

Sustainability in crop protection - Willingness to pay for crop protection smartphone apps

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Abstract – Smartphone based decision support tools (DST), i. e. apps, related to crop protection have been developed, but little is known about the utilization of smartphones and crop protection apps by farmers. To gain insights, an online survey with 174 German farmers was conducted in 2017. Thus, this study explored which topics farmers perceive as useful in the form of an app for crop protection and which factors influence their willingness to pay (WTP) for these apps. Weather forecasts on demand and tools to identify pests, disease and weeds are perceived as the most useful functions by the farmers. Since we asked about functions instead of specific apps, the results are also of interest to agricultural sectors and developers of apps outside of Germany. The results of the WTP analysis show that farmers' age, farm size and the potential to reduce costs as well as negative environmental effects have a statistically significant positive effect on their WTP for crop protection smartphone apps. Smartphones and apps are relatively inexpensive, which makes them affordable and attractive for farmers of all scales not just in Germany but also in other countries.

INTRODUCTION

Conflicting objectives, such as extending production in order to satisfy global food demand, while simultaneously decreasing negative environmental effects and ensuring sustainability, are the major challenges farmers face worldwide. With respect to crop protection, the European Union (2009) has implemented mandatory regulations for integrated pest management to improve sustainability in agriculture.

One of the key technologies assisting farmers in dealing with these challenges is precision agricultural technologies (PAT) and DST. Recent developments in smartphone technology gave rise to the availability of smartphone-based DST. The mobility of smartphones is well suited to the nature for daily operational activities in agriculture. Furthermore, with the in-built sensors smartphones are also able to replicate some PAT at a lower price. Proving and evaluating the financial value of a DST from a users' point is an important part of the development process (Rose et al., 2018). Moreover, the prices of DST and PAT have been named as one of the reasons

why adoption has been below the expected level. Consequently, factors affecting the WTP for crop protection smartphone apps should be evaluated to identify barriers of adoption. Furthermore, very little is known about smartphone and app use in agriculture, which is also one field to be explored within this study.

MATERIAL AND METHODS

An online survey with 174 German Farmers was conducted in August 2017. Perceived usefulness of topics in form of smartphone app functions was measured with 5-point Likert scale (1= fully incorrect, 5= fully correct). The general WTP as the dependent variable was collected in a discrete form and defined as 0= not willing to pay and 1= willing to pay. To identify the factors which affect the WTP for crop protection apps, a binomial probit model was applied. The descriptive statistics of the sample are given in Table 1.

Table 1. Definition of and descriptive results for variables included in the probit model (N=174).

Variable	Definition	Mean ^{b)}
CostReduction ^{a)}	Perceived potential of apps to reduce costs	2.99 (1.03)
Environmental ^{a)}	Perceived potential of apps to reduce negative environmental effects	3.26 (0.86)
Age	Age of the farmer in years	35.65 (11.98)
AgriUni	1= farmer held an agricultural university degree	1= 31.03 % 0= 68.97 %
Farmsize	Farm size in hectares	219.21 (338.46)
KnowApps	1= farmer knew specific crop protection apps	1= 77.01 % 0= 22.99 %
Livestock	1= farm was engaged in livestock farming	1= 56.32 % 0= 43.68 %
WTP	1= farmer is willing to pay for crop protection apps	1= 82.76 % 0= 17.24 %

^{a)} 1 = fully incorrect; 5 = fully correct

^{b)} Standard deviations are in parentheses

The sample can be described as comparatively young (36 years) and well-educated (31 % agricultural university degree) in comparison with the German average (53 years old; 12 % university degree). Farm size with a mean of 219 ha lies also above the German average of 60 ha (DBV, 2016). However, with respect to digitalization and the future development of DST, it is worthwhile to focus on the younger and well-educated generation of

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farmers, since they are most likely to be the long-time users (Rose et al., 2016).

RESULTS AND DISCUSSION

Perceived usefulness of various app functions was evaluated (Figure 1). Access to weather forecast on demand was perceived as the most useful function followed by functions with respect to the identification of pests, diseases and weeds. Recommendations of manufactures of plant protection products and for spray nozzels are perceived as the most non-effective functions.

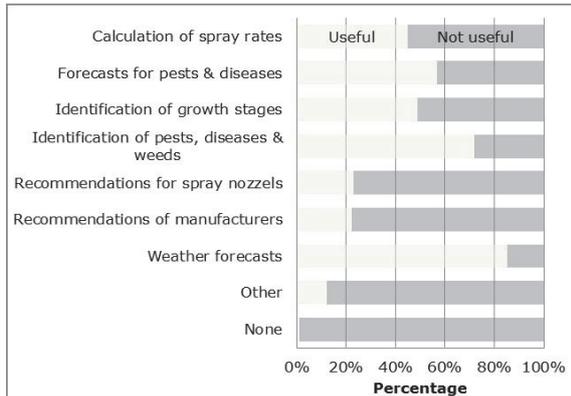


Figure 1. Responses (N=174) regarding the perceived usefulness of apps related to various crop protection topics

The marginal effects (Table 2) for the two variables "CostReduction" and "Environmental" show that the perceived potential for the reduction of costs or negative environmental effects increase the likelihood of a positive WTP. The results imply that farmers value the utility of apps to reduce costs associated with crop protection at the farm level. Furthermore, farmers also approve of the ability of the apps to help reduce negative environmental effects in crop protection. The results are in accordance with Rose et al. (2018) who emphasize that proving the benefits resulting from using a DST is important to increase the uptake of and WTP for DST.

Table 2. Results of the binomial probit model of the general WTP for crop protection apps. Marginal effects are calculated as average marginal effects (N=174)^{a)}.

Variable	Coefficient	Marginal Effects	Std. Error
Constant	-0.966	-	-
CostReduction	0.264	0.0548*	0.0294
Environment	0.427	0.0883***	0.0335
Age	-0.019	-0.0040*	0.0023
AgriUni	-0.480	-0.0992*	0.0577
FarmSize	0.001	0.0003**	0.0001
KnowApps	0.639	0.1321**	0.0541
Livestock	0.080	0.0165	0.0551
Log Likelihood	-64.164		
Pseudo R ²	0.1978		

a) ***P<0.01, **P<0.05, *P<0.10

Age has a statistically significant negative effect on the likelihood of a positive WTP. This is plausible, since younger farmers are more familiar with digital

technologies (Rose et al., 2016) and thus are more likely to know the benefits of these technologies. An agricultural university degree has a statistically significant negative effect on the likelihood of a positive WTP. This result could be explained by the fact that crop protection apps may not provide any knowledge which has a significant additional value for highly-educated farmers, i.e. current apps could be too simple. Previous knowledge of specific crop protections smartphone apps statistical significantly increases the likelihood of a positive WTP. Knowledge of apps implies that farmers can utilize the apps better. Furthermore, the positive effect on WTP can be seen as an indicator that farmers are willing to change their habit and behaviour, which is one of the most challenging factors, when farmers are dealing with new developments in agricultural systems (Rose et al., 2016). Farm size has also a statistically significant positive effect on the likelihood of a positive WTP which could be explained by the concept of economies of scale. Furthermore, larger farms are most likely innovators and therefore the first user of new technologies (Tey and Brindal, 2012). A slightly positive, but not statistically significant effect was found for the production diversification of a farm on the likelihood of a positive WTP, which implies that specialized and diversified farms value the benefits of an app equally.

CONCLUSION

This is the first study to explore factors influencing the willingness to pay for crop protection apps and assess which types of apps are perceived as useful by German farmers. As smartphones and apps are relatively inexpensive, they can serve as an economically feasible DST for farmers of all scales in developed and, especially for extension services, in developing countries. Thus, the results are also of interest for agricultural sectors and developers of smartphone apps outside of Germany.

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