December 2002

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Abstract

Recently there has been a spate of interest in how to find feasible applications for mobile devices. Compared to the great expectations in mobile applications that were created by visionary masterminds, the actual acceptance rates of users both in commercial and private sectors lagged far behind. This is especially true for Europe, whereas in other countries, such as Japan, companies like DoCoMo[1] literally created their own demand. This paper suggests that, instead of pursuing a supply-oriented strategy, it would be better to look at the actual demands of potential users and develop products which would meet their needs. In doing so we concentrated on a specialized sector of the economy, i.e. the agricultural sector, and analyzed the needs of farmers and their willingness to adopt new technologies. A statistical analysis helped us to evaluate our findings and served as the basis for the creation of a set of possible applications that could help farmers to carry out their work more effectively and efficiently.

Introduction

Although in most countries the use of mobile applications is lagging behind the prognoses market researchers published in recent years (Mahrer and Brandtweiner, 2001), there is still a lot of interest in developing feasible mobile products (Sheedy 2001). Especially in Europe, where mobile carriers invested lots of money in getting licences for the Universal Mobile Telecommunications Service (UMTS) (Cava and Valetti 2000), chances are that they will lose plenty of it if they aren't able to find potential customers (Steimer et al. 2001). In Electronic Commerce most of the revenues come from Business-to-Business (B2B) applications whereas the Business-to-Consumer (B2C) applications account only for 20 to 30 percent (depending on which sources you use) (OECD 2000). Chances are that in the mobile sector business applications also will outperform private usage (Wiedmann et al. 2000), although many companies are still trying to concentrate their business efforts on the private sector (Mahrer et al. 2000).

This paper focuses on finding out possible mobile applications in a specialized sector of the economy, namely the agricultural sector. Even though in most industrialized countries it accounts only for a small percent of Gross Domestic Product (GDP) it can be seen as the backbone of almost any national economy. This is especially true when taking into account that most nations tend to reach a certain level of self-sufficiency. Another important aspect is that for centuries efforts have been made in order to make farming more efficient and effective. In former years improvements in the farming techniques have led to drastic output gains.

[1] http://www.nttdocomo.co.jp/index.shtml.

Today the use of information is an increasingly important factor in helping to raise the yield. Much data has to be gathered and stored and, even more important, it has to be recalled at varying places at different times. Since a lot of the actual work takes place outdoors, it seems natural that the data should be recorded and processed at the location where it occurs, which in most cases means the fields, the forests or the stables. Furthermore, by the use of scanners, stored data can be read and made available immediately. More sophisticated applications can be used for the navigation of tractors and the operation of machinery and thereby supporting farmers in their daily work routine. All these possibilites mentioned above can help farmers not only to save time and money but also to use their natural resources more efficiently.

After having analyzed the economic importance and the overall background of the recent use of mobile applications in agriculture, it seemed quite important for us to find out the actual needs that could serve as a basis for the innovation of future applications.

Methodology

The survey was conducted in Austria between June 1st and July 20th 2001. 250 questionnaires were either mailed or personally given to farmers. A total of 156 questionnaires were returned, 6 being filled out either incompletely or with contradictory statements. Of the remaining 150 questionnaires 58 were returned by mail and 92 were personally collected. We had a high rate of return of 60% which offered us the opportunity to provide a representative analysis.

During the preparation of the questionnaire a lot of pretests were made in order to ensure the comprehensibility of the questions and to structure the samples. A reasonable way of organizing the branches of the different industries can be seen in Table 1. The numbers in the brackets show the total amount of entries in the respective categories.

Table 1. Branches in the Agricultural Sector

Agriculture	Stock farming	Forestry
Arable farming (114)	Pig breeding (30)	Forestry (31)
Horticulture and Viniculture (46)	Cattle breeding (35)	
	Other animals (28)	
Total: 160	Total: 93	Total: 31

Due to the fact that a lot of farmers are occupied in different branches double counting occurs and the numbers in total do not add up to 150. Another way of structuring our sample is by the size of the farms. Since a lot of farms can be described as small and medium-sized enterprises (SMEs) a reasonable grouping is shown in Table 2.

Table 2. Size of the Enterprises

Small (< 50 hectare)	Medium (50 – 100 hectare)	Large (> 100 hectare)
43	81	26

Interest in Mobile Applications

In order to test whether there are any significant differences between the different groups (either by size or by branch of industry) a chi-square test was used and five different hypotheses were created:

1) a) Null hypothesis: There exists no dependency between the size of the enterprise and the interest in agricultural software products.
   b) Alternative hypothesis: There exists a dependency between the size of the enterprise and the interest in agricultural software products

2) a) Null hypothesis: There exists no dependency between the size of the enterprise and the interest in mobile commerce products
   b) Alternative hypothesis: There exists a dependency between the size of the enterprise and the interest in mobile commerce products

3) a) Null hypothesis: There exists no dependency between the branch of the industry and the interest in agricultural software products
   b) Alternative hypothesis: There exists a dependency between the branch of the industry and the interest in agricultural software products

4) a) Null hypothesis: There exists no dependency between the branch of the industry and the interest in mobile commerce products
   b) Alternative hypothesis: There exists a dependency between the branch of the industry and the interest in mobile commerce products

5) a) Null hypothesis: There exists no dependency between the existing use of agricultural software and the interest in mobile commerce products
   b) Alternative hypothesis: There is a dependency between the existing use of agricultural software and the interest in mobile commerce products

In the following sections these hypothesis are tested and evaluated with two different levels of significance (1%, 5%).

Table 3. Dependency between the Size of the Enterprise and the Interest in Agricultural Software (Hypothesis 1)

		Possible Usage of Agricultural Software Products in the Future			
		Yes	Maybe	No	
Size	Small	22,34 / 20	12,97 / 14	4,69 / 6	40
	Medium	44,13 / 47	25,61 / 26	9,26 / 6	79
	Large	14,52 / 14	8,43 / 7	3,05 / 5	26
		81	47	17	145

The probability that χ^2 (test statistic) $\geq$ chi-square is 0,4708 ($\approx$ 47%), which means that our null hypothesis 1 (no dependency between the size of the enterprise and the interest in agricultural software) on both the 1% and the 5% level cannot be rejected.

Table 4. Dependency between the Size of the Enterprise and the Interest in Mobile Commerce Products (Hypothesis 2)

Dependency between the Size of the Enterprise and the Interest in Mobile Commerce Products		Possible Usage of Mobile Commerce Products in the Future			
		Yes	Maybe	No	
Size	Small	16,47 / 9	9,49 / 11	10,05 / 16	36
	Medium	32,93 / 38	18,98 / 20	20,09 / 14	72
	Large	9,60 / 12	5,53 / 3	5,86 / 6	21
		59	34	36	129

The probability that χ^2 (test statistic) ≥ chi-square is 0,0206 (≈ 2,06%), which means that our null hypothesis 2 (no dependency between the size of the enterprise and the interest in mobile commerce products) on the 1% level cannot be rejected whereas a level of significance of 5% would allow us to reject.

Table 5. Dependency between the Sector of the Enterprise and the Interest in Agricultural Software (Hypothesis 3)

Dependency between the Sector of the Enterprise and the Interest in Agricultural Software		Possible Usage of Agricultural Software Products in the Future: Yes	Maybe	No	
Sector	Agriculture	62,99 / 60	37,56 / 42	14,45 / 13	115
	Stock Farming	30,67 / 29	18,29 / 19	7,04 / 8	56
	Forestry	15,34 / 20	9,15 / 4	3,52 / 4	28
		109	65	25	199

The probability that χ^2 (test statistic) ≥ chi-square is 0,2449 (≈ 24,49%), means that our null hypothesis 3 (no dependency between the sector of the enterprise and the interest in agricultural software) on both the 1% and the 5% level cannot be rejected.

Table 6. Dependency between the Sector of the Enterprise and the Interest in Mobile Commerce Products (Hypothesis 4)

Dependency between the Sector of the Enterprise and the Interest in Mobile Comerce Products		Possible Usage of Mobile Commerce Products in the Future: Yes	Maybe	No	
Size	Agriculture	47,07 / 49	27,16 / 24	25,95 / 32	105
	Stock Farming	21,07 / 19	12,16 / 12	11,61 / 16	47
	Forestry	9,86 / 10	5,69 / 9	5,44 / 3	22
		78	45	43	166

The probability that χ^2 (test statistic) ≥ chi-square is 0,1504 (≈ 15,04%), which means that our null hypothesis 4 (no dependency between the sector of the enterprise and the interest in mobile commerce products) on both the 1% and the 5% level cannot be rejected.

Table 7. Dependency between the Current Usage of Agricultural Software and the Interest in Mobile Commerce Products (Hypothesis 5)

Dependency between the Current Usage of Agricultural Software and the Interest in Mobile Commerce Products		Possible Usage of Mobile Commerce Products in the Future			
		Yes	Maybe	No	
Usage	Yes	31,56 / 38	18,19 / 23	19,26 / 8	69
	No	27,44 / 21	15,81 / 11	16,74 / 28	60
		59	34	36	129

The probability that χ^2 (test statistic) $\geq$ chi-square is 0,0000524 ($\approx$ 0,005%), which means that our null hypothesis 5 (no dependency between the current usage of agricultural software and the interest in mobile commerce products) on both the 1% and the 5% level can be rejected. In both cases the null hypothesis is accepted.

Table 8 and Table 9 show the influencing factors with two different levels of significance. In both tables the influencing factors are shown at the y-axis whereas the influenced variables appear at the x-axis. When using a level of 5% the current use of agricultural software and the size of the enterprise both affect the decision whether to use mobile commerce products in the future.

Table 8. Influencing Factors on the Usage of the Future Use of Agricultural Software and Mobile Commerce Products with a Level of Significance of 5%

	Usage of Agricultural Software in the future	Usage of Mobile Commerce Products in the Future
Size of the Enterprise	no	yes
Sector of the Enterprise	no	no
Current use of Agricultural Software	<not evaluated>	yes

A 1% level of significance leaves the current use of agricultural software as the remaining factor of influence.

Table 9. Influencing Factors on the Usage of the Future Use of Agricultural Software and Mobile Commerce Products with a Level of Significance of 1%

	Usage of Agricultural Software in the future	Usage of Mobile Commerce Products in the Future
Size of the Enterprise	no	no
Sector of the Enterprise	no	no
Current use of Agricultural Software	<not evaluated>	yes

As shown in the previous sections the current usage of agricultural software, i.e. the familiarity with the deployment of the computer as a means of assistance in the daily work is the major criterion for an interest in M-commerce products. The size of the enterprise may or may not influence further decisions, depending on the level of significance and leaving space for future detailed investigations. The sector of the enterprise seems turns out to be irrelevant for any further usage decisions.

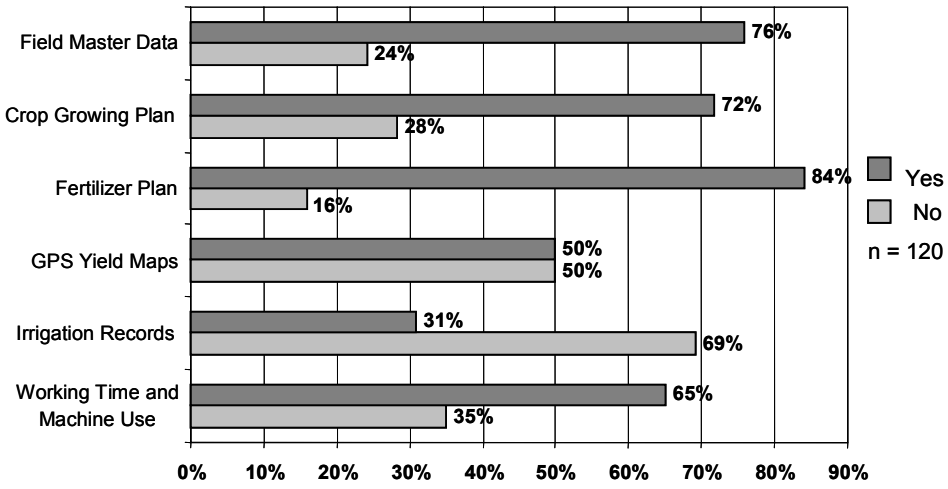
Demands on Mobile Applications

After having analyzed who is interested in M-Commerce and what factors this depends on we concentrated on finding the demand for feasible solutions in the respective sectors. We asked farmers which applications they would consider to be useful in their daily work. The tables 10 to 12 show the results of our survey.

Agriculture

There is a high demand for mobile applications in the agricultural sector as table 10 shows. 84% of the farmers want to record a fertilizer plan, 76% want to store a field master data plan and 72% want to record a crop growing plan. In addition to this it would be useful for a majority to also record the general working time und the use of machinery (65%). As far as Global Positioning System (GPS) field maps are concerned half of the respondents considered this to be useful. The use of mobile devices for irrigation records is only seen as useful by 31%.

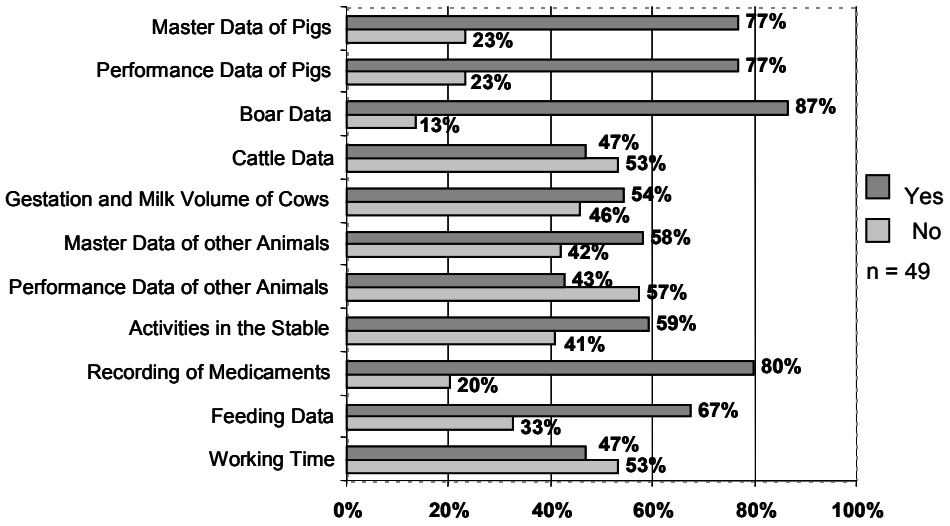
Table 10. Useful Mobile Applications in Agriculture



Stock Farming

In general it can be seen that there is a high demand for information as far as data about animals (cattle, pigs and other animals including poultry and sheep) is concerned. This information can help farmers to keep track of the different locations an animal has been and even what it has been fed. Especially pig breeders would appreciate ways to record data such as boar data (87%), performance data (77%) and master data (77%) by the use of mobile devices. 80% of the breeders also want to be able to use M-Commerce applications for the recording of medications given thus ensuring proper medical treatment of the animals. Another 67% would like to have the respective feeding data available independent of time and place. As far as other information is concerned (e.g. activities in the stable, performance data of other animals such as poultry and sheep, master data of other animals, data of gestation and milk volume of cows and cattle), between 43% and 59% of the farmers would like to use it with mobile devices.

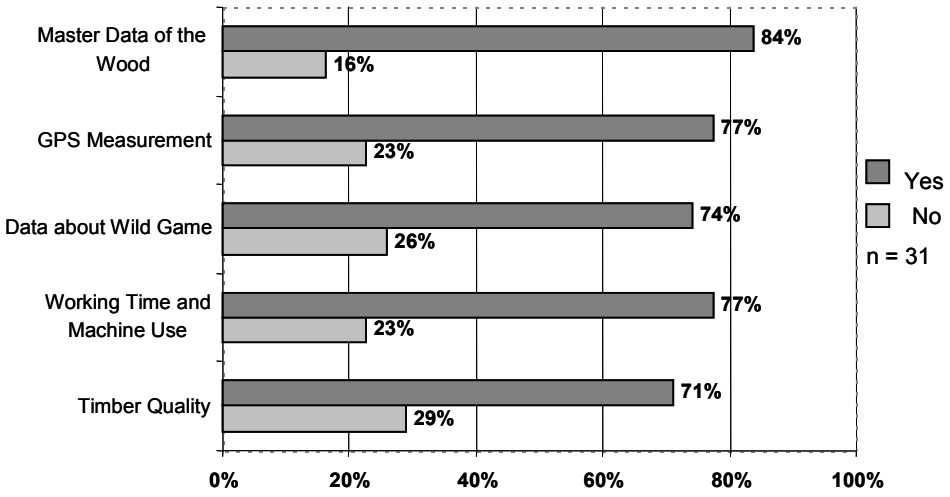
Table 11. Useful Mobile Applications in Stock Farming



Forestry

As can be seen from Table 12 there is definitely a high demand for mobile applications in forestry. This is due to the fact that nearly all work is done far from an office and the use of mobile devices helps to avoid unnecessary and overlapping work. 84% of the farmers would like to record the master data of the forest, followed by the GPS measurement (77%) and working time and the use of machinery (77%). 74% of the farmers would like to have the possibility to process their data about wild game outdoors whereas 71% would like to do so with the data about timber quality.

Table 12. Useful Mobile Applications in Forestry



Demands on Hardware

There exists a variety of PDAs (Personal Digital Assistants) from various vendors (3com, Handspring, Sony, Casio, Symbol and TRG, Nokia, NEC, Compaq etc.) with different operating systems (Palm OS, Windows CE, Epoc32). Due to the fact that these products were customized for the mass market they are not well-equipped for the use on farms or in the forests. In spite of this, these devices have proven sufficiently robust when treated properly (Graf 2000). When used for a longer period of time an extra supply of energy can be useful. This can be accomplished by the use of the vehicle's (e.g. tractor) electricity system.

The average life-time of such mobile devices lasts about two years which can be ascribed to the fact that there are above-average requirements on the device (Holtmann 2000). The PDA can be linked with a GPS-System by using a GPS-mouse, which is a GPS-receiver with an integrated GPS-antenna. Also available are additional protection devices like a so-called outdoor cradle that protects the electronic parts from water, dirt and physical strain. Especially useful are scanners that are able to read barcode-labels and help to avoid errors when data is entered. The main advantages of a PDA in comparison to a notebook are the small size and the cheaper price. There exists a variety of increasingly small notebooks that usually cost a multiple of the price of a PDA. In addition to this, a notebook is unsuited for the strain of outdoor work and the environmental forces which it is exposed to.

In stock breeding transponders are used to allow a unique identification of the cattle. These transponders are usually attached to the ear and contain a silicon chip and an antenna. They don't have their own power supply but instead get their energy from the reader, which produces an electromagnetic field that provides the necessary power.

Demands on Software

There are different ways to program a PDA. Possible solutions include for example:

- Programming in C with the CodeWarrior
- Programming in C with the GNU GCC-Compiler
- Java-development with Jump
- Programming in Assembler with ASDK
- Development in CASL (Compact Application Solution Language)
- Programming in Basic with HotPaw Basic

On of the major problems is the lack of existing software that deals with agricultural issues. Usually farmers don't have enough time and expertise to write their own solutions. By taking into account how many feasible solutions are asked for by the farmers this sector bears a lot of potential for future development.

Conclusion

Although our survey concentrated on Austria we took into account international developments and analyzed the markets both for hardware and software. The specific demands in other countries may vary due to the average farm-size or the concentration on mass markets versus niche markets. We believe that a industry that specializes in mass production is more likely to adopt new technologies that could help rationalize production. The hardware market turned out to be standardized with a couple of market leaders that offer products which, although not explicitly tailored for the use in an agricultural environment, can be used to solve many of the problems that arise in the daily farm work. In this respect the software market is deficient which, in our opinion, is due mainly to the fact that these specialized applications cannot be used on the mass market. On the other hand one can argue that, as stated in the introduction, many telecommunication carriers are looking for possibilities to gain a foot in the market and, even more important, to get people used to mobile devices (Zobel 2001). In a sector of the market where not only the price acts as an entry barrier but also technical obstacles exist, applications with a clear-cut value for the customer are definitely sought after. Additionally, one can argue that in many cases these applications smooth the way for other services, as soon as their advantages become evident. Before we started to propose specific applications we analyzed the main influencing factors which would determine the interest in agricultural software in general and in mobile applications. We found out that the size of the enterprise could be seen as a key driver (depending on the level of significance you use when analyzing the data). Even more important is the familiarity with the use of the computer and agricultural software. This turned out to be the main key driver in our survey and showed an extremely high degree of dependency. By taking into account the different stages an innovation process usually comprises (knowledge, persuasion, decision, implementation, confirmation) (Rogers 1995), we suggest the following strategies in order to get the use of agricultural software widespread and help farmers organize their work:

- In the first phase of the launching process of a new product, a concentration on opinion leaders and users with prior experience seems to create the best results.

- In addition to offering specialized products, the availability of training and support will help to reduce entry barriers due to lack of prior experience.

- There is some evidence that larger enterprises are more likely to adopt these new products and technologies faster. So we would suggest that marketing strategies should be targeted on these early adopters who could serve as role models for their respective peer groups.

- We also recommend a demand-driven strategy which means that software applications should be custom-tailored to the needs of the potential customers. As has been shown above there is still a high demand for specialised solutions in certain sectors of agriculture. Whereas in some cases a simple spreadsheet-calculation file would fit the needs mostly specialised software would do a better job.

- All sectors of agriculture (agriculture, stock breeding and forestry) seem to have sufficient demand for mobile solutions with different emphases. It is up to commercial software companies to fulfill these needs.

- Although certain modifications of the hardware (e.g. protection against water or dirt) could improve overall performance, software applications remain the key factor.

By taking into account all of these conditions and requirements the process of customizing applications based on hardware and software to human needs should lead to some modifications in the ways daily work in the agricultural sector is done. Our research has shown that there is definitely a need for feasible solutions that exceeds the existing supply and that there are ways to meet these demands.

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