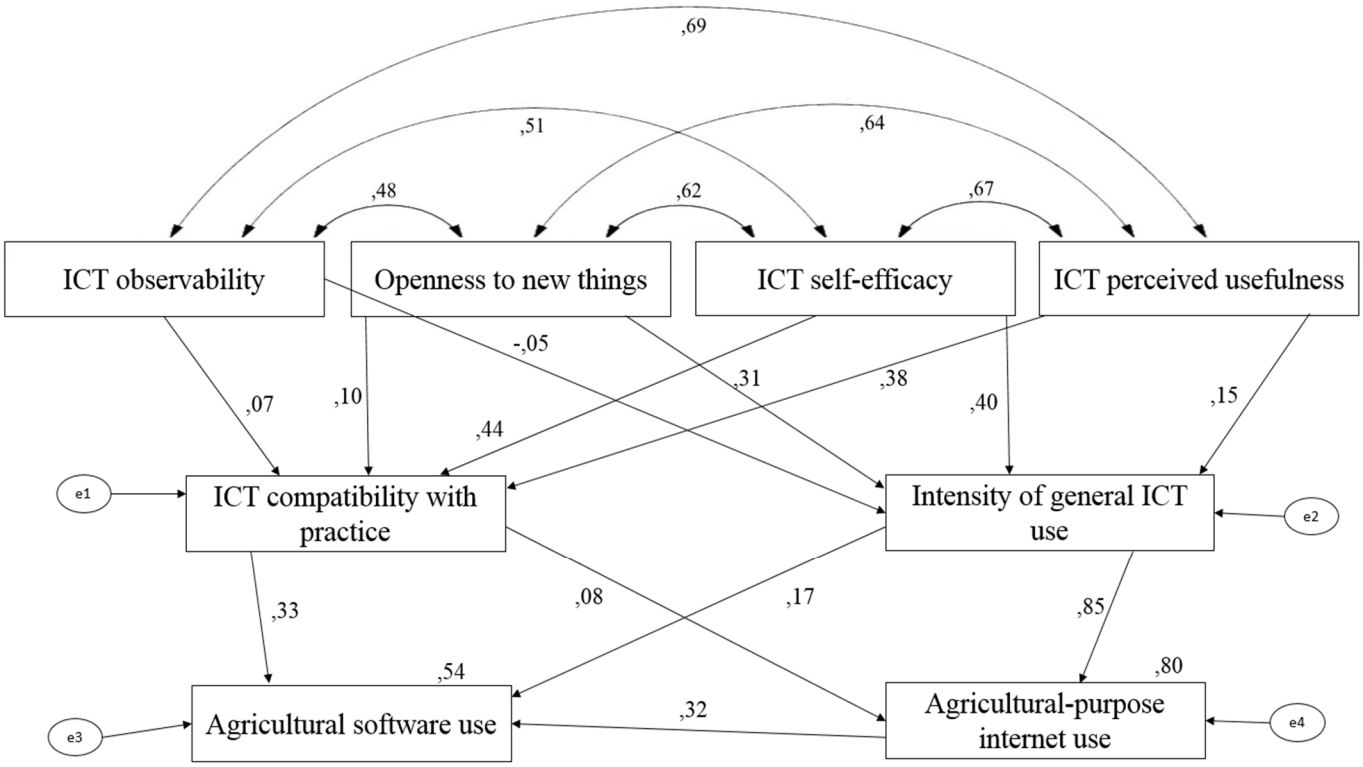
confirms that it is not sufficient to analyse the identified factors individually; they need to be arranged into an explanatory model.

I also compared the fundamentally latent variables of my research model (openness to new things, ICT compatibility with practice, self-confidence in regard to ICT use, perceived success/profitability, ICT observability) with internet use, the presence or absence of smartphones, and agricultural software use. A significant correlation resulted in each case, except between ICT observability and agricultural computer use. Hence, it has been confirmed based on the research that these influencing factors are present and **hypothesis H3.3** is proven with the exception of the aforementioned correlation.

3.4. Testing the accumulation model

After conducting the path analysis I examined the direct impacts (fig. 8) and found that ICT self-efficacy exerts the same and highly significant influence on the farmers' general use of ICT and on the degree of ICT compatibility with their current farming practices. The more confident a farmer is in regard to ICT use, the more he or she will feel that ICT can be integrated into his or her daily farming activities. A similar influence can be seen exerted on farmers' sense of ICT compatibility when they perceive the usefulness of ICT solutions. Interestingly enough, openness to innovation and new things barely exerted an influence on this factor, so an open personality is no guarantee by itself that ICT use in farming will be evaluated positively by farmers; ICT observability exerted even less influence in this regard. This result adds a small twist to the communication-based approach of the diffusion of innovations theory. After an additional analysis of the direct impacts it became clear that the intensity of general-purpose ICT use is impacted by the aforementioned self-efficacy and openness, while observability plays no role in this case either, and perceived usefulness only has a very slight influence. These findings demonstrate the same dynamics that was previously manifest in regard to the diffusion of (general-purpose) ICT: fundamentally open personality, ICT knowledge and self-efficacy (acquired in school and at training courses) have a decisive influence not only on use but also on its intensity.

Fig. 8. Direct impacts measured in the path model



Source: own research

Taking a step 'forward' it can be seen that the intensity of general ICT use virtually determines agricultural-purpose internet use, while it influences agricultural software use too but to a far lesser degree. What is truly noteworthy here is that this factor exerts a far stronger influence on agricultural software use indirectly, through agricultural internet use. In other words, if someone is already an active internet user, they will sooner or later start using online agricultural sources and applications, and this is likely to eventually lead to agricultural software use. The situation is far simpler in the case of the compatibility factor: it has a relatively strong influence on software use but its indirect influence is negligible (table 4), all the more so because it virtually has no direct influence on agricultural-purpose internet use.

In addition to the already mentioned direct impacts, it can be seen that ICT self-confidence also has a significant indirect influence, while it can also be seen that openness, the impact of an innovative spirit, makes itself felt more perceptibly in the area of internet use. To sum

up, the latent influencing factors do form a structure, and they exert different, culminating impacts on agricultural ICT use, i.e. **hypothesis H4 is proven.**

Table 4. Direct and indirect relations in the path model (regressive coefficients)

	Usefulness	Obser-vability	Openness	Self-confi-dence	Gen. ICT use	ICT compati-bility	Agr. internet use
Direct influences							
Intensity of general-purpose ICT use	,121	,000	,309	,392	-	-	-
ICT compatibility	,380	,071	,103	,437	-	-	-
Agricultural internet use	-	-	-	-	,848	,076	
Agricultural software use	-	-	-	-	,173	,333	,318
Indirect influences							
Agricultural internet use	,132	,005	,270	,366	-	-	-
Agricultural software use	,189	,026	,174	,330	,269	,024	-

Source: own research

4. NEW AND NOVEL OUTCOMES OF THE PHD THESIS

The novel outcomes of my work are as follows:

1. The adaptation pattern of farmers for general-purpose ICT (computers, internet, smartphones) as well as the diffusion of these technologies corresponds to the values measured for the adult Hungarian population, showing no significant diversion from those. Based on the results of the questionnaire survey I have concluded that the general-purpose ICT use of farmers in Hajdú-Bihar county accords with the average for the Hungarian population.

2. Farmers have different preferences in regard to using sources, based on which they can be divided into distinct categories, while the information space that results from their choices of these sources gives a clear clue to ICT adaptation. During the main component analysis and cluster analysis I conducted about farmers' preferences of sources of information I set up three distinct groups, each having their own attributes, information preferences and information activities: 'the information accumulators', 'the analytically-minded' and 'the isolated ones'. Those in the first group are active users of sources of information, characterised by an openness to ICT, although they do not integrate ICT into their farm management activities. The second and third groups are each other's opposites. The analytically-minded (group 2) are open to new things and agricultural ICT use is perfectly in line with their management style; moreover, they have good computer skills and are well aware of the benefits of ICT. Their agricultural qualifications help them to form an analytical way of thinking, thus significantly raising the use of agricultural-purpose software. The members of group 3 are typically closed to innovations, have little knowledge of ICT, nor do they see its advantages; consequently, ICT does not match their management style. This rather large third group mainly bear the traits of those members of the late majority or laggards, which can be seen clearly in the low adoption rates of smartphones in this group in comparison with the other two groups. The members of group 1 represent a kind of transition between the other two as they are aware of the advantages of ICT and the internet, they regularly experience the benefits of these technologies in their surroundings but their ICT skills are low, which probably prevents them from the agricultural use of ICT.

Beyond the primary digital divide, a ‘secondary agricultural digital divide’ can be seen among farmers in regard to the use of agricultural-purpose ICT innovations.

3. The personal characteristics of farmers (age, education, agricultural qualification, participation in ICT courses) exert a decisive influence on the adaptation of general-purpose ICT, while the attributes of farms (size, complexity, income, profitability) do not impact general-purpose technologies but only have an influence on specific solutions. In the case of agricultural applications, the positive influence of size cannot be confirmed in the case of the livestock, which is significantly caused by the virtual lack in Hungary of software designed for small- and medium-sized farms. Thus, the attributes of farms markedly influence agricultural ICT use and moderate the influence exerted by the characteristics of farmers. In addition to the ‘hard’ variables, factors influencing the diffusion speed of ICT innovation (ICT self-efficacy, compatibility with farming practices, innovative personality, perceived utility of ICT, observability) also positively impact the adaptation of ICT. It can be stated that the nature of a given innovation, its integratability into farm management practices as well as the perception of various aspects of innovation by farmers are all important factors that are ‘deposited’ on top of the diffusion of general-purpose ICT innovation.

4. The factors impacting the diffusion of ICT innovations form a clear structure with their influences ‘accumulating’ as we move from general-purpose ICT use to specifically agricultural use. Hence, the adoption of agricultural ICT innovations can be regarded as a process in which openness to innovation, ICT self-confidence and the perception of the utility of ICT exert a significant indirect influence on the use of agricultural-purpose ICT solutions through the factors of ICT compatibility of with the given farming practices and the intensity of general-purpose ICT use. The greater self-confidence a farmer has in ICT and the greater benefits he or she expects from a given application, the more the given ICT solution can be integrated into the farm management solutions. The intensity of general-purpose ICT use almost directly determines agricultural-purpose internet use and has an impact on agricultural software use too – its indirect influence exerted through agricultural internet use outweighs its direct influence; in other words, farmers who are intensive internet users will sooner or later start to use online agricultural sources and applications, which is likely to lead to agricultural software use.

5. PRACTICAL IMPLICATIONS OF THE RESEARCH OUTCOMES

Several conclusions can be drawn from the findings of my research. They can be successfully applied in the following areas: communication strategies with farmers, reducing the information deficit in the agricultural sector, designing ICT applications for farmers. Of these one of the most important uses of my results concerns the diffusion of general-purpose ICT: it can help the ICT adaptation among Hungarian smallholder farmers to accord with the average in the Hungarian population, i.e. this could be used as a rule of thumb during the design process of applications aimed at them.

It seems unambiguous that a significant group, amounting to close to one third of farmers, has no openness to ICT innovations, its members not at all adapting these technologies, or even if they do, they do not exploit the potential benefits inherent in them – e.g. the numerous group of farmers who only use their mobile phones for conversations. The saturation of the "S" curve also suggests that a significant proportion of these people are not likely to use the most basic, general technologies in the near future. As a result of the previously described accumulation effect, the likelihood of today's farm management support software being used by this group of farmers is negligible, since the intensity of their general-purpose ICT use and the self-confidence this would be coupled with do not reach the level which would enable the integration of such ICT solutions into daily farming activities. At the same time, information reaches the members of this group mainly via the general mass media: those organising agricultural applications and ICT solutions as well as the leaders in the agricultural sector must be aware of the specific needs and ways of reaching the members of this group. In the case of this group (about one third of farmers) intermediaries and agriculture extension workers will continue to play a great role in providing the mandatory transaction services and personalised information.

At the moment about one third of farmers (the most innovative third) fully and strategically exploit the benefits of ICT, even if the success of the farming log book software is partly explained by its mandatory nature. These farmers practically already base their farm management activities on ICT; they actively gather information, use online transaction services and are open to using agricultural software. They can be the direct target groups

and first users of new applications launched in the area, and they can be best reached at agricultural product presentations, fairs and via the agricultural press.

One quarter of farmers practically use ICT to the same extent as the previously mentioned group, they are still lagging behind in regard to agricultural ICT use, mainly because of their deficiencies in ICT knowledge and self-confidence, as well as the lack of an analytical way of thinking, these factors enhancing one another and resulting in a kind of 'secondary agricultural digital divide'. It is expected that with a relatively small investment this quarter of farmers can be turned into more active users if they are given sufficient support and the opportunity to try and use newly developed applications coupled with continuously available practical assistance. These efforts can be consolidated by increasing the self-confidence of these farmers as well as by clearly and transparently communicating to them the advantages inherent in ICT – this is made easier by the fact that these farmers can be reached by a larger number of information channels. For those developing services and applications must clearly see that these farmers can be at best reached by solutions whose model and even user interface are 'hidden' behind a simple communication method (e.g. SMS consultation) in which knowledge transfer does not require farmers to adopt practices significantly different from the ones they are using.

It is an important conclusion of the research that agricultural qualifications have a significant impact on the use of different types of management software, this being a result of analytical thinking. The agricultural educational programmes emphasise the use of online agricultural sources of information, applications and software from the start, and their integration into daily management tasks; thus, those open to ICT to start with can be orientated towards solutions aimed at enhancing efficiency.

The accumulation model shows that online sources of agricultural information and other solutions are major drivers of agricultural software use. Thus, it is of the essence (especially for the government and professional organisations) that the existing sources of information and online applications are published and developed in a way that can be easily understood, accessed and used by a wide public. It has a negative effect in this regard that for a long time an important source of information on legal matters in agriculture was available on an 'amateur' website. The availability of suitable applications can further increase the agricultural-purpose ICT activity among farmers. However, the opposite can also be true,

which means great responsibility lies with the official institutions in this sector and also with private developers of ICT solutions, software and online (or cloud-based) applications for farmers in the hope of quick ROI. A "digital ecosystem" that includes a wide variety of easy to use agricultural informational sources and applications, and can provide significant support to the effective use of ICT and to its perceived usefulness while also boosting farmers' self-efficacy.

To sum up, it can be declared that the role of ICT solutions and their diffusion are worth being addressed as a priority in any future agricultural strategy since ICT has practically become one of the key pillars of success in the entire sector.

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List of publications related to the dissertation

Article(s), studies (10)

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