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Mobile devices in agriculture: attracting new audiences or serving the tech-savvy?

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A B S T R A C T
The latest wave of ICT-innovations are based around mobility (smart phones, tablets, wireless networks etc.). Mobility can be a decisive success factor of ICT-adoption, because of the spatial, local and remote nature of farming. New generation mobile devices can also have a lower barrier to entry in terms of skills and cost for the user/farmer. The question is whether these new devices, especially smart phones and tablets are adopted by the farmers who are already using computers and Internet or they are attracting new audiences as well? The author's research in Hungary on the supply and demand side of the phenomenon shows that the "agri-app-economy" is still in its infancy, and both the supply and demand side are reflecting the current state and the earlier development of ICT-usage in agriculture. At the moment, new generation of mobile devices are not acting as a tool to overcome earlier and existing barriers of adoption, rather as an indicator of the general level of ICT-use in agriculture. Mobile devices are mainly used by "tech-savvy" farmers, as a general purpose technology – partly because of the lack of relevant applications in agriculture.

1. Introduction

Science and technology are at the core of agricultural change. Fundamental and applied research in biology, chemistry and genetics has resulted in a constant flow of innovations and technical changes that have greatly influenced agricultural systems (Vanloqueren & Baret, 2009). It is the same with information and communication technologies (ICT): the toolkit of the information society offers new opportunities for efficient operation, decision-making and adaptation to the environment (Herdon, 2009).

Despite these opportunities, ICT take-up in agriculture has been low in the last few decades, for various reasons. As Alvarez & Nuthall (2006) put it: encouraging farmers to change their information management has not been easy. The latest wave of ICT-innovations are based around mobility (portable devices, wireless access technologies etc.) which can be a decisive success factor of the adoption process, because of the spatial, local and remote nature of farming. New generation mobile devices also have a lower barrier to entry (mobile phones are especially widely adopted by the farmer community) in terms of skills and cost for the farmer. The "app-economy" also provides the opportunity for service providers and developers to create new services and applications for a smaller, specialized user-base.

The aim of this paper is to examine the main factors of the adoption of mobile devices, through the example of smart phones among Hungarian farmers, using the results of a quantitative survey conducted in the summer of 2015 in Hajdú-Bihar county, Hungary, and a desktop research on the availability of farming applications in Hungarian language.

2. Theoretical background: ICT-adoption in agriculture

ICT can play a fundamental role in modern agriculture. As Kuhlmann and Berg (2002) summarized the dominant path of agriculture development: *"...it may be safely stated that modern large scale farming technology in combination with large land parcels and separated farm road systems, and*

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controlled by state of the art information and communication technology *has the potential for substantial reductions of the production costs for agricultural commodities. This would result in more competitiveness for European agriculture in a liberalized world market and would therefore be certainly adopted by the agricultural entrepreneurs."* Nuthall (2004) summarized the advantages of ICT in the increase in farmer profits due to better price-choice from more comprehensive information, a decrease in time spent on managerial duties, better timing of activities due to acquiring more information when needed, more effective interaction with markets, dealers and experts, more opportunities for learning and entertainment for children and also better connections with other farmers and neighbors.

We can safely state that ICT became essential to effective agricultural production, but numerous studies show that the adoption of these e-innovations in agriculture is limited, especially among smallholders. According to Offer (2005) it can be concluded that since the late 1970s and early 1980s service and technology developers have been making the same mistake, i.e. they fail to satisfy user needs, which is a key challenge in this area. Alvarez & Nuthall (2006) also use the term "knowledge gap", which is a clear distinction between the relative knowledge of the famer and the relative knowledge of the developer about a given software. The wider the knowledge gap the lower the chance that the farmer will regard the innovation as useful.

Since the early 1990s, numerous studies has been to attempt to discover the factors influencing the use of ICT. In one of the earliest works of this kind, Apps & Iddings (1990) mentioned the complexity of the farm, the degree of external support, the age, experience, personality, approach to learning and personal network of the farmer, time and the availability of information. Additional factors were raised by Taragola & Gelb (2005): lack of ICT proficiency, lack of ICT benefit awareness, complexity of use, lack of technological infrastructure, cost of technology, trust level in the ICT system and the lack of training. This latter factor was also emphasized by Gelb & Parker (2005). The low adoption rate is also caused by the fact that managerial duties have a low priority, especially on smallholder farms (Taragola et al. 2002), and the same person who is responsible for those tasks are also involved in production, which creates time constraints (Warren 2002) – a factor that partly could be overcome with mobile devices.

In their review, Taragola & Van Lierde state that farmers' personal and business characteristics strongly influence their adoption of computers and the Internet. They confirmed the influence of education (special agriculture-related education has no significant effect) and age, but the size of the business played a smaller role than expected and among Flemish horticulture growers (Taragola & Van Lierde 2010). The role of education and the age of the farmer in the adoption process were also proved in many studies, for example among beef cattle and peanut producers in the United States, while farm characteristics also played a role, but only the type of farm production had a significant effect on the use of computers and the Internet (Hall et al. 2003). It can be seen that as the farmer is at the center of the information system of the farm, the choice of information technology is an individualistic process, affected by the farmers' characteristics, such as experience, age, education, goals and personality (Alvarez & Nuthall 2006). The characteristics of the farm also play a role, but the effect of these factors are not straightforward: in some cases, the size, the complexity and the location of the farm, or the type of production can play a role, but as it was seen earlier, in other studies, they were not significant, or only one dimension contributed to the adoption decision.

The influence of education, age and the size of the settlement of residency on the general adoption of computers and the Internet in Hungary was proved by many research (e.g. Bognár & Galácz 2004, Dessewffy et al. 2005, Csótó & Herdon 2008). The age and earlier experience with information technology influenced the adoption and also the intensity of ICT-use among farmers in Hajdú-Bihar county, Hungary (Botos & Cseh 2011). In the same county, the findings of Botos (2014) showed that, the aim of use is reduced only to communication (e-mail) and some information seeking among agriculture SME-s, but the bigger and more diverse enterprises use more applications (e.g. commerce).

Based on the different research on this topic, two basic components of the adoption of e-innovations can be found: the characteristics of the farmer (age, experience, personality, education, decision-making and information management style, professional networks) and the characteristics of

the farm (size, type, complexity, geography). Perceived and real benefits and usability of new tools however can significantly influence the adoption process as well (Rogers, 1983).

2.1 Mobile devices in agriculture: the same pattern of adoption?

Many authors in the agriculture and ICT domain have written since cca. 2010 that mobile devices have reached a stage of development that makes them potentially able to support farming in a high level, for example in precision viticulture (Cunha et al. 2010) or in livestock management (Voulodimos et al. 2010). With the recent progress in digital cameras, network bandwidth and information storage capacities, the production (and consumption) of multimedia data has also become an easy task with mobile devices (Joly et al. 2015). Applications that are running on mobile devices became mainstream. There is an app for everything – and this is also the case in agriculture. Karetsos, Costopoulou & Sideridis (2014) summarized the different groups of agriculture related applications as follows:

- Agriculture/Farm Management Information Apps
- Agriculture Information Resource Apps
- Agriculture Calculator Apps
- Agriculture News Apps
- Weather Apps
- M-government Apps

The mobile revolution can be observed in the whole world. According to a recent report from the International Telecommunication Union (ITU), by the end of 2015, there are more than 7 billion mobile cellular subscriptions worldwide (up from 738 million in 2000). As it is shown in Figure 1., mobile broadband is the most dynamic market segment: we can say that the last 5-10 years were dominated by the "mobile revolution". As the ITU report also points out, mobile devices, mainly cell phones, are embedded in daily routines and represent the most common and widely used technology today.

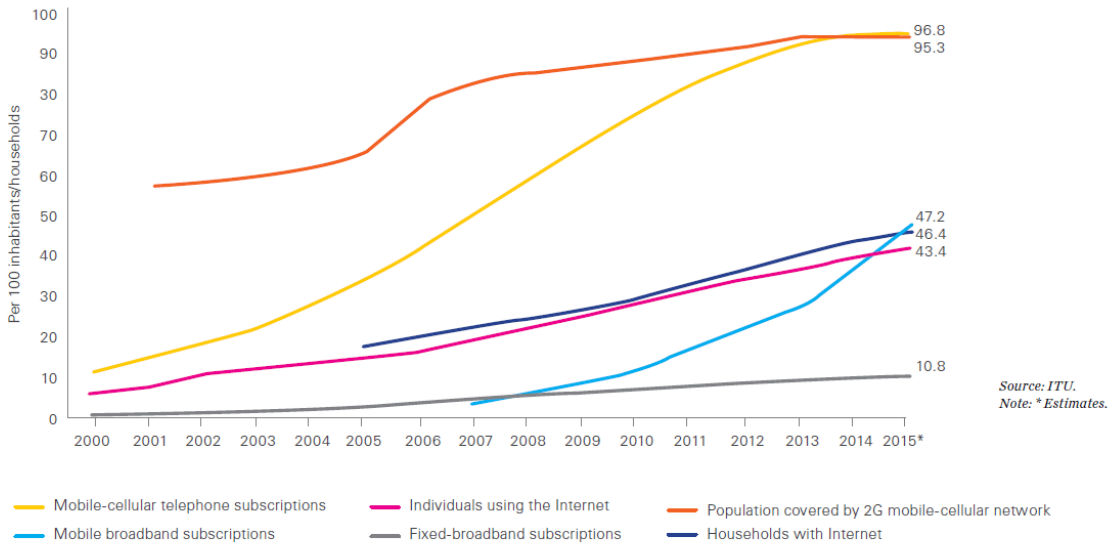

Figure 1. Basic changes in telecommunications in the last 15 years (ITU 2015)

Even if ICTs are an important factor in the success of farming, exhaustive, timely and comprehensive statistics are hard to find in this topic (especially in Hungary where there is no official statistics on this topic), because farm statistics rarely contains this kind of data, and also farmers are a

very diverse group that is difficult to reach and national surveys rarely access them or if so they are asking only the ownership of ICT.

However, there are some data to start with. One such example is the survey by Float Mobile Learning (2012) which showed that 94% of the farmers owned a mobile phone, and 49% owned a smartphone in North America in the beginning of this decade. Smart phone penetration in the Hungarian society is about 39% (Kutatópont, 2015), and 51% of all Internet users in Hungary use their smart phones to access the Internet, according to the Hungarian National Media and Infocommunications Authority (NMHH, 2015). The data of NMHH also show that smart phones are basically used for communication purposes and for some information consumption, complicated tasks or transactions are not widespread.

Agriculture market research firm „Agrostratéga" asked almost 1500 farmers ("the decision makers of the farm") in 2014 in Hungary, the main results can be seen in figure 2. 45% of the farmers use a smart phone (in this research, this means a cell phone with Internet) and 14% use tablets. There is also limited available information on the actual usage patterns, but the report says that 63% of the farmers have bought machines or accessories through the Internet ever, and 17% can be declared as a regular Internet shopper, while 57% have ever sold goods on the Internet.

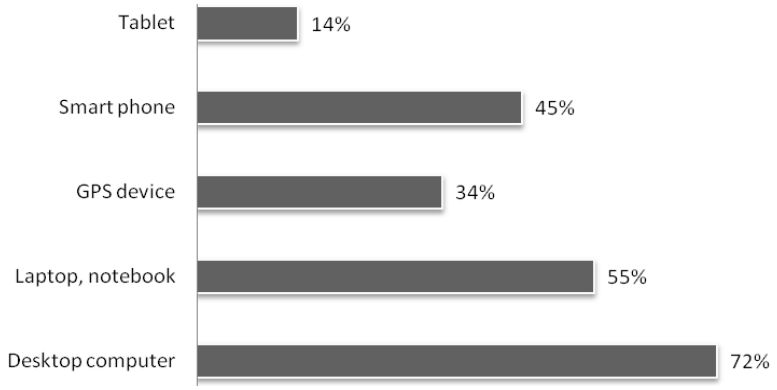

Figure 2. Basic ICT-usage among Hungarian farmers (Agrostratéga 2014)

3. Methodology and research questions

The research consists of two main parts: the first part was a desk research of the available agriculture related apps in Hungarian language and the analysis of the results of a recent survey in Hungary. The second was a survey which was conducted in Hajdú-Bihar county, Hungary, during May and June 2015, with the help of extension network of the Chamber of Agriculture of the county. Every extension worker (called Falugazdász in Hungarian) asked the same number of randomly selected clients (registered farmers, eligible for CAP-subsidies) to fill out our questionnaire relating to the use of and attitudes towards ICT. The extension workers in a county usually serve the same amount of farmers, and they were asked to collect the same number questionnaire. A total amount of 148 filled out questionnaires were collected.

The main aim of the survey was to examine the ICT use (especially the use of the Internet), and the questionnaire focused on the availability of different devices, the usage patterns and also the attitudes and opinions towards the Internet. With the selections of variables, the adoption patterns of smartphones can be revealed, using the question "Do you own a mobile phone or a smartphone?" as the main dependent variable. Based on the literature review, two main questions were formulated:

1. How socio-demographic characteristics of the farmer influence the adoption of smartphones?
2. Has the characteristics of the farm any impact on the adoption of smartphones?

Concerning the first questions, variables of gender (What is your gender?), age (What is your age?), education (What is the highest degree or level of school you have completed?), IT-training (Have you ever taken part in any kind of IT-training?), the size of the place of residence (Which of the following best describes the area you live in?), personal network (How many farmers are you discussing farming issues with?, Are you a member of a farm association?), occupation (Which of the following best describes your connection to farming?), the frequency of Internet use (How often do you use the Internet) and - among Internet and computer users - IT-proficiency (How do you rate your computer/Internet skills?) and IT-experience (When did you start to use a computer?). Farm characteristics were examined using the size of the farm (size of agricultural area, number of livestock units), income of the farm, complexity (calculated from the number of different activities in the farm (arable land, livestock breeding, horticulture, grasslands etc.)), the location of the farm from the county seat and the perceived productivity of the farm (whether the farm making profit or not).

4. Results

4.1. Findings of the farmer-survey

According to the main findings of the survey, 80% of the respondents have access to any kind of computer at home: a desktop computer (59%) or a notebook (44%) or a tablet (10%), 5% of the respondents has access to all three devices at home in Hajdú-Bihar county.80% are also using the Internet, and the majority (70% of all respondents) of them are weekly or daily users of the web. The tablet ownership is limited to 10% of the respondents, so we choose to concentrate on smart phones later on (as tablets almost exclusively were additions to other computers and smart phones). Also 80% of the respondents said that they have Internet-subscription at home. Table 1 shows that almost every farmer owns some kind of cell phone, sometimes a smart phone and a feature phone at the same time. These findings are basically in line with the earlier presented country-data.

Table 1. Cell phone ownership among farmers in Hajdú-Bihar county (Author's survey, 2015)

Cell phone use	Percentage
Using a smart phone	45,3%
Using a feature phone	45,9%
Using smart phone and feature phone as well	4,1%
Not using a cell phone	4,7%

We could see that half of the respondents (49%) use smart phones ("*a device that can be used to connect to the Internet, install applications on it and mainly has some kind of touching screen or keyboard*"). 40 percent of the respondents use the Internet on their cell phones at least on a weekly basis, and one-third of them (32,4%) using their phone to check and write e-mails. So, what factors determine the adoption of a smart phone? In Table 2 we present the more interesting (and/or significant) results (those who indicated that they are using a smart phone and a feature phone as well, were counted as smartphone-users).

In terms of the first research question, we can clearly see, that the basic factors of ICT-adoption are playing a decisive role in the use of smart phones: age and education significantly affects the adoption of the tool: the majority of the younger, more educated farmers adopt the smartphone. The distinction between the respondents with a college or university degree and between the 50+ and the other half of the respondents is especially strong. Earlier IT-training also has a strong positive influence, and the existence of agriculture education also has some weak correlation with the use of smartphones.

Respondents with a workplace outside their farms also own more likely a smartphone. Gender, the place of residence and the personal professional network has no/little effect on the use of smartphones.

Among Internet/computer users, the frequency of the Internet use, experience and perceived IT-proficiency all significantly influence smartphone-ownership: the more frequent a farmer use the Internet the higher the chance they adopt mobile devices. Farmers with a longer record (at least ten years of experience) of computer use are also adopting smartphones more often, and IT-skills and self-confidence plays a crucial role: almost every respondent, who rated his/her IT-skills excellent or good, own a smartphone. These latter findings show that mainly the adopters of earlier IT-innovations switched to smartphones, as they can easily use them, can value their usefulness and the new tools are also compatible with their information-management practices.

The characteristics of the farm has no influence on the adoption of smartphones: neither the farm size, the level of income nor the complexity and the distance from the county seat have an effect on smartphone-use. Only the perceived productivity correlates with the adoption: the more productive the farm is, the higher the chance that the farm manager use a smartphone.

Table 2. Cell phone and smartphone ownership in different categories among farmers in Hajdú-Bihar county (Author's survey, 2015)

Categories	Smart phone users	Feature phone users and non-users
Age		
between 18-30	92%	8%
between 31-40	83%	17%
between 41-50	68%	32%
between 51-60	37%	63%
above 60	6%	94%
Education		
primary school	0%	100%
vocational school	26%	74%
secondary vocational school	39%	61%
general secondary school	50%	50%
college or university	83%	17%
Education in agriculture		
Have	61%	39%
Do not have	32%	68%
Occupation		
farming is primary activity	50%	50%
farming is the primary activity, has a part-time job elsewhere	85%	15%
has a job, farming part-time	67%	33%
farming during retirement	14%	86%
ICT-proficiency		
Excellent	100%	0%
Good	87%	13%
Not bad	52%	48%
Weak	18%	82%

Earlier ICT-training		
Yes	77%	23%
No	26%	74%
Frequency of Internet use		
Daily	78%	22%
Weekly, some days in a week	38%	62%
Monthly	17%	83%
Never	3%	97%
First use of a computer		
before 1995	70%	30%
1996-2000	73%	23%
2001-2005	69%	31%
2006-2010	33%	67%
after 2011	25%	39%
Farm productivity		
The farm suffers losses	50%	50%
Incomings equals outgoings	21%	78%
The farm is making some profit	54%	46%
The farm is making enough profit for investments	73%	27%

4.2 The agriculture app-environment in Hungary

The author has also made a desktop research of the Hungarian agriculture-related apps to have a picture about the supply-side of this phenomenon (as it can contribute to the perceived usefulness, observability and trialability dimensions during the adoption process). The result shows that the agri-app-economy is still in its infancy in Hungary. Farm management information application that runs only on mobile devices is hard to find in Hungary and/ or in Hungarian language. There are around 10-15 entities who are developing a desktop software of any kind in this domain and some of their products can handle mobile devices as well. There are also a few applications that help to fine tune machinery in the field (mainly developed by specific manufacturers).

Information resource apps are also hard to find, only a few notable examples exist (e.g. an information app that combines weather forecasts with fertilizer needs and deficiency symptoms for four plants, a seed variety guide or some animal physiology apps, targeting mainly agriculture engineer students). The Hungarian National Chamber of Agriculture has developed an application with the basic information about the organization and its work, including a news section. The National Agricultural Advisory, Training and Rural Development Institute developed an application to assist short supply chains[2], while the National Food Chain Safety Office of Hungary (NÉBIH) published an application called "NÉBIH Navigator" to support food safety consumer awareness raising – so this latter application is mainly for consumers and not for farmers[3].

Simple agriculture calculator apps that can be used during field activities are virtually nonexistent at the moment in Hungarian language. The major agriculture news sites and journals also do not have specific applications for mobile devices, but mainly they use responsive web design. There are a plenty of weather apps available, a few specific Hungarian solution as well. There is also a notable m-

[2] https://play.google.com/store/apps/details?id=hu.nakvi.appiac
[3] https://play.google.com/store/apps/details?id=hu.gov.nebih.playstore.launcher

government application which makes available the registration of simplified employment on mobile devices[4]. This application is relevant for agriculture as the high number of seasonal/casual workers in the sector.

Despite the fact that slowly but surely almost the half of the Hungarian farmer community is going to own a smart phone, they have very limited options to use specific agriculture apps in Hungarian language. It means that specific, agriculture-related use of this devices is limited and not exploited.

Conclusion

Looking at the state of ICT-development in the last few years, we can see that mobile devices became common, smart devices are overtaking (or have overtaken) feature phones in many developed countries. Mobile devices have also reached a stage of development that makes them potentially able to support farming in a high level, but this potential is yet to be fully exploited. In the example of Hungary, we could find in terms of the supply-side that there are only a few agriculture-related applications in Hungarian language, and most of these applications are not specific for field operations (but they can be used on the go which helps to tackle time constraints, but they are not related only to support fieldwork) or they are only an extension of already existing, more complicated solutions and as such cannot be a sole object of adoption. These latter applications only give advantages to the users who are already familiar with ICT.

The results of the research also show us that the attributes of earlier ICT-use are mirrored in the current state of the usage of mobile devices (especially in the case of smart phones). Factors innfluencing the adoption of smarphones are basically the same as the factors were in the case of earlier ICT-innovations - the same pattern of diffusion can be observed. Despite the lower barrier of entry both in terms of skills and cost, new generations of mobile devices are not acting as a tool to overcome earlier/existing barriers of adoption, rather as an indicator of the general ICT-use in agriculture: early adopters and the early majority are adopting smart phones as an addition to their ICT-environment – and the rate of adoption is in line with the country-average (as it was observed with other ICT-innovations, because the rich farming community is also reflects the characteristics of the whole Hungarian society). Smartphone use is basically determined by the personal attributes and the earlier ICT-experience of the farmers, and is used as an extension of their current infomation management system.

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