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German Farmers' Attitudes on Adopting Autonomous Field Robots: An Empirical Survey

Friedrich Rübcke von Veltheim * and Heinke Heise

Department of Agricultural Economics and Rural Development, Georg-August-University of Göttingen, Platz der Göttinger Sieben 5, 37073 Göttingen, Germany; heinke.heise@agr.uni-goettingen.de
* Correspondence: veltheim@uni-goettingen.de; Tel.: +49-551-39-24264

Abstract: Agricultural production methods in Europe are increasingly subject to public criticism from which many farmers suffer. This applies, among other areas, to the widespread use of pesticides. Autonomous field robots (AFR), as the next stage of agricultural automation, have the potential to farm more intensively and, at the same time, in a more environmentally friendly way. However, a certain skepticism towards autonomous systems is suspected among farmers. Whether farmers adopt a technology depends largely on their uncertainty about the consequences of its use and the resulting attitude on the adoption. In order to quantify the attitude on adopting AFR in Germany and to identify possible group differences within the population, 490 German farmers were surveyed using an online questionnaire, which is based on an extended version of the Unified Theory of Acceptance and Use of Technology (UTAUT). In the subsequent cluster analysis, the statements inquiring the intention to use AFR served as cluster-forming variables. As a result, three groups ("open-minded AFR supporters", "convinced AFR adopters", "reserved AFR interested") could be identified according to their response behavior. Despite existing group differences, an overall attitude in favor of autonomous field robots was observed. The results complement the existing research with a further empirical study and provide interesting starting points for further analysis, field robot manufacturers, and political decision makers.

Keywords: adoption; autonomous; cluster analysis; farmer; Germany; robot; technology

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1. Introduction

The ongoing automation of mobility systems as part of the "fourth industrial revolution" [1] has recently gained increasing medial and, hence, societal and political relevance [2,3]. In addition to the car industry, this development particularly affects agriculture, which is considered a classic example of an automation process across the individual industrial revolutions [4]. In contrast to industry, however, the social transformations of the 19th century were not the consequence, but the starting point of the agricultural revolution [5]. While all necessary operations (such as soil cultivation, sowing, pest control, harvesting, and threshing) were still carried out manually at that time, the increasing use of machines, such as tractors and combine harvesters, led to an ever higher degree of automation of agricultural production processes. Given food shortages and needs (especially during and after years of war or natural calamities) combined with the scarcity of arable land due to urban expansion, as well as its use for energy production, the associated increases in productivity were widely supported by politics and society, even though jobs were eliminated and substituted by machines [5]. Since the food demand of the population in industrialized countries, such as Germany, could eventually be met, process characteristics, such as the sustainability of common agricultural production methods, came to the fore of public debates and increasingly attract criticism [6,7]. This criticism reaches to the extent that negative effects on the reputation and the associated "license to operate" of farmers are feared [8].

A potential solution to the conflict between a socially demanded more sustainable food production and current agriculture, which is limited by the constraints of economic efficiency, can be found in the adoption of autonomous field robots (AFR). AFR represent a next generation of agricultural field technology, which is already highly automated in industrialized countries [9]. Operating on their own or in smart-connected swarms, AFR can perform certain operations (e.g., scouting, crop protection, or fertilization) sensor-based and more precisely than human operators. This would enable pesticide use and on-demand fertilization at an individual plant level in a more resource-efficient and environmentally friendly manner than current practices, while providing economic benefits in certain crops [10]. Due to their relatively light weight, AFR would allow for more soil-conserving management of arable land [11]. Besides, omitting a driver from certain farm operations would address the increasing shortage of skilled labor in agriculture and generate new jobs for maintenance, etc., of AFR in parallel. Given improved scalability of AFR, smallholder farms, which have often been deemed uneconomical, could become more profitable through the adoption of such robots leading to a rethinking process of agriculture [10,12]. This aspect can be particularly important for organic farms, which are generally smaller than conventional ones and much more limited when it comes to the application of crop protection products. Since most AFR concepts are electrically powered, they offer farmers an opportunity to save fuel while using self-generated electricity for charging. Thus, all three pillars of sustainability (ecological, economic, and social) could be rebalanced and the previously mentioned conflicting interests appeased.

However, the introduction of unmanned vehicles into off-farm agriculture, such as AFR, is also accompanied by concerns. Although it eliminates farm machinery operators, new tasks would be added, such as monitoring and programming AFR, for which farmers may face a shortage of skilled labor [13]. In [14], the author worries that AFR working out of farmers' sight may lead to a lack of trust in this technology. In addition, the successive replacement and execution of formerly manual operations by robots might result in unlearning of farming skills over time and an associated loss of social recognition for farmers [14]. Regarding the adoption of smart farming technologies in general, ref. [15] see the risk that mainly farmers in wealthier countries will be able to afford these technologies, which would further reduce the competitiveness of farmers in poorer countries. This is also expressed in the innovativeness-needs paradox described by [16], according to which, the individuals in a social system who have the greatest need for a technical innovation are the last to adopt it.

Despite all concerns, there is widespread agreement that AFR will be adopted in farming systems, the only question is when and to what extent this will happen [17,18]. If skepticism and distrust in AFR prevail, this would hinder the development and diffusion of the technology and represent a serious adoption barrier [18]. Following [16], individuals decide whether to adopt or reject an innovation whenever uncertainty about the expected consequences reaches a tolerable level. There is a wide variety of models analyzing factors influencing the user acceptance of innovations. The Unified Theory of Acceptance and Use of Technology (UTAUT) model by [19] combines previous findings from well-documented acceptance research models and was specifically designed to predict technology acceptance. Furthermore, it has already been applied in various studies addressing issues in the agricultural context (e.g., [20,21]). Thus, the UTAUT model forms the theoretical basis of our analysis. Previous studies using the UTAUT model in an agricultural context suggests that the attitudes towards the expected performance and effort, as well as the expected social influence, are relevant for the technology acceptance of farmers (e.g., [21,22]). However, previous studies on digital farming technologies in general, consisting of precision and smart farming [23], provide a diverse profile of farmers' attitudes on technology adoption depending on different parameters [13,14,24–27]. This leads to the assumption that distinguishable groups also exist for farmers' attitudes toward AFR in particular.

To identify the potential target groups, this study analyzes the results of a quantitative online survey among German farmers (n = 490) on the expected consequences of adopting

AFR. The aim is to detect different clusters and strategic groups regarding farmers' attitudes on adopting AFR in order to add an empirical study to the existing research. Furthermore, the results might be of interest for the strategic orientation of additional stakeholders, such as AFR manufacturers or political decision makers.

2. Materials and Methods

2.1. Study Design

The data for this study were collected using a standardized online survey on farmers' attitudes towards the adoption of AFR, in the period from July to August 2019. For this purpose, farmers (n = 490) in the entire federal territory of Germany were contacted via various channels, requesting them to follow a personalized hyperlink and complete the survey. Distribution channels included the email lists of the regional offices of the German Farmers' Association, published lists of German apprenticeship farms, social media websites of relevant agricultural magazines, an interview with f3 magazine, and private contacts within the agricultural community (network sampling approach). This approach is not uncommon in agriculture (e.g., [28]) but means that the results must be interpreted with caution due to incomplete representativeness. In order to prevent a misunderstanding of the questions, the survey was pre-tested for two weeks by experts from agri-economics research and farmers using the software Unipark (Globalpark AG). Since it was not possible to assume homogeneous knowledge of AFR among the respondents, the survey was preceded by a three-minute informational video on the functionality and possible applications of AFR presented as objectively as possible. In addition to nominal scaled questions about socioeconomic characteristics and economic practices, control questions were included to ensure the quality of responses.

The questions used were derived from a comprehensive literature analysis (e.g., [13,14,24,29]), and were based on the UTAUT model by [19] (Figure 1). Thus, different statements for the underlying key constructs performance expectancy, effort expectancy, and social influence, as well as for the moderators age, gender, and experience were formulated as closed questions. Following the authors in [30], the moderator voluntariness was not included in the research model of this work because farmers are free to decide whether to use AFR. Performance expectancy is defined in this paper following the author in [31] as the degree to which a farmer believes that using AFR would enhance his or her job performance. To define effort expectancy, the definition of the construct perceived ease of use from the author in [31] was combined with the findings from the author in [32]. In this study, it includes variables describing the degree to which a farmer believes that the use of AFR is free of finite resources that he or she may allocate to the various farm activities for which he or she is responsible. Social influence is defined in this paper as the degree to which a farmer perceives that his or her social environment believes he or she should use AFR [19].

Aside from these key constructs, existing studies on technology adoption in agriculture indicate that other factors influence farmers' adoption decisions as well [14,33–39]. Therefore, the factors trust, anxiety, and technology commitment (divided into the three facets of technological interest, technological competence beliefs, and technological control beliefs) were additionally surveyed in terms of AFR among farmers. Trust is defined in this study as the belief in the performance of AFR with personal integrity and reliability [35]. Trust in a technology is essential for its successful diffusion and has been proven to influence adoption decisions among farmers [35,37,40], while a lack of trust in technologies can be a cognitive barrier to adoption [14]. The antonym of trust is represented by anxiety about a technology [41]. Anxiety is defined in this study as eliciting negative emotional reactions from AFR use [35]. Technology commitment provides a validated psychometric factor that addresses the use of new technologies in general [39]. The factor is composed of three facets: technological interest, technological competence beliefs, and technological control beliefs.

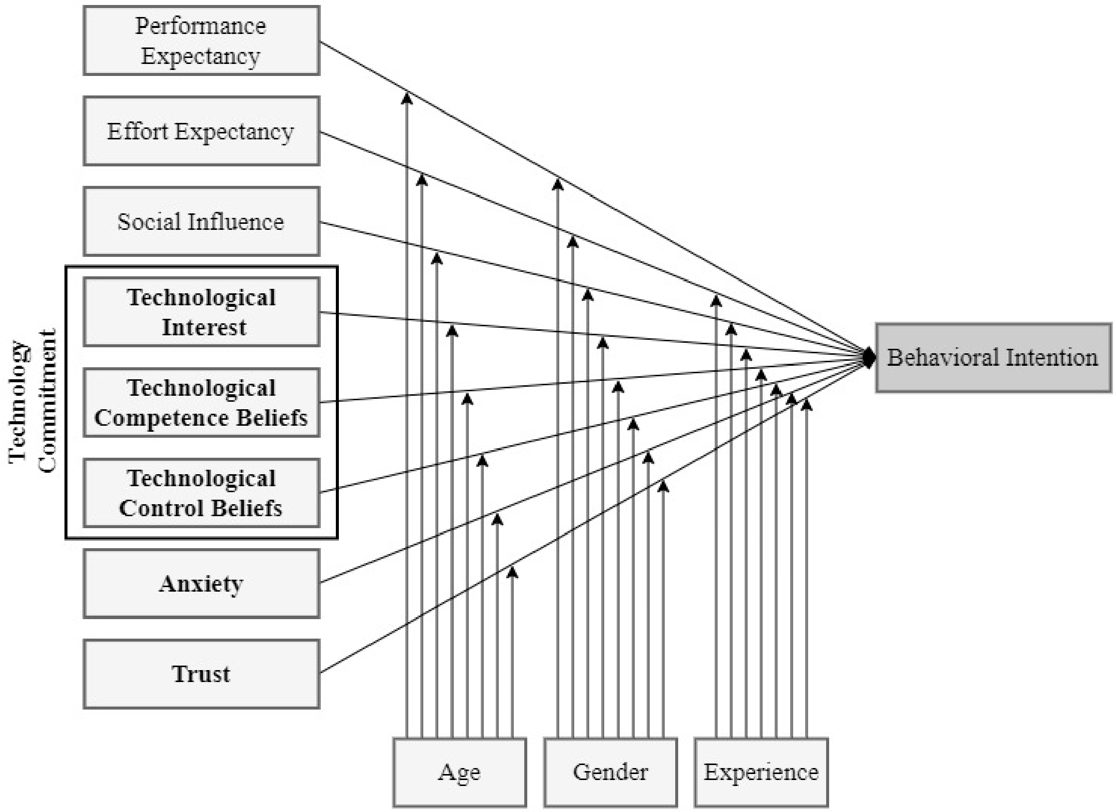

Figure 1. Modified UTAUT model in the context of AFR; bold letters = added factors.

In order to answer the survey, the farmers had to confirm or deny these statements by means of a 5-point Likert scale, where 1 = "totally disagree" and 5 = "totally agree". Further, farmers were asked to indicate their attitude towards the use of AFR on an 8-point acceptance–unacceptance scale (ref. [42] based on [43]). This scale ranges from 1 = "I oppose the use of AFR" to 8 = "I promote the use of AFR" and is available in the attached questionnaire (Appendix A). The dataset was examined for inconsistencies. For example, if the response time was far below average (average was 18 min), if there was systematic response behavior, or if the control questions were answered incorrectly. After data cleaning, 490 datasets remained for further analysis.

2.2. Statistical Analysis

The analysis was done using the software "IBM SPSS Statistics Subscription (2020)". First, the socio–demographic attributes of the sample and information on the farm structure of the surveyed farmers were analyzed using univariate methods. To better interpret the set of items for further analysis and to verify the constructs obtained from the literature, a hierarchical cluster analysis was performed. The four statements on intention to use AFR served as cluster-forming variables (Table 1). The goal was to form groups (clusters) that were as homogeneous as possible from the heterogeneous population. This was done by first removing outliers by applying the single-linkage method, whereby the clusters with the smallest distance (in this study: squared Euclidean distance) to each other were determined [44]. The optimal number of clusters was then determined using Ward's method supported by the elbow criterion. In this process, individual clusters were combined with each other and checked if the variance thereby increased as little as possible [45]. The result was finally compared with the dendrogram. In this way, the optimal number of three clusters could be identified.

Table 1. Results of the clustering variables.

Statements	CLUS A (n = 257)	CLUS B (n = 151)	CLUS C (n = 82)	Total (n = 490)
I would use AFR immediately on my farm. ***	3.46 ^{bc} (0.744)	4.38 ^{ac} (0.500)	1.87 ^{ab} (0.643)	3.47 (1.056)
I plan to use AFR on my farm in the future. ***	2.48 ^{bc} (0.880)	3.83 ^{ac} (0.781)	1.33 ^{ab} (0.498)	2.70 (1.160)
I'm sure I would spend time studying AFR during the first days they are used on my farm. ***	4.43 ^{bc} (0.682)	4.97 ^{ac} (0.161)	4.07 ^{ab} (0.813)	4.54 (0.688)
I would plan to learn how to properly operate AFR during the first days they are used on my farm. ***	4.53 ^{bc} (0.619)	5.00 ^{ac} (0.000)	4.06 ^{ab} (0.866)	4.61 (0.642)

Significance level at *** $p \leq 0.001$; a–c signify a significant difference to the corresponding cluster (Tamhane post-hoc multiple comparison test at significance level 0.05). Number without parentheses: mean values; numbers within parentheses: standard derivations. All statements were scored with a scale from 1 = "totally disagree" to 5 = "totally agree". n = 490.

Subsequently, the results of the hierarchical cluster analysis were compared with the results of the k-means cluster analysis to improve interpretability, and then tested in a discriminant analysis [45]. To check the suitability of the sample for a discriminant analysis, the eigenvalues with the canonical correlations of the discriminant functions and their Wilks–Lambda value served as quality criteria. Eigenvalues provide information about the relative efficacy of the discriminant functions. It should be as large as possible, like the canonical correlations, which was achieved in the present study. Wilks–Lambda resulted relatively low for all three discriminant functions, meaning that the groups differed well from each other. These differences were tested for significance using the chi-square test. They all proved to be highly significant ($p \leq 0.001$). Thus, the model was suitable for discriminant analysis. In the discriminant analysis, the correct cluster could be predicted for 85.6% of the cases, fulfilling the requirements in the literature [45]. To analyze the differences between the identified clusters, mean differences were compared by univariate ANOVA table and the conservative post hoc multiple comparison test Tamhane T2. Finally, the clusters were considered according to the socio–demographic characteristics of the individual cases for possible correlations.

3. Results

3.1. Sample Description

The sample (n = 490) is composed of 91.6% men and 8.4% women. This approximately represents the relative composition of the population of farmers in Germany (90.4% male; 9.6% female) [46]. The average age of the participants was 43 years, which was not representative for the population (53 years). The age structure of the sample was more youthful (sample: 57% younger than 45 years; national average: 38%) [47]. Nearly half of the participants (48%) held a university degree, which was disproportionately high compared to the population of German farmers (12%) [47]. Despite the relatively low average age and higher education level, work experience was not low. For example, about 67% of respondents have worked in agriculture for more than 10 years. Moreover, 36% of the respondents originated from the northern German federal states (Bremen, Hamburg, Lower Saxony and Schleswig-Holstein) followed by 20% from the eastern states (Berlin, Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt, and Thuringia), 18% from the south–western states (Baden-Württemberg, Rhineland-Palatinate, and Saarland), 16% from the western states (North Rhine–Westphalia and Hesse), and 10% from the south–eastern state of Bavaria. The German average contrasts with the sample, as most farmers are located in Bavaria (33%) and the fewest in the eastern states (10%) [47]. The average farm size as well is not consistent with the German population, insofar as small farms (5 to 19 hectares) are underrepresented with 4.9% (national average: 6.6%) and large farms (200 to 499 hectares) are overrepresented with 20.6% (national average: 16.3%). The distribution of farm sizes in the sample almost matches the national average, with most farms (sample: 21.9%; Germany: 20.4%) in the 100 to 199 hectares class [47]. Most respondents (86%) have farming as their main occupation, which is only about 46% of the national average. The sample distribution by type of farming (organic or conventional) differs from the German average. In the sample, 79% of the respondents farmed conventionally (national average: 87.1%) and 21% organically (national average: 12.9%) [47].

3.2. Results of the Cluster Analysis

The four statements on farmers' intention to use AFR served as cluster-forming variables for the cluster analysis performed (Table 1). This was done to divide the surveyed farmers into distinct groups based on their attitudes towards the adoption of AFR for better interpretation of the data. The results of the cluster analysis are illustrated in Table 1, showing the mean values and standard deviations of the four cluster-statements.

Three clusters were formed (CLUS A, CLUS B, CLUS C). CLUS A as the first of the three identified clusters is the biggest one and composed of 257 farmers. This cluster is characterized by an open to slightly AFR favorable setting, but does not yet plan to adopt it (μ = 2.48; σ = 0.880), which is why they are labeled the "open-minded AFR supporters" in the following. Once the time is ready, they are slightly willing to immediately use AFR on their farm (μ = 3.46; σ = 0.744) and they are willing to spend time studying the technology in depth (μ = 4.43; σ = 0.682). Even more, they are willing to learn how to operate AFR properly (μ = 4.53; σ = 0.619).

The second cluster (CLUS B) includes 151 farmers and is defined as a very positive tenor towards the adoption of AFR in agriculture. Therefore, the individuals in this cluster will be labeled as the "convinced AFR adopters". They would agree to an immediate use of AFR (μ = 4.38; σ = 0.500) and plan to use them in the future as well (μ = 3.83; σ = 0.781). They would be eager to interact with the technology (μ = 4.97; σ = 0.161) and have a very strong interest in learning how to properly operate AFR (μ = 5.00; σ = 0.000).

CLUS C covers the responses of 82 farmers. Farmers in this cluster have the comparatively most negative view of the sample on adopting AFR in agriculture. They are therefore labeled as the "reserved AFR interested". Neither would they want to use AFR on their farm immediately (μ = 1.87; σ = 0.643), nor do they plan to do so in the future (μ = 1.33; σ = 0.498). However, if this were to happen, they would want to deal the technology (μ = 4.07; σ = 0.813) and learn how to use it properly (μ = 4.06; σ = 0.866). To get a more detailed understanding of the individual clusters, they were evaluated below in terms of influencing factors on AFR adoption as cluster descriptive variables, as mentioned in Section 2 (Table 2).

Table 2. Results of the cluster descriptive variables.

Statements	CLUS A (n = 257)	CLUS B (n = 151)	CLUS C (n = 82)	Total (n = 490)
Performance Expectancy				
AFR could lighten my workload in certain operations. ***	4.49 ^{bc} (0.656)	4.85 ^{ac} (0.362)	3.84 ^{ab} (0.962)	4.49 (0.730)
AFR enables me to save work force. ***	4.00 ^{bc} (1.029)	4.36 ^{ac} (0.933)	3.60 ^{ab} (1.226)	4.05 (1.057)
With AFR, I could operate more efficiently. ***	3.96 ^{bc} (0.865)	4.33 ^{ac} (0.846)	2.95 ^{ab} (1.083)	3.92 (1.000)
AFR would make farming more environmentally friendly. ***	3.95 ^{bc} (0.830)	4.22 ^{ac} (0.832)	3.00 ^{ab} (0.962)	3.88 (0.943)
Through the use of AFR, additional profit can be generated. ***	3.19 ^{bc} (0.836)	3.62 ^{ac} (0.809)	2.72 ^{ab} (0.939)	3.24 (0.905)
Effort Expectancy				
I imagine the operation of AFR to be difficult. ***	2.89 ^{bc} (0.899)	2.52 ^{ac} (0.859)	3.49 ^{ab} (1.009)	2.87 (0.839)
Learning how to handle AFR would be difficult for me. ***	2.30 ^{bc} (0.789)	1.96 ^{ac} (0.734)	2.73 ^{ab} (0.903)	2.27 (0.839)
A safe handling of AFR would be difficult for me. ***	2.15 ^{bc} (0.835)	1.89 ^{ac} (0.771)	2.51 ^{ab} (0.864)	2.13 (0.850)
The maintenance/repair of AFR would be a problem on my farm. ***	3.10 ^{b} (1.056)	2.66 ^{ac} (1.059)	3.28 ^{b} (1.080)	2.99 (1.087)

Table 2. *Cont.*

Statements	CLUS A (n = 257)	CLUS B (n = 151)	CLUS C (n = 82)	Total (n = 490)
Social Influence				
I think that other farmers would like to see AFR used on my farm. ***	3.27 ^{bc} (0.864)	3.57 ^{ac} (0.893)	2.61 ^{ab} (0.926)	3.25 (0.938)
I think it would make a good impression on society if I used AFR. ***	3.46 ^{bc} (0.957)	3.96 ^{ac} (0.926)	2.60 ^{ab} (1.064)	3.47 (1.061)
Trust				
I would trust AFR to make the right decisions. ***	3.42 ^{bc} (0.801)	3.77 ^{ac} (0.818)	2.62 ^{ab} (0.925)	3.39 (0.913)
I would follow the instructions given to me by an AFR. ***	3.13 ^{bc} (0.828)	3.42 ^{ac} (0.852)	2.76 ^{ab} (0.976)	3.16 (0.892)
Anxiety				
If I were to use AFR, I would be afraid of misusing it. ***	2.30 ^{b} (0.937)	1.97 ^{ac} (0.916)	2.59 ^{b} (1.065)	2.24 (0.972)
Using AFR, I would be afraid to damage it. ***	2.13 ^{b} (0.983)	1.76 ^{ac} (0.854)	2.23 ^{b} (1.092)	2.03 (0.977)
I find AFR frightening. ***	1.47 ^{c} (0.697)	1.32 ^{c} (0.659)	2.06 ^{ab} (1.093)	1.52 (0.804)
I find AFR intimidating. ***	1.41 ^{bc} (0.657)	1.22 ^{ac} (0.528)	1.87 ^{ab} (0.953)	1.43 (0.712)
Technological Interest				
I am very curious about new technical innovations. ***	4.42 ^{bc} (0.726)	4.60 ^{ac} (0.555)	4.13 ^{ab} (0.926)	4.42 (0.733)
I am always interested in using the latest technical devices. ***	3.47 ^{bc} (0.875)	3.89 ^{ac} (0.858)	3.10 ^{ab} (0.976)	3.54 (0.922)
[I] would (. . .) use much more frequently technical products than I currently do. ***	3.67 ^{bc} (0.998)	3.94 ^{ac} (0.876)	3.41 ^{ab} (1.065)	3.70 (0.994)
I quickly find interest in new technical developments. ***	4.01 ^{c} (0.859)	4.19 ^{c} (0.862)	3.67 ^{ab} (0.982)	4.00 (0.901)
Technological Competence Beliefs)				
Technical innovations mostly overwhelm me. *	2.09 (0.861)	2.01 ^{c} (0.852)	2.30 ^{b} (0.898)	2.12 (0.876)
I find it difficult to deal with new technology—as a rule, I simply do not know how to do that. *	1.81 ^{b} (0.824)	1.58 ^{a} (0.6898)	1.82 (0.788)	1.76 (0.803)
When dealing with modern technology, I am often afraid of failing. **	1.75 ^{b} (0.802)	1.51 ^{ac} (0.765)	1.83 ^{b} (0.767)	1.68 (0.779)
I'm afraid I'll be more likely to break down technological innovations (. . .). **	1.59 (0.708)	1.45 ^{c} (0.709)	1.78 ^{b} (0.832)	1.58 (0.728)
Technological Control Beliefs				
It is in my hands whether I succeed in using technical innovations (. . .). *	4.14 ^{b} (0.950)	4.41 ^{a} (0.790)	4.26 (0.858)	4.24 (0.894)
What happens when I deal with [technology] is (. . .) under my control. **	3.91 ^{b} (0.789)	4.15 ^{ac} (0.870)	3.78 ^{b} (0.847)	3.96 (0.836)

Significance level at * $p \leq 0.05$; ** $p \leq 0.01$; *** $p \leq 0.001$; a–c signify a significant difference to the corresponding cluster (Tamhane post-hoc multiple comparison test at significance level 0.05). Number without parentheses: mean values; numbers within parentheses: standard derivations. All statements were scored with a scale from 1 = "totally disagree" to 5 = "totally agree". n = 490.

3.2.1. The "Open-Minded AFR Supporters"

The "open-minded AFR supporters" cluster rather sees benefits in using AFR and agrees with the expected performance statements that, in doing so, their workload could be lightened (μ = 4.49; σ = 0.604), work force could be saved (μ = 4.00; σ = 1.029), and certain processes could be done more efficiently (μ = 3.96; σ = 0.865). Moreover, they are convinced that AFR enables them to operate in a more environmentally friendly way (μ = 3.95; σ = 0.830). However, the "open-minded AFR supporters" are rather indifferent to the economic benefits (μ = 3.19; σ = 0.836). The expected effort is slightly higher than that of the "convinced AFR adopters" and slightly lower than that of the "reserved AFR interested". They rate the operation of AFR as not being too easy (μ = 2.89; σ = 0.899), but see less problems in learning how to handle them properly (μ = 2.30; σ = 0.789). They disagree with the statement that deploying it safely would be difficult for them (μ = 2.15; σ = 0.835), but vary in their opinions on whether AFR maintenance or repair would be a problem on their farm (μ = 3.10; σ = 1.056). Regarding the statements related to the influence of their social environment on the decision to adopt AFR by the respondents, the "open-minded AFR supporters" are rather indifferent to slightly positive. The influence of society (μ = 3.46; σ = 0.957) was rated slightly higher than the influence of professional colleagues (μ = 3.27; σ = 0.864). Further, farmers from CLUS A would tend to trust the functioning of AFRs (μ = 3.42; σ = 0.801) rather than follow instructions from them (μ = 3.13; σ = 0.828), with an overall indifferent to slightly approving attitude on the factor trust. In contrast, no significant anxiety of the "open-minded AFR supporters" regarding AFR could be measured, with the tendency of misunderstanding AFR (μ = 2.30; σ = 0.937) prevailing over damaging (μ = 2.13; σ = 0.983) or even fearing (μ = 1.47; σ = 0.697) it. In general, the results of the technology commitment factor (divided into the three facets of technological interest, technological competence beliefs, and technological control beliefs) show that farmers in CLUS A are interested in new technology, trusting in their own technical abilities, as well as the functioning of the technology, and do not fear loss of control.

3.2.2. The "Convinced AFR Adopters"

The farmers of CLUS B totally agree with the statements about expected benefits from using AFR while a slight uncertainty about the economic added value of AFR could be observed (μ = 3.62; σ = 0.809). For instance, they see the possibility of simplifying certain work processes (μ = 4.85; σ = 0.362) and saving work force (μ = 4.36; σ = 0.933) through AFR. The expected increase in efficiency is likewise rated as positive (μ = 4.33; σ = 0.846). Compared to the other clusters, "convinced AFR adopters" attribute the greatest environmental added value (μ = 4.22; σ = 0.832) to the use of AFR. At the same time, they are the cluster that fears the least effort due adoption of AFR. Thus, they are characterized by only a slight uncertainty about the ease of use of AFR (μ = 2.52; σ = 0.859). In contrast, they see almost no difficulty in learning how to handle AFR (μ = 1.96; σ = 0.734) and in operating it safely (μ = 1.89; σ = 0.771). The greatest indifference occurs when assessing whether repair or maintenance of AFR would be problematic on their farm (μ = 2.66; σ = 1.059). The social influence on decision-making to adopt AFR is rated comparatively highest by CLUS B compared to the other clusters. Thus, respondents in this cluster agree with the statements that both the attitude of professional colleagues (μ = 3.57; σ = 0.893) and public opinion (μ = 3.96; σ = 0.926) have an influence on their decision to adopt AFR. Thereby, the attitude of society appears to be more relevant. Moreover, their trust in AFR is greater than that of CLUS A and C. Analogous to CLUS A, farmers in CLUS B would rather trust AFR to make the right decisions (μ = 3.77; σ = 0.818) than to follow instructions given to them by AFR (μ = 3.42; σ = 0.852). As a counterpart to trust, "convinced AFR adopters" expressed the fewest anxieties about this technology. Neither do they fear operating it incorrectly (μ = 1.97; σ = 0.916), nor damaging it in the process (μ = 1.76; σ = 0.854). Least of all clusters, they find AFR frightening (μ = 1.32; σ = 0.659) or intimidating (μ = 1.22; σ = 0.528). Among the three identified clusters, farmers of CLUS B have the greatest technology commitment. This is expressed by a high technological interest, very low fears regarding a lack of technology competence beliefs and high technology control beliefs.

3.2.3. The "Reserved AFR Interested"

In contrast to CLUS A and CLUS B, "reserved AFR interested" (CLUS C) have the lowest expectations of AFR performance. They agree that the use of AFR can both reduce the work (μ = 3.84; σ = 0.962) load and save work force (μ = 3.60; σ = 1.226), although the latter varies widely. However, there is an indifferent to slightly negative attitude regarding possible environmental benefits (μ = 3.00; σ = 0.962) and efficiency gains (μ = 2.95; σ = 1.083) by using AFR. They are most critical of the possibility of generating more profit through AFR (μ = 2.72; σ = 0.939). In line with their more critical attitude toward possible benefits from the adoption of AFR, the "reserved AFR interested" fear the greatest effort compared with the other two clusters. Whereby this overall rather reveals an indifferent mind-set. While they consider the operation of AFR to be slightly difficult (μ = 3.49; σ = 1.009), they are more confident that they could learn it (μ = 2.73; σ = 0.903) and use it safely (μ = 2.51;

σ = 0.864). About existing repair and maintenance possibilities on their farm, a slight skepticism could be observed (μ = 3.28; σ = 1.080). The farmers in CLUS C, compared to the "open-minded AFR supporters" and the "convinced AFR adopters", make their decision to adopt AFR least dependent on their social environment. They are not particularly interested in the opinions of their professional colleagues (μ = 2.61; σ = 0.926) or of society (μ = 2.60; σ = 1.064). In addition, "reserved AFR interested" have little trust in how AFR works (μ = 2.62; σ = 0.925), which is also true for instructions that are given to them by AFR (μ = 2.76; σ = 0.976). Here they differ significantly from the other two clusters. Reflecting the lack of trust and compared to the "open-minded AFR supporters" and the "convinced AFR adopters", they have slightly higher levels of anxiety from using AFR, although they are dismissive of the statements on the anxiety factor overall and analogous to the other clusters. Thereby, they are most likely to fear using AFR incorrectly (μ = 2.59; σ = 1.065), which is in line with the statement of expected effort about difficulty of operation. AFRs neither really seem frightening (μ = 2.06; σ = 1.093) nor intimidating (μ = 1.87; σ = 0.953) to CLUS C as well. In terms of the technology commitment factor, while their curiosity about new technology (μ = 4.13; σ = 0.926) coincides with that of CLUS A (μ = 4.42; σ = 0.726) and CLUS B (μ = 4.60; σ = 0.555), they are less eager to always use the latest technology (CLUS A: μ = 3.47; σ = 0.875; CLUS B: μ = 3.89; σ = 0.858; CLUS C: μ = 3.10; σ = 0.976). Overall, the "reserved AFR interested" rate their technical competence beliefs slightly lower than those of the "open-minded AFR supporters" and "convinced AFR adopters ", but do not fear a loss of control should they have to operate these new technologies, although this is lower than in CLUS A and B (Table 2).

3.2.4. Characteristics inside the Clusters

A more detailed description of the characteristics of those farmers within the clusters is presented in Table 3. In addition to their socio-demographic characteristics, farm statistics were also compared. No significant differences were found regarding age, gender, experience, education, vocational training, main or secondary occupation, farm type, and farm size. These characteristics are almost equally distributed across the individual clusters, although it is noticeable that the farmers in CLUS C tend to be younger and more male than those in the others. Most conventional farmers tend to be part of CLUS B. Yet, there is a significant difference regarding the farmers' willingness to take risks. Thus, the "convinced AFR adopters" are more willing to take risks (μ = 3.56; σ = 0.797) than the "open-minded AFR supporters" (μ = 3.35; σ = 0.782). The "reserved AFR interested" are risk averse compared to the other two clusters, but overall still indifferent to slightly willing to take risks (μ = 3.13; σ = 0.790). All clusters agree with the statement that they would be willing to make strategic changes if there was an economic benefit in doing so, with "convinced AFR adopters" agreeing fully (μ = 4.60; σ = 0.713) and "reserved AFR interested" agreeing only slightly (μ = 3.51; σ = 0.989). While the "convinced AFR adopters" would definitely want to be more environmentally friendly (μ = 4.50; σ = 0.704), this is true for the "open-minded AFR supporters" to a not quite as strong but still clear degree (μ = 4.23; σ = 0.713). However, the "reserved AFR interested" are more cautious about this (μ = 3.58; σ = 1.045). On the 8-point acceptance-unacceptance scale presented in Section 2.1, the "reserved AFR interested" rank on average between level three ("I am torn about the use of AFR") and level four ("I am indifferent to the use of AFR"), whereas the "open-minded AFR supporters" find themselves in level six ("I would accept the use of AFR") and the "convinced AFR adopters" in level seven ("I approve the use of AFR"). Regarding the summarizing statement, whether the interviewed farmers consider AFR to be a good idea, a smart move or positive, highly significant differences between the individual clusters could also be identified. AFR was rated most optimistically by "convinced AFR adopters" and "open-minded AFR supporters". The "reserved AFR interested" have a less positive picture than CLUS A and CLUS B, but still slightly agree with the three facets (good idea, smart move, positive) of this statement.

Table 3. Farmers' characteristics inside the clusters.

	CLUS A (n = 257)	**CLUS B (n = 151)**	**CLUS C (n = 82)**	**Total (n = 490)**
Age [1] Ø in years [n.s.]	44	43	41	43
Gender male (female) [1] in % [n.s.]	91 (9)	92 (8)	93 (7)	92 (8)
Experience [1] Ø in years [n.s.]	26	26	23	25
Education in [1] % [n.s.]				
lower than secondary school leaving certificate	6	2	10	5
secondary school leaving certificate	24	18	21	22
High school diploma	22	29	28	25
University degree	48	51	41	48
Vocational training [1] in % [n.s.]				
agricultural vocational training	30	20	31	27
agricultural university degree	70	80	69	73
Main occupation (secondary occupation) [1] in % [n.s.]	85 (15)	89 (11)	83 (17)	86 (14)
Farm type conventional (organic) [1] in % [n.s.]	82 (18)	77 (23)	76 (24)	79 (21)
Farm size class [1] in % [n.s.]	6.16 (100–200)	6.19 (100–200)	5.93 (100–200)	6.14 (100–200)
less than 5 ha	0	1	4	1
5–9 ha	2	1	3	1
10–19 ha	3	3	5	3
20–49 ha	12	8	10	11
50–99 ha	19	21	21	20
100–199 ha	20	25	20	22
200–499 ha	22	23	12	20
500–1.000 ha	11	9	10	10
more than 1.000 ha	11	9	15	12
Are you willing to take great risks asa farm manager? [2] μ (σ) ***	3.35 [b] (0.782)	3.56 [ac] (0.797)	3.13 [b] (0.790)	3.38 (0.787)
I like to make a strategic changeif there is an economic benefit to doing so. [2] μ (σ) ***	4.23 [bc] (0.713)	4.60 [ac] (0.517)	3.51 [ab] (0.989)	4.23 (0.801)
I would like to produce in a more environmentallyfriendly way. [2] μ (σ) ***	4.18 [bc] (0.730)	4.50 [ac] (0.704)	3.58 [ab] (1.045)	4.18 (0.835)
AFR acceptance level [3] μ (σ) ***	6.10 [bc] (1.232)	6.87 [ac] (0.921)	4.67 [ab] (1.626)	6.09 (1.419)
In summary, I consider the use of AFR to be . . .				
a good idea [2] μ (σ) ***	4.48 [bc] (0.703)	4.81 [ac] (0.412)	3.40 [ab] (1.041)	4.40 (0.844)
a smart move. [2] μ (σ) ***	4.23 [bc] (0.934)	4.72 [ac] (0.569)	3.48 [ab] (1.080)	4.26 (0.953)
positive [2] μ (σ) ***	4.35 [bc] (0.792)	4.78 [ac] (0.462)	3.39 [ab] (1.015)	4.33 (0.875)

Significance level at *** $p \leq 0.001$; n.s. = not significant; a–c signify a significant difference to the corresponding cluster. [1] Chi-square test according to Pearson. Pairwise comparison using Bonferroni correction. [2] These statements were scored with a scale from 1 = "totally disagree" to 5 = "totally agree". Tamhane post-hoc multiple comparison test at significance level 0.05. [3] These statements were scored with a scale from 1 = "I oppose the use of AFR" to 8 = "I promote the use of AFR". $n = 490$.

4. Discussion and Conclusions

The objective of this paper was to identify different target groups related to the attitudes of German farmers towards the adoption of AFR. For this purpose, the answers of 490 farmers could be evaluated based on an online survey.

First, it can be stated that the entire sample stands neutral to positive towards the adoption respectively the use of AFR for agriculture. These results are consistent with those of [13], according to whom farmers interviewed by them were enthusiastic about the opportunity to test AFR prototypes for weed control. The positive expectations of the sample are also reflected in the expected performance of AFR. The major role of expected benefits on the adoption of a new technology has been confirmed many times in the literature and is considered a basic requirement of successful innovation diffusion [10,19,24,25,29,48]. In [14], the authors emphasized in their study that farmers' perceptions of an overall advantage of AFR is an important adoption requirement of this technology, which seems to be given in this study. Thereby, hoping that more autonomous agricultural technology reduces the workload is in line with the results of [24]. In their Canadian case study, ref. [49] confirm improved farmer health because of workload reduction and potential efficiency gains using AFR. Exploring the motives of adopting robots in agriculture, ref. [50] found that, in addition to reduced physical stress, it leads to more free time and, thus a better quality of life. References [10,48] found—in their analyses of the economic feasibility of AFR—that saving relatively expensive workforce for monotonous operations contributes to the economic benefits of AFR compared to existing technology. The non-perception of an economic advantage or disadvantage of AFR may be due to the partly low level of knowledge or the lack of experience with this technology. The missing experience might also explain the ambiguous attitude of the respondents regarding the effort expectancy. In absolute terms, however, this is still limited. Nonetheless, the tendency for farmers surveyed to be more concerned about having difficulty operating AFR is shared by [13]. She has found that Australian farmers fear the level of complexity of AFR. For German farmers, this might become a problem as well since they also work in an industrialized country. The relevance of the feared complexity was also confirmed in the literature, including European AFR manufacturers, who see it as an important potential adoption barrier [51]. In [29], the authors concluded in their literature review that perceived performance of new technologies only have a positive effect on the attitude towards the adoption of them if they do not lead to a significant increase in perceived effort as well. In this context, given the slight-to-large expected benefits, and little-to-almost-no feared effort across all clusters, a certain potential of future adoption and diffusion of AFR can be assumed. On the other hand, it is important to note that mainly technical effort and safety concerns were surveyed; thus, other aspects may have been neglected. At the same time, in the absence of experience with new technology, an intention-behavioral gap is often observed regarding its use [52]. The perceived neutrality, in terms of trust and social influence, can be seen as positive, as [14] identified a lack of trust in new technology and the loss of social cognition as important cognitive factors to the adoption of AFR. A certain social pressure on farmers in Europe, especially in Germany, results from the public debate on modern production methods in agriculture. The often emotionally charged conflict between economically driven, conventional production methods (e.g., the use of pesticides) and environmentally oriented demands from society are a burden on many farmers influencing them in their strategic decisions (e.g., [28,53–55]). Farmers tend to be particularly affected by this, as they are considered important members of rural communities [56] and are influenced in their adoption behavior by social norms [57]. At the same time, farmers are considered to be at high-risk of being partially replaced by artificial intelligence (AI) through increasing automation from 2030 onwards [58]. The absence of anxieties regarding AFR and the high level of technology commitment could be explained by the fact that farmers deal with agricultural technology on a daily basis, and this technology is constantly changing. In [59], the authors have already shown that farmers are more likely to use new production methods if they have a high technical interest; even more so if they want to adopt a new technology as a pioneer [60].

Second, the partly high standard deviations in the overall sample indicate an inconsistent response behavior. It can therefore be assumed that, with regard to the adoption behavior of AFR among German farmers, there are distinguishable subgroups, analogous to the results of other studies that have investigated, for example, the attitude and investment behavior of farmers [61–64]. One possible classification of such groups was introduced by [16]. In his theory, he described the diffusion of innovations over time. Following him, innovations are initially adopted slowly by a small number of individuals, then more quickly, and by an increasing number of individuals, until a degree of saturation is reached, and they are finally adopted again more slowly by progressively decreasing numbers of individuals. He assigns a total of five groups ("innovators", "early adopters", "early majority", "late majority", and "laggards") to the respective phases of diffusion. Since this is a sample that is basically in favor of AFR, the last groups ("late majority" and "laggards") can be excluded when transferred to the identified clusters. Based on this, a cluster analysis was used to examine possible target groups in this study, whereby three distinguishable clusters (CLUS A, CLUSB, CLUS C) could be formed and compared using cluster-describing variables. These are discussed below and recommendations for further action are given.

4.1. The "Open-Minded AFR Supporters"

CLUS A ("open-minded AFR supporters"), which has a slightly positive stance towards the immediate use of AFR, but is not currently planning to do so, reveals neutral expectations regarding the possibility of generating additional profit through AFR within the basically positive performance expectancy, similar to the overall sample. To encourage this potential target group (which represents the largest share of the sample) to adopt AFR, its economic benefits over existing agricultural technology should be communicated to them. This is also applicable as CLUS A farmers would be willing to make strategic changes, despite low risk appetite, should economically benefits result. For example, experience reports from test farms or studies that prove these benefits (e.g., [10]) could be presented in practical workshops. Similarly, an attempt would have to be made to target the other uncertainties, such as the feared complexity of AFR operations or certainty regarding their repair and maintenance options. First, this can be done through practical field demonstrations. Second, it places the demand on AFR manufacturers to design the technology in such a way that it is compatible with existing agricultural technology or the prevailing circumstances on the farm. It is not the farmer who should adapt to the technology, but the technology to the farmer [58]. If the effort required to operate AFR (e.g., to calibrate the sensors) is too high, this can have a negative impact on farmers' attitudes towards the adoption of the technology [14]. Besides, efforts should be made to emphasize the benefits of AFR for society (such as less emitted noise near populated areas or ecological benefits, such as less pesticide use and less soil compaction), since the "open-minded AFR supporters" on the one hand can be influenced by society's view of AFR, and on the other hand, want to farm in a more environmentally friendly way.

4.2. The "Convinced AFR Adopters"

CLUS B ("convinced AFR adopters"), the second largest cluster, would use AFR immediately and is planning to do so in the future. Due to the high affinity of the "convinced AFR adopters" towards the adoption of AFR, this target group should be particularly courted, as they are likely to be the first to adopt AFR. If the positive expectations of these pioneer farmers are confirmed as a result of AFR use, this could convince more farmers of its viability as a promising technology. Since farmers in this cluster are more willing to take risks and more technophile than farmers in the other two clusters, AFR manufacturers could establish test farms among the "convinced AFR adopters". This could, on the one hand, address existing uncertainties regarding compatibility with existing agricultural technology and additional profit from the use of AFR and, on the other hand, generate technical input from farmers on the practical feasibility of AFR without losing them as potential customers. Besides the strong economic influence in their strategic farm orientation, farmers of CLUS B are influenced in their adoption decision by the ecological added value of AFR, and especially by the society's mood, which is why this should be particularly addressed. The "convinced AFR adopters'" trust in the functioning of AFR can also be considered positive for its fast adoption, as it is a lack of reliability in new technologies such as AFR that represents an important adoption barrier [13,14].

4.3. The "Reserved AFR Interested"

In order to attract the smallest and most skeptical of the identified clusters (CLUS C; "reserved AFR interested") as a target group to adopt AFR, greater efforts have to be made, as they would neither use AFR immediately nor plan to do so in the future. The non-expected efficiency gains and increased environmental performance from the use of AFR can be refuted with various studies. However, it is not certain that this alone would be enough, as farmers prefer to avoid risk rather than increase efficiency [65]. The slight risk aversion of CLUS C farmers might be addressed in several ways. For instance, insurance offers and personal customer support on the part of the manufacturer or risk mitigation for farmers trialing new technologies on the part of policymakers could be an option [14]. Farmers are more inclined to feel that technologies are good or bad based on their own experiences or the experiences of others. Since "reserved AFR interested" are unlikely to be influenced in their decision-making by their social environment, targeted field trials would also be an option for increasing acceptance among this target group. At the same time, this could reduce the anxiety of being overwhelmed by the operation of AFR, provided that AFR manufacturers implement a simple user interface design [14]. Therefore, as in Australia, CLUS C could be more strongly involved in product development and, thus, further promote existing potentials, while reducing possible uncertainties about this technology [13]. Ignorance of operational requirements or compatibility of AFR with existing equipment could be alleviated through focused training or workshops, analogous to CLUS A and CLUS B.

4.4. Conclusions and Limitations

If the identified clusters of this study are finally transferred to the groups of the theory of diffusion of innovations by [16], and compared with their classification on the surveyed 8-point acceptance-unacceptance scale, the "convinced AFR adopters" who assign themselves to level seven ("I would approve the use of AFR") correspond most closely to the "innovators", the "open-minded AFR supporters" who assign themselves to level six ("I would accept the use of AFR") correspond to the "early adopters", the "reserved AFR interested" who assign themselves between level three ("I am torn about the use of AFR") and four ("I am indifferent to the use of AFR") to the "early or late majority", as CLUS C would be the last to use AFR immediately, despite the perceived benefits at a manageable cost [16]. In this context, it would probably be purposeful to address each group in its corresponding phase, starting with the large potential of "convinced AFR adopters". On the other hand, all clusters are at an early stage of opinion formation about AFR, since only a few farmers are likely to be well informed about such a new technology. This would be supported by the indifferent attitude of the "reserved AFR interested" regarding the factor performance expectancy, which could indirectly turn positive by a better communication of, e.g., the ecological advantages of AFR in society.

Nevertheless, the results must be viewed with caution given its limitations. Since the hyperlink to the survey was sent by mail, it can be assumed that farmers interested in AFR or AFR opponents tended to respond to the call (self-selection bias) and, thus, a substantial part of the population remained unnoticed [66]. Furthermore, respondents in such surveys tend not to express their true opinions, but succumb to the phenomenon of social desirability, or show a tendency towards the middle (in this case 3 out of 5) in their response behavior [67]. Compared to the population of farmers in Germany, the age and farm size structure of the sample studied is younger and larger, which could result in a more technophile setting among the respondents, although this may not be misguided against the background of a future technology, such as AFR. On the other hand, given the economic benefits of AFR especially for smaller farms, the larger farm structure of the sample could lead to an underestimation of the actual attitudes towards the adoption of AFR. In addition, relatively high standard deviations appear sporadically in the results. This is an indication that the clusters formed are partly heterogeneous and combine farmers who would possibly form a separate cluster. Further, it must be noted that AFR adoption in general was asked about. The attitude of the farmers could be more positive or more negative depending on the specific AFR type.

Despite these limitations, this study provides interesting results on the attitudes of German farmers towards the adoption of AFR. Especially the knowledge about the characteristics of different target groups is essential to address them systematically and, thus, promoting the diffusion of this new technology. The results are likely to be of interest to AFR manufacturers, which were largely made up of startups, as successful establishment, and diffusion of AFR is probably vital to their future success. Disregarding any claim to representativeness of the sample, there seems to be a lot of interest in this new technology that AFR manufacturers can build on, for example, by better promoting the benefits of AFR to society, as they in turn influence policy and, thus, not only directly, but also indirectly, farmers in their farming activities. In addition, field demonstrations or targeted training opportunities could reduce the expected effort among farmers and increase their knowledge of the benefits of the new technology. Since many AFRs are still in the prototype phase, it would also be conceivable to involve farmers in the AFR production process [13]. This would more quickly reduce uncertainty about farmers' consequences to a tolerable level, which, according to [16], would lead to an eventual adoption decision. Since the use of AFR would reduce production costs, especially on small to medium-sized farms, and these would henceforth be less dependent on government subsidies, politicians might also have a certain interest in promoting AFR [10]. They have various funding instruments that could act either as a supply-side promotion, in the sense of a technology push, or as a demand-side promotion, in the sense of a market pull [68].

Finally, the results motivate further studies. It would be interesting, for example, to survey the perspective of other stakeholders, such as agricultural machinery manufacturers or society, on AFR and to compare it with the farmers' one. After all, a new technology increasingly stands and falls with its public backing (i.e., genetically modified plants) [69]. Methodologically, a more in-depth analysis of influencing directions of the factors formed would be plausible to better understand the cause–effect correlations. For example, choice-based experiments could be used to explore the conditions under which farmers would be willing to adopt this new technology or to determine the willingness to pay for AFR. In addition, it would be interesting to determine the de facto sustainability of AFR with the help of a life cycle assessment.

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Appendix A

Questionnaire

Socio–demographic characteristics

How old are you?

Please indicate as a number (e.g., 54).

Age: _____ years old.

Please mark your gender here.

- Male (1)
- Female (2)

How many years of experience do you have working in agriculture?

Please indicate as a number (e.g., 5).
Experience: _____ years.
Which educational level did you graduate from?
Please mark your highest degree with a cross.

- No school-leaving certificate
- Still in school-based education
- Secondary or elementary school leaving certificate
- Graduation from polytechnic high school
- Secondary school leaving certificate
- (Technical) high school diploma
- (Specialized) university degree

What vocational training have you completed?
Please mark your highest degree with a cross.

- No vocational qualification
- Agricultural training
- Agricultural master
- 1-year technical college
- 2-year technical college
- Bachelor's degree
- Master's degree/Study Diploma
- Doctorate

Questions about your farm
In which region is your farm located?
Please tick only one box.

- North (Bremen, Hamburg, Lower Saxony, and Schleswig-Holstein)
- South-West (Baden-Württemberg, Rhineland-Palatinate, and Saarland)
- South-East (Bavaria)
- West (Hesse and North Rhine-Westphalia)
- East (Berlin, Brandenburg, Mecklenburg-Western Pomerania, Saxony, Saxony-Anhalt, and Thuringia)

What type of business do you run on your farm?
Please tick only one box.

- Main occupation (1)
- Secondary occupation (2)

How is your farm managed?
Please tick only one box.

- Conventional (1)
- Organic (2)

Please mark with a cross approximately how many hectares of agricultural land are cultivated on your farm.
Please tick only one box.

- less than 5 ha (1)
- 5−9 ha (2)
- 10−19 ha (3)
- 20−49 ha (4)
- 50−99 ha (5)
- 100−199 ha (6)
- 200−499 ha (7)
- 500−1000 ha (8)
- more than 1000 ha (9)

What percentage of your farmland is leased?
To do this, please drag the slider (click and hold) to the side until the desired percentage is reached.

0%	100%

How willing are you to take risks as a farmer?

No Willing to Take Risks				**Very Willing to Take Risks**
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

The following statements address your very personal attitude towards and use of modern technology. This is not about a single device, but about your attitude or your experience in the use of modern technologies/electronics in general.
Please mark with a cross.

	Totally Disagree			**Totally Agree**	
I am very curious about new technical innovations.	1	2	3	4	5
Technical innovations mostly overwhelm me.	1	2	3	4	5
I find it difficult to deal with new technology — as a rule, I simply do not know how to do that.	1	2	3	4	5
t is in my hands whether I succeed in using technical innovations (. . .).	1	2	3	4	5
I am always interested in using the latest technical devices.	1	2	3	4	5
When dealing with modern technology, I am often afraid of failing.	1	2	3	4	5
I would (. . .) use much more frequently technical products than I currently do.	1	2	3	4	5
I'm afraid I'll be more likely to break down technological innovations (. . .).	1	2	3	4	5
What happens when I deal with [technology] is (. . .) under my control.	1	2	3	4	5
I quickly find interest in new technical developments.	1	2	3	4	5

This question serves as a quality check.
Please tick "totally agree".

Totally Disagree				**Totally Agree**
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Evaluation autonomous field robots (AFR)

How do you assess the use of AFR concepts on your farm?
Please tick only one box.

- I oppose the use of AFR (1)
- I fundamentally refuse the use of AFR (2)
- I am torn about the use of AFR (3)
- I am indifferent to the use of AFR (4)
- I would tolerate the use of AFR (5)
- I would accept the use of AFR (6)
- I approve the use of AFR (7)
- I promote the use of AFR (8)

How would you rate the following statements about AFR if you imagined handling such machines?

Please mark with a cross.

	Totally Disagree			Totally Agree	
AFR could lighten my workload in certain operations.	1	2	3	4	5
AFR enables me to save work force.	1	2	3	4	5
I imagine the operation of AFR to be difficult.	1	2	3	4	5
I find AFR intimidating.	1	2	3	4	5
I would trust AFR to make the right decisions.	1	2	3	4	5
Using AFR, I would be afraid to damage it.	1	2	3	4	5
With AFR, I could operate more efficiently.	1	2	3	4	5
A safe handling of AFR would be difficult for me.	1	2	3	4	5
If I were to use AFR, I would be afraid of misusing it.	1	2	3	4	5
AFR would make farming more environmentally friendly.	1	2	3	4	5
Learning how to handle AFR would be difficult for me.	1	2	3	4	5
I think that other farmers would like to see AFR used on my farm.	1	2	3	4	5
I would follow the instructions given to me by an AFR.	1	2	3	4	5
The maintenance/repair of AFR would be a problem on my farm.	1	2	3	4	5
I find AFR frightening.	1	2	3	4	5
I think it would make a good impression on society if I used AFR.	1	2	3	4	5

In summary, I consider the use of AFR to be . . .

a bad idea				a good idea
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
an unwise move				a smart move
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
negative				positive
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

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