

## Totally Digital? Adoption of Digital Farm Management Information Systems

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**Abstract:** Digital applications are widely used in agricultural practice and offer opportunities to increase agricultural productivity and safety. In recent years, especially digital farm management information systems (FMIS) combined with mobile applications have made technical progress, which has significantly increased their potential to e.g. enhance sustainability, facilitate networking processes, reduce working time or cut costs. However, the low number of active FMIS users shows that their potential has not yet been fully exploited in practice. This study examined the factors that influence agricultural adaptation behaviour of FMIS using data from a survey of 285 German farmers. Results show that the actual use of FMIS was determined particularly by the assessment of the suitability of the systems for the respective farm, economic efficiency and compatibility of the systems were the main factors that affected intended use. To transform farmers from intended to actual users, the providers of FMIS should work on overcoming these barriers.

**Keywords:** Farm management information systems, agriculture, regression analysis, digitization

### 1. Introduction

Especially in the context of the increasing sustainability of production and transparency of farms, digitalisation is gaining importance [Wa17]. The amount of digital equipment by farmers is constantly growing. In the last four years, the ownership of smartphones and tablets by German farmers has increased two and a half times and four times, respectively [K118]. Digital farm management tools have been integrated into the daily work process and “easy” apps on mobile devices, such as weather data, can nowadays be regarded as almost obligatory [MBM19]. However, more complex digital farm management information systems (FMIS) are still rarely used, and almost half of the farmers keep the handwritten form of documentation [K118] or use spreadsheet systems (Microsoft Excel). Reasons for low adoption rates might be, among others, the high initial costs, farmers’ habits and preferences, a lack of economic benefits [EA15] and the lack of knowledge about the applications [K118]. Further barriers to acceptance are data protection concerns and the incompatibility of the various digital applications [Ga17]. Nevertheless, complexity and scope of data acquisition and processing in agriculture are increasing considerably, which is gradually changing the landscape and the approaches to developing such digital and mobile farm management systems [HAF17]. High demands for digital data management as well as new and improved farm management systems will stimulate

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a growing market. Yet, little is known about the factors that influence the adoption of FMIS by German farmers. This paper aims to assess the status quo regarding the use of farm management systems as digital applications by agricultural enterprises in Germany. It also provides indications regarding which factors influence the adaptation of FMIS. The results should support the further development process of FMIS and its marketing.

## **2. Materials and Methods**

The results are based on a standardised online survey of German farmers, which was disseminated with the snowball effect: the link was forwarded via personal contacts, e-mail, and social networks in June 2019. Predominantly, 5-point Likert scales (from 1 "fully agree" to 5 "fully disagree") were used, on which respondents could share their attitudes towards farm management information systems as well as make other selected statements. In addition, participants were asked how frequently, to what extent and for which applications they used agricultural apps and farm management systems. After data cleaning based on fast, unusual or incomplete cases, 285 valid sets out of 328 data sets remained for further analysis. Data analysis was carried out with the SPSS 25 statistical software using univariate, bivariate, and multivariate analysis methods. First, a factor analysis (main component analysis) to compress the large number of items into one factor was performed [Bü14]. Subsequently, a linear regression model to estimate the factors that influence the actual and intended use of FMIS was used. The requirements necessary for a regression analysis were validated by means of variance inflation factor, significance of the F-test, and the Durbin-Watson test, where all indicators were within permissible limits.

## **3. Results**

The farms surveyed were predominantly (> 85%) conventional, professional farms with an average farm size of about 350 hectares. 45% of the farms were integrated farms (animal husbandry and arable farming), while 25% and 24%, respectively, focused on arable farming and fodder production. On average, the surveyed farmers were 37.5 years old and more than 45% of the respondents held a university degree. The study is not representative of the entire national farming population, as participants were younger, relatively better educated, and managed larger farms than the average farmer in Germany. This result can partly be attributed to the fact that the survey was conducted online and only reached a certain type of audience. This should therefore be taken into consideration when interpreting the results. Nevertheless, it should also be kept in mind that these young, well-educated, large-scale farmers represent the new generation of farm managers and thus the future user group of FMIS.

Regarding the operational use of internet-enabled mobile devices, 98% of the respondents stated that they used a smartphone. 89% of the respondents used agricultural apps, mainly

weather, communication, and documentation apps. Within the sample, 55% stated that they already used FMIS, with 72% claiming that they had been using FMIS for more than one year. The majority of FMIS users (90.5%) stated that they applied FMIS on mobile devices (smartphones/tablet), where the systems were accessed more frequently in the form of apps (93%) rather than through a mobile browser (55.2%). The systems were most frequently accessed in the areas of documentation (93.7%) and planning (68.4%). Respondents stated that they used FMIS on a daily to weekly basis. The results show that farmers were only moderately satisfied with the current range of FMIS, with less than half of the farmers (39%) being satisfied. The future readiness-for-use is around 75% overall. Of the non-users, about 48% plan to use FIMS in future. The aim of the present study was to identify the factors that determine the current and potential future use of FMIS and to rank their importance. For that reason, a factor analysis was carried out.

Statements	FL <sup>b</sup>	Mean
<b>Technical self-confidence of respondents</b> Cronbach's Alpha: 0.784		
For me, both the handling and use of farm management systems are easy to learn.	0.819	2.45
I am confident that I will be able to familiarize myself with farm management systems.	0.802	1.94
I am confident that I will be able to solve numerous operational tasks with the help of farm management systems.	0.667	2.52
Farm management systems are easy to integrate into my daily work routine.	0.603	2.53
<b>Willingness to pay for FMIS</b> Cronbach's Alpha: 0.719		
I am willing to pay permanently for the use of farm management systems (monthly, annually).	0.830	2.98
The use of farm management systems should be free of charge.	-0.724	2.60
I am willing to pay for additional features that complement the free basic versions of farm management systems.	0.721	2.76
I am willing to pay a one-time fee for the use of farm management systems.	0.557	2.42
<b>Perceived Economic advantages of FMIS</b> Cronbach's Alpha: 0.715		
Farm management systems are cost-effective.	0.757	2.78
I can see/assume that my business success increases using farm management systems.	0.745	3.14
Farm management systems save time.	0.598	2.40
<b>Mistrust of FMIS</b> Cronbach's Alpha: 0.766		
I consider FMIS to be a threat in terms of potential data misuse.	0.852	2.70
I am afraid that my data will be misused.	0.832	2.68
I don't trust the providers of farm management systems.	0.638	3.52
<sup>a</sup> 5 Likert Scale (1 fully agree to 5 fully disagree); <sup>b</sup> Factor loading; KMO=0.853; EV= 63.65%		

Tab. 1: Results of factor analysis

Table 1 shows the results of the factor analysis. Farmers were confident that they would be able to familiarise themselves with FMIS on their own but only partly confident that they would be able to solve operational and daily tasks with FMIS. The mean values show that respondents only partially trusted in FMIS and their willingness-to-pay was in a moderate range. Economic efficiency and time advantages were more strongly associated with FMIS than cost-effectiveness.

Independent Variable	Dependent Variable	A: Current use behaviour <sup>b</sup>		B: Intended use <sup>a</sup>	
		Size of effect ( $\beta$ )	T-Value	Size of effect ( $\beta$ )	T-Value
	Technical self-confidence <sup>a</sup>	0.178***	3.244	0.266***	5.242
	Willingness to pay <sup>a</sup>	0.079	1.500	0.202***	4.144
	Perceived Economic efficiency <sup>a</sup>	0.171*	3.322	0.377***	7.923
	Mistrust of FMIS <sup>a</sup>	-0.133*	-2.618	-0.147**	-3.137
	I would use FMIS more often if they were more compatible with existing technology or systems <sup>a</sup>	0.016	-0.311	0.209***	4.273
	Farm management systems are not suitable for my business <sup>a</sup>	-0.308***	-5.670	-0.011	-0.223
	Age	-0.113*	-2.077	0.059	1.167
	University degree (1)	-0.014	-0.269	-0.041	0.848
	Farm size	-0.176*	-3.399	-0.009	-0.193
Reference:	Growth	-0.117*	-2.186	-0.090*	-1.819
hold current	Restructuring	-0.050	0.943	-0.057	-1.156
status	Cessation	-0.028	0.565	-0.023	0.504

A: Dep. Variable "Current use"; Cor. R<sup>2</sup>: 0.320; F: 12.145\*\*\*; Durbin-Watson 1.97;  
 B: Dep. Variable "I intend to use FMIS more frequently in the future"; Cor. R<sup>2</sup>: 0.420; F: 18.139\*\*\*; Durbin-Watson 1.99; <sup>a</sup>5 Likert Scale (1 fully agree; to 5 fully disagree); <sup>b</sup>5 Likert Scale (1 daily to 5 never). Significance at the level of  $p \leq 0.05$ (\*),  $p \leq 0.01$ (\*\*),  $p \leq 0.001$ (\*\*\*)

Tab. 2: Factors influencing current and future FMIS usage

By means of a regression analysis, the relationship between the identified factors, the compatibility and suitability of the FMIS, and farmers' current and intended future use of FMIS was examined. In addition, socio-demographic data (age, education) as well as the farm size were considered. The results show that about 32% (R<sup>2</sup>) and 42% (R<sup>2</sup>) of the variance of the estimated current and future FMIS usage can be explained by the identified factors (see Tab. 2). The results show that the identified factors can model the intended use more precisely than the current use. According to the standardised coefficient (beta), current use was particularly dependent on how suitable a farmer considered his farm to be

for FMIS ( $\beta=-0.308^{***}$ ). The suitability was not significant for the intended use; here, the compatibility of the systems was a much more decisive factor. A better compatibility of FMIS would have a positive impact on farmers' intention to use FMIS. Technical self-confidence had the second strongest influence on actual and intended usage, where a higher degree of technical confidence was positively correlated with current and future FMIS use behaviour. Whether a farmer planned to use or continue to use FMIS in the future depended most strongly on the system's economic advantages. However, economic advantages influenced the intention to use more strongly than the current use. While a lack of trust in FMIS was a relevant factor for current and intended use, the willingness-to-pay (WTP) also positively affected the intention to use. Farmers with a higher WTP were more likely to use FMIS in the future. Results show that with increasing age and farm size the intensity of use increased. Age, farm size and educational level did not significantly influence the intention to use, which could possibly be explained by the characteristics of the sample. However, whether a farmer used or intended to use FMIS on his farm depended significantly on his growth orientation.

#### 4. Discussion and conclusion

This study provides first insights into the current and intended usage behaviour of farm management information systems by farmers in Germany. The results help to understand the potentials and challenges of farm management information systems. The high utilisation rate, compared to other studies [Ts17], confirms a positive trend in the implementation of FMIS. While in earlier studies, the smartphone was given a minor role as an access medium to FMIS [Ts17], a strong tendency towards mobile FMIS use can be observed today.

Lack of IT know-how is often mentioned as a barrier [Ga17]. The results of this study could lead to the assumption that it is maybe not the farmers' technical competence but their technical self-confidence that is responsible for the implementation of FMIS. This becomes even more relevant, since the systems become significantly more complex and combine many functions, which might unsettle farmers. The effect of the WTP and the economic efficiency is stronger for the intended use than for the actual use. This might be explained by the fact that, today, there are often free isolated solutions available which are mostly integrated as "nice gimmicks" into the daily business routine. Future systems, on the other hand, will become more complex and more costly, and farmers will look much more for their economic benefits, as the pressure on a more sophisticated agriculture is increasing. Moreover, if the benefits of the systems are not proven, farmers could be "smart" not using them, therefore the advantageousness of the systems should be further explored. As other studies have also mentioned [Ga17], mistrust of these systems and their providers is one of the key barriers to acceptance and data security issues should be communicated more strongly. While the current usage behaviour is most strongly determined by whether a farmer considers the systems to be suitable for his farm, the compatibility of these systems will be a more decisive factor for future users. Therefore,

the compatibility of FMIS applications with other systems should be optimized and communicated, especially for the conviction of potential users. The increase in the intensity of use with increasing age could be due to the low average age of the sample, which means that farmers in their mid-40s can already be regarded as older. However, farmers in this middle age group have already taken over farms and are beginning to convert them into a digital form. In accordance to Rogers' theory of diffusion [Ro03], actual users might be considered as "early adopters". In our digital age, we can expect that FMIS adoption will eventually reach the "early and late majority" of users. By reaching the majority, sociodemographic and farmographic differences will become smaller.

It can be stated that digital FMIS have a strong potential, especially in mobile applications via smartphone. To transform farmers from intended to actual users, the providers of FMIS should work on the barriers e.g. the economic efficiency and compatibility of the systems. In addition, farmers should be better informed about the potential applications and their practical use in order to increase their confidence in the use of FMIS.

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