Barriers to Adoption of Smart Farming Technologies In Germany

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Abstract. *The number of smart farming technologies available on the market is growing rapidly. Recent surveys show that despite extensive research efforts and media coverage, adoption of smart farming technologies is still lower than expected in Germany. Media analysis, a multi stakeholder workshop, and the Adoption and Diffusion Outcome Prediction Tool (ADOPT) (Kuehne et al. 2017) were applied to analyze the underlying adoption barriers that explain the low to moderate adoption levels of smart farming technologies. Results of the media analysis show that incompatibility (between different software and/or hardware products), lack of decision algorithms, profitability, inconvenience issues, data protection, and data sovereignty are the most important adoption constraints. While low profitability seems to have declining importance over time, the lack of decision algorithms and inconvenience issues remain important. Despite expectations, incompatibility is gaining importance over time; and both data protection and data sovereignty are relatively new aspects in the discussion. These findings were largely confirmed by participants in the workshop conducted. ADOPT was applied to examine the use of sensor technology for site-specific nitrogen management. Based on available information on adoption rates of these technologies we see ADOPT as a valuable tool for predicting peak adoption levels and the time to peak adoption. Scenario analyses with ADOPT show that increasing the ease and convenience of use of nitrogen sensor technologies can significantly increase adoption levels of such environmentally friendly technologies. To conclude, our results provide useful information for industry and policy makers to increase adoption levels of environmentally friendly smart farming technologies.*

Keywords: *Adoption and Diffusion Outcome Prediction Tool (ADOPT), Digital Farming, Media Analysis, Multi-stakeholder Workshop*

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Introduction

A steadily growing world population, loss of agricultural land, climate change and environmental constraints pose a challenge for agriculture worldwide. Additionally, consumer requirements in the field of production conditions, transparency and documentation are increasing along the entire value chain. Many authors conclude that digitizalization in agriculture offers great advantages for all stakeholders involved (e.g., Reichardt and Jürgens 2009). Although applications of digital farming entered the market quite some time ago, farmers appear to be hesitant to adopt them (Aubert et al. 2012). Germany shows a particularly slow adoption rate for these technologies, especially when compared to countries like Denmark, Sweden or the United Kingdom (Blackmore et al. 2006). In literature, several reasons for low adoption rates are identified. However, few recent studies have been conducted to identify adoption constraints in Germany. Therefore, to analyze the underlying adoption barriers that explain the low to moderate adoption levels of smart farming technologies, a media analysis, a multi stakeholder workshop, and the Adoption and Diffusion Outcome Prediction Tool (ADOPT) (Kuehne et al. 2017) were used. This analysis allows us to identify possible starting points for obtaining higher acceptance rates, either through improved products, or through policy actions.

Materials and Methods

Media Analysis

For the media analysis, we chose three German farm journals that cover the full spectrum of agriculture. Out of these, both the journals “top agrar” and “dlz agrarmagazin” are sold across Germany, whereas the target audience of the journal “Bayerisches Landwirtschaftliches Wochenblatt” is small, family-run farms in Bavaria. We analyzed the time period from 01/01/2009 to 12/31/2016. The search keywords used were automation, autonomous, cloud, digital farming, digitization, farming 4.0, precision farming, sensor-controlled, and smart farming. In the next step, we analyzed the content of the articles we obtained using these keywords. All articles that contained information about adoption barriers were considered for further analysis, while articles without information on adoption barriers were excluded. We then assigned each of the adoption barriers identified to categories of adoption constraints derived from relevant literature. Finally, we carried out a quantitative analysis of the data.

Various adoption barriers that can be used as categories can be found in the literature, such as “lack of decision algorithms” (Batte and Arnholt 2003), “lack of awareness” (Daberkow and McBride 2003), “incompatibility” (between differing software and hardware products) and “lack of IT know-how” (Reichardt et al. 2009). In addition, Reichardt and Jürgens (2009) identify the barriers “susceptibility to failure”, “major capital expenditure”, “complicated handling” and “questionable economic efficiency”. Other authors point to the importance of “data protection” (Wendt et al. 2004) and “insufficient broadband availability” (Jensen et al. 2013). After analyzing a subset of the articles, the categories “data sovereignty” and “risk of accident” were added. Following this analysis, we calculated the relative frequencies of the adoption barriers for each of two different time periods.

Multi-stakeholder workshop

A multi-stakeholder workshop was conducted on October 24, 2017 in the city of Grub (south-west of Munich, Germany) to get deeper insights into specific adoption barriers from various perspectives. The workshop was organized in the course of the EU project Smart AKIS, (Grant Agreement N. 696294). A total of 67 participants were present of which 22% were farmers, 8% consultants, 42% researchers and 28% industry representatives.

Six companies were asked to give presentations (max. 10 min) describing innovative systems, products or services they offer. The innovative farming tools presented were assigned to two focus groups - marketing and crop management – whereas crop management was mainly focused on decision support and automation in the application of fertilizer (Tab 1).

Table 1. Focus groups and companies presenting a smart farming technology during the multi-stakeholder workshop.

Focus group	Company	Smart farming technology
Marketing	Agrar2b GmbH	Online marketing platform
	Farmbörse GmbH	Online marketing platform
Crop management	FarmFacts GmbH	Satellite imagery for fertilizing system
	Fritzmeier Umwelttechnik GmbH & Co. KG	Sensor based fertilizing system
	Vantage ES GmbH	Field zoning and guidance
	Zunhammer GmbH	NIR-sensor-based on-the-go manure analysis

Following the industry presentations, four groups of a roughly equal distribution of stakeholders were formed and each group was asked to work in a "world café" structure. The world café method makes use of different thematic tables at which each group works together to answer a particular question. After a predetermined amount of time of discussion at one table, the groups change thematic tables, and discuss the question associated with a different thematic table. In this case each group of participants spent 30 minutes at each of the four predefined thematic tables.

The questions posed at the four thematic tables were

1. Which digital innovations are particularly suited to small-scale agricultural areas?
2. Where does the added value (economic, ecologic, and social) of smart farming technologies lie in the context of small-scale agricultural regions?
3. What obstacles to the acceptance of digitalization in small-scale agricultural areas do you see as relevant?
4. What types of research and policy changes would promote increased use of digitalization in small-scale agricultural areas?

This method allows each participant to give input on a certain topic while working in small and therefore, more efficient groups. The results collected at each of the thematic tables were structured and displayed on posters on the wall. After a short open discussion to settle general questions, participants were asked to prioritize the topics collected by placing stickers next to them on the wall posters. Multiple nominations per person were possible. The prioritization process was recorded and the results analyzed.

Adoption and Diffusion Outcome Prediction Tool (ADOPT)

In the final step of our analysis, we applied the Adoption and Diffusion Outcome Prediction Tool (ADOPT) developed by Kuehne et al. (2017). ADOPT was used to quantify the impact of the adoption barriers identified on the adoption levels and time to peak adoption of selected smart farming technologies. The application of ADOPT requires input on 22 questions grouped into four fields: (1) "characteristics of the practice that influence its relative advantage", (2) "characteristics of the population that influence their perceptions of the relative advantage of the practice", (3) "characteristics of the practice that influence the ease and speed of learning about it", and (4) "characteristics of the potential adopters that influence their ability to learn about the practice" (Kuehne et al. 2017). We applied ADOPT to analyze the adoption of sensor technology for site-specific nitrogen management. To parameterize ADOPT (i.e., answer the 22 required questions) we used published data and expert knowledge.

Results and Discussion

Media Analysis

Using the aforementioned keywords, we identified a total of 210 relevant articles published within the period from 01/01/2009 to 12/31/2016 in the three farm journals analyzed (dlz agrarmagazin: 31, top agrar: 124, Bayerisches Landwirtschaftliches Wochenblatt: 55). Adoption barriers are addressed in 43 of these articles, and in the majority of cases, multiple adoption barriers are addressed. The most frequently mentioned barrier is “major capital expenditure (37 % of all articles analyzed), followed by “data protection” (33 %). The third most important constraint is “incompatibility” (between different software and/or hardware products) (30 %). The topics “data protection” and “data sovereignty” are particularly common in more recent years (see Fig. 1). One reason for this may be the emergence of internet data platforms that collect and combine data from various sources. The fact that sensitive business data is commonly recorded, could explain farmers’ concerns about these applications. As new products and platforms emerge, “incompatibility” is addressed more frequently. The wide variety of available systems results in a high number of different interfaces for data exchange, which seems to increase problems with compatibility. The constraint “major capital expenditure” lost some of its importance over the investigation period. This may indicate a perception of reduction in costs due to technological progress. The barriers “lack of IT know-how” and “complicated handling” both show a significant loss in importance.

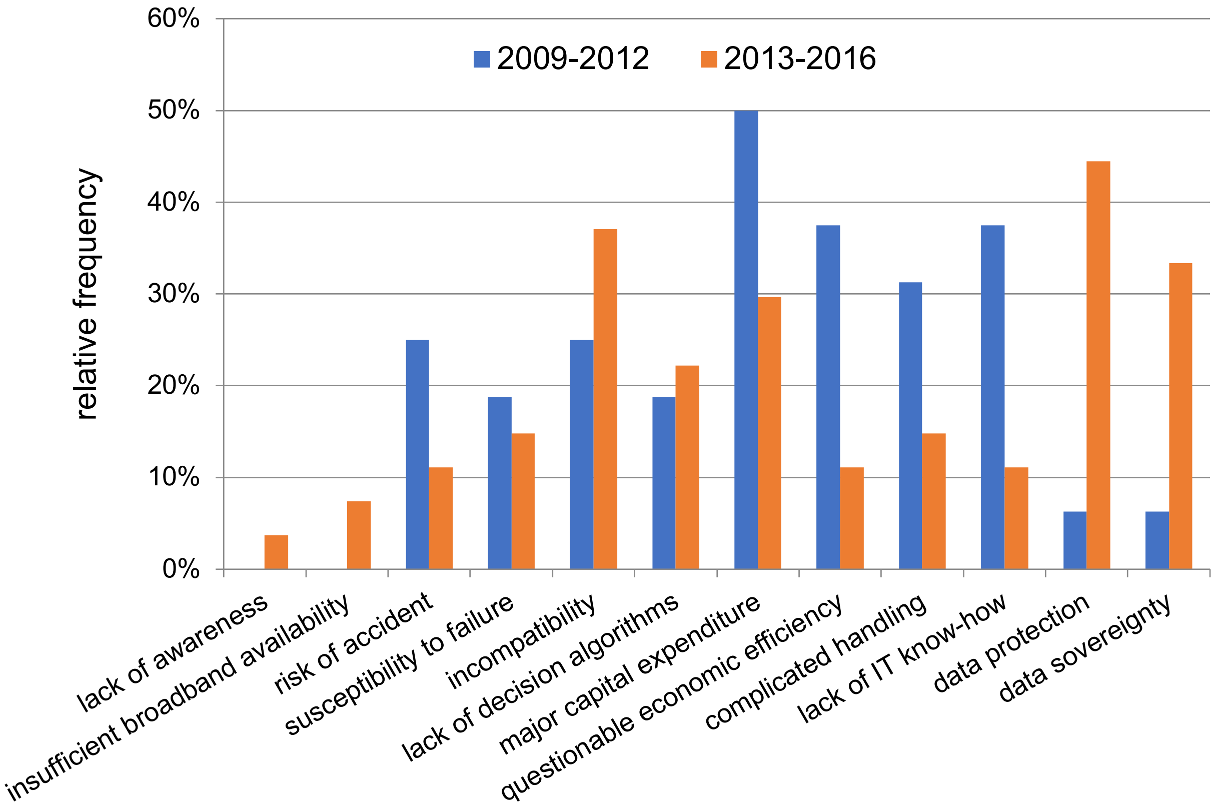

Fig 1 Barriers to adoption of smart farming technologies in Germany: Results of a media analysis

Multi-stakeholder workshop

In the world-café working period conducted during the multi-stakeholder workshop, participants in small groups answered four questions regarding the use of smart farming technology, and the results were recorded and posted on the wall. Subsequently, participants of all groups were asked to prioritize the results to highlight the most important factors limiting adoption of smart farming technologies in small-structured agricultural regions.

From these discussions four main obstacles were identified that hinder widespread adoption of smart farming technologies (SFTs) on small farms:

1. data security / data sovereignty
2. user friendliness
3. input-benefit-relationship
4. deficit of information

Technology itself was selected by 35 out of the 67 participants to be an important factor for adoption. The majority of this group (23) stated that GPS (global positioning system) within the group of technology has the greatest influence on adoption. Added value due to additional social or environmental benefits was selected by 30 stakeholders as an important factor, whereas political aspects like education or subsidies were selected by 37 stakeholders. By far the most important factor for adoption of smart farming technologies in practical farming (selected by 50 stakeholders) were obstacles like missing connectivity, user unfriendly design or complicated user interfaces (Figure 2).

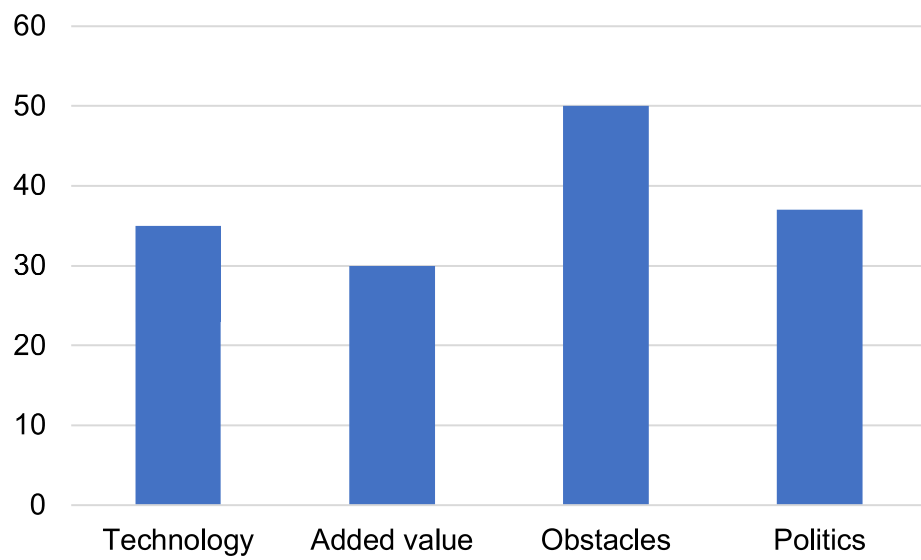

Fig 2 Prioritization of factors for adoption of smart farming technologies (SFTs) in practical farming evaluated by participating stakeholders (Numbers indicate votes received)

Adoption and Diffusion Outcome Prediction Tool (ADOPT)

In the next step of our analysis, we applied ADOPT to the case of sensor technology for site-specific nitrogen management. This technology has been available on the German market since approximately 2000. However, adoption still lags behind expectations. A recent survey shows that only 10% of Bavarian farmers use technologies for site-specific fertilizer application (Roosen and Groß 2017).

Based on the baseline scenario applied, ADOPT predicts 17 years to peak adoption of site-specific nitrogen management, with a predicted peak adoption level of 2% (Tab. 2). Therefore, ADOPT predictions are quite consistent with the actual situation in Bavaria (Germany). In addition to the baseline scenario, we investigated a scenario that assumes that the ease and convenience of use of the sensor technology is increased. This can be achieved, for example by using advanced nitrogen application algorithms that eliminate the necessity for additional calibration of the system. In this case, predicted peak adoption increases from 2% in the baseline scenario to 7 %. In an additional scenario (scenario 2) we assume that the large up-front cost of investing in the sensor technology is reduced for example due to subsidies for investing in environmentally friendly technologies. This scenario shows that predicted peak adoption level increases from 2% in the baseline scenario to 13%. Therefore, the results show the importance of ease and convenience issues as well as up-front costs when it comes to the adoption of new technologies.

Table 2. Predicted adoption levels and predicted time to peak adoption of sensor technology for site-specific nitrogen management for three different scenarios in Germany.

	Base Scenario	**Scenario 1: higher convenience**	**Scenario 2: lower upfront cost**
Definition of Scenarios			
Relative up-front cost practice (Question 14)	Large initial investment	Large initial investment	Moderate initial investment
Profit benefit in years that it is used (Question 16)	No profit advantage or disadvantage in years that it is used	No profit advantage or disadvantage in years that it is used	Moderate profit advantage in years that it is used
Ease and Convenience (Question 22)	Moderate decrease in ease and convenience (e.g., calibration)	No increase/decrease in ease and convenience	Moderate decrease in ease and convenience (e.g., calibration etc.)
ADOPT Predictions			
Predicted peak adoption level (%)	2	7	13
Predicted time to peak adoption (years)	17	17	15

* Only selected questions that differ among the three scenarios are displayed.

Conclusions

To conclude, our results provide useful information for industry and policy makers to increase adoption levels of environmentally friendly smart farming technologies. A clear statement about data sovereignty and security could promote trust between farmers and technology providers. Developing user-friendly systems requires communication with potential users during initial set-up of the systems. Benefits must be communicated more clearly and evaluated and confirmed by independent institutions in order to increase the perception that they are reliable. If farmers were better able to understand the real benefits of smart farming technologies, adoption would most probably increase. To overcome large initial investments needed for some smart farming technologies support through investment subsidies could also increase adoption. Alternatively machine cooperatives could also lead to reduced fixed cost of smart farming technologies.

At the moment, overly complicated systems that lack compatibility with each other and with existing systems do not provide the necessary flexibility farmers need. This is additionally fueled by the lack of education in universities and technical colleges on these technologies, which should be the basis for their successful implementation in practical farming. At the moment, technological progress is outpacing education, policy and the adaption capability of farmers.

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