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E-commerce in agriculture – The case of crop protection product purchases in a discrete choice experiment

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Abstract

The internet is playing an increasing role in the development of rural areas. For farmers in particular, reliable internet access creates opportunities concerning farm management decisions. Hence, the goal of this study was to investigate German farmers' willingness to buy inputs online. Primary data was collected by conducting a discrete choice experiment about the purchase of crop protection products. Selection decisions of 165 arable farmers were analyzed by a generalized multinomial logit model (GMNL) resulting in willingness to accept (WTA) space estimation. WTA estimates show that farmers are willing to switch to an online merchant if they are offered a significantly lower price. However, word-of-mouth-reputation and consultation offered via traditional media do not influence farmers' WTA for an online merchant. In contrast, delivery time significantly affects farmers' WTA for inputs purchased online. We also show that farmers' risk attitudes, prior online shopping experiences, and education are influential factors for the WTA for an online merchant. Surprisingly, age and farm size do not impact farmers' WTA. Since e-commerce has not been widely established in agriculture yet, these results are of great practical importance. The findings of this study give online merchants of agricultural inputs a first orientation for choosing appropriate marketing measures. Moreover, results are interesting for education policy.

Keywords: Internet use; E-commerce; Input purchasing; Online merchants; German farmers

1 Introduction

Nowadays, in most rural areas in Europe, the internet is no longer a new territory. The Digital Agenda driven by the European Commission aims to achieve nationwide coverage of high-speed internet (30 Mbps) for all member countries by 2020 (European Commission, 2016). To mention a few specific examples, even in rural areas in Germany, 97.3 % of households had the ability to go online in 2014 (BMEL, 2014) and 98.2% of rural communities had a minimum broadband internet speed between 2 Mbps and 6 Mbps in 2016 (BMVI, 2016a). Very fast internet speeds of 50 Mbps or more were reached in 29.9% of rural communities. By 2018, the German government wants to supply every household with 50 Mbps (BMVI, 2016b). These developments in internet infrastructure make life in rural areas more appealing, such as by enabling home office work and online shopping (BMEL, 2014; Rentenbank, 2015). Especially for farmers, access to high-speed internet is more important than ever due to the growing importance of internet-linked management innovations (Rentenbank, 2015). Kaloxylos et al. (2012) suggested that there is a change from outdated farm management systems to sophisticated ones which make use of the internet.

The use of future internet technologies is expected to affect the agricultural sector to a great extent (Kaloxylos et al., 2013). Regarding business purposes in particular, the availability of the internet plays a promising role for farmers (Canavari et al., 2010; Hennessy et al., 2016; Warren, 2004). Farmers can improve farm income and performance by benefiting from the capabilities of the internet (Chang and Just, 2009) in order to reduce transaction costs (Doluschitz, 2002, Hennessy et al., 2016; Mishra et al., 2009). In this respect, the internet facilitates acquisition of price and product information and supports interaction with a broader pool of both suppliers and customers (Henderson et al., 2004; Zapata et al., 2016). Therefore, e-commerce, defined as internet use for business purposes (Fruhling and Digman, 2000), is an interesting field for agriculture (Mueller, 2001; Wen, 2007). Leroux et al. (2001) described that there is much optimism about the development of e-commerce in the US. Similarly, the prominent German farmers' magazine *top agrar* reports that experts attach great importance to e-commerce for agriculture in the future (top agrar, 2000). The New Media Tracker provides first numbers on German farmers' online purchases. In 2015, machine parts were bought online by 71% of German farmers, whereas only a small share bought fertilizers and crop protection products online (Kleffmann Group, 2016). In this context, the agriculture industry's economic barometer gives insights into German farmers' intentions to use the internet for business purposes in the future. Interestingly, around 70% of farmers stated that selling and purchasing by means of e-commerce are conceivable for future decision making (Rentenbank, 2015). In addition, the internet was used by 95% of German farmers in 2016, of which more than two thirds were online daily (Kleffmann Group, 2016).

However, it is surprising that, as of yet, few German farmers buy production inputs online, although the growing internet infrastructure opens up new markets. Against this background, the objective of this paper is to analyze German farmers' preferences for the use of e-commerce for input purchases. Our research contribution is further highlighted by prior studies, which have mentioned that recent literature in the field of internet use by farmers is rather rare (Mishra et al., 2009) and that the vast majority of studies in this field concentrate on US farm businesses (Hennessy et al., 2016). Although Batte and Ernst (2007) delivered first experimental results on US farmers' internet purchasing behavior concerning herbicides and machine parts, their study is now several years old. To derive recommendations for both online merchants and policy makers, new research is necessary since the development of internet infrastructure in rural areas is a great political goal in the European Union. Furthermore, Batte and Ernst (2007) did not consider how merchant reputation and the buyer-supplier relationship impact e-commerce behavior of farmers. To the best of our knowledge, we are the first to focus on this topic.

To get first insights into the acceptance of e-commerce in German agriculture, we conducted a discrete choice experiment (DCE). In a hypothetical scenario, farmers were invited to imagine that they had to decide today where they will buy all their crop protection products for the upcoming year. In addition to choosing to stick with their current merchant, farmers could alternatively choose a local merchant or an online merchant. Farmers' preferences and willingness to accept (WTA) e-commerce were investigated using a generalized multinomial logit model (GMNL) in WTA space. With this approach, we build on previous studies in the fields of agricultural and environmental research estimating farmers' WTA (Christensen et al., 2011; Schreiner and Latacz-Lohmann, 2015; Schulz et al., 2014). All of these prior studies estimated the WTA in preference space, which, unfortunately, often leads to unrealistic and invalid WTA estimations (Hensher and Greene, 2011; Scarpa et al., 2008). Nevertheless, models in WTA space have been found to produce more realistic estimations (Train and Weeks, 2005). Therefore, the model estimation in WTA space is an important feature in our study. Compared to Batte and Ernst (2007), this is also a further improvement made by our study.

This paper is organized as follows. In the next section, research hypotheses are derived on the basis of a review of literature in the fields of e-commerce and technology adoption by farmers. In section 3, the idea of the DCE approach is explained, followed by a presentation of the experimental setting and the introduction of the econometric model. Findings are presented and discussed in section 4. Finally, the paper ends up with a conclusion section.

2 Factors influencing e-commerce activities

In the following section, we derive our research hypotheses from a literature review. Firstly, we concentrate on literature related to attributes characterizing merchants (Hypotheses 1a-1d).

Subsequently, we formulate hypotheses concerning the influence of personal characteristics on e-commerce (Hypotheses 2a-2c).

2.1 Price in e-commerce

The price of traded products is known to be of great importance for online purchasing decisions (Kim et al., 2012). In line with this, Reibstein (2002) showed that price influences a customer's initial decision to buy from an online store. First evidence in the agricultural context was provided by Batte and Ernst (2007). They conducted a joint analysis on U.S. farmers' herbicide and machine parts purchasing behavior. They found, amongst other things, that farmers are willing to buy from an online or national merchant outside their community if they can expect a significantly lower price. As an example, the estimated price advantage to justify an online purchase has to be around 10% in the case of herbicides. Additionally, around 34% of those surveyed stated that price influences their decision to purchase inputs online. Similar findings are conceivable for German farmers' behavior regarding online purchasing. Also taking into account that e-commerce introduces risk compared to traditional commerce (Chang et al., 2005; Chiu et al., 2014; Hong, 2015; Tan and Thoen, 2002; Wu and Chang, 2007), we therefore hypothesize that:

Hypothesis 1a: Farmers have a higher WTA for an online merchant than for a local merchant.

2.2 Trust in e-commerce

Aside from price, trust is also an important factor in the online shopping context. Lack of trust is often discussed as an important reason for consumers' avoidance of online shopping (Kim et al., 2012; Kim and Benbasat, 2003; Lee and Turban, 2001; Perea y Monsuwé et al., 2004). Doney and Cannon (1997) described that the salesman is the most important source of trust in the buyer-supplier relationship. Unfortunately, this physical salesman is not available in the online shopping context (Hong, 2015; Lohse and Spiller, 1999). In this respect, Walsh et al. (2017) suggested that a positive reputation of an online merchant reduces consumers' perceived risk and engenders trust. Hence, merchant reputation can serve as an important trust-building factor (Caruana and Ewing, 2010; Eisenbeiss et al., 2014). Cheung and Lee (2012) argued that word-of-mouth reputation in particular plays a prominent role in the e-commerce setting. In more detail, recommendations of acquaintances can influence a consumer's evaluation of merchant competence and reduce perceived risks (Senecal and Nantel, 2004). In the agricultural context, Jarvis (1990) found that the adoption of computers is affected by the actions of peers and family. Additionally, Foster and Rosenzweig (1995) suggested that farmers learn from neighbors concerning the adoption of new technologies. Underpinned by the fact that 43% of German farmers stated in a recent survey that they distrust e-commerce (Kleffmann Group, 2016), we hypothesize that:

Hypothesis 1b: Recommendations of peers reduce the farmer's WTA for the online merchant.

2.3 Service quality in e-commerce

Ho et al. (2010) provided a broad literature review showing that 87% of the papers have focused on quality in the supplier selection process. Service quality is one of the mentioned attributes. Kolesar and Galbraith (2000) argued that the internet is a poor service delivery medium, and, hence, service quality experience is influenced by the relationship between buyer and supplier. Thus, the interaction between buyer and supplier is important in an e-commerce setting since there is uncertainty about whether ordered products will meet prior expectations (Weathers et al., 2007). For instance, Basso et al. (2001) provided evidence that consultation via richer communication media can reduce this uncertainty. In the agricultural context, Schulze et al. (2006) suggested that communication is a very important determinant of the buyer-supplier relationship. In line with this, service quality was found to influence farmers' relationship satisfaction (Aji, 2016). Furthermore, 45 % of German farmers stated the lack of personal consultation makes online purchasing unattractive (Kleffmann Group, 2016). Similarly, Briggeman and Whitacre (2008) noted that the acceptance of e-commerce in agriculture is impeded by a lack of personal interaction. We therefore hypothesize that:

Hypothesis 1c: The more personal the consultation offered by the merchant, the lower the farmers' WTA for the online merchant.

2.4 Delivery time in e-commerce

Furthermore, a good delivery service plays a decisive role in e-commerce as well (San Martín and Camarero, 2009). In line with this, Ho et al. (2010) found that delivery is an important criterion considered by the decision maker for selecting a suitable merchant: around 82% of the reviewed papers focused on delivery aspects in consumers' choice of merchant. Batte and Ernst (2007) provided evidence regarding the importance of delivery in the agricultural context. Their investigation showed that, besides price, improved delivery service influences a farmer's decision to buy outside his/her community. More concretely, farmers are around

51% less likely to choose an online or national merchant if they expect longer waiting times for urgently needed machine parts. Surprisingly, they did not find an influence of delivery time on herbicide purchases outside farmers' communities. However, the delivery service would logically seem to be an important criterion for farmers' merchant selection, especially regarding crop protection products. This can be illustrated with an example: concerning cost-effective crop protection, farmers often refer to economic thresholds. These thresholds are critical infestation levels at which measures should be implemented to avoid economic losses (Ramsden et al., 2017); therefore, delayed delivery would waste valuable time. In this respect, issues with timely delivery could cause the failure of merchants in e-commerce (Briggeman and Whitacre, 2008). Hence, we hypothesize that:

Hypothesis 1d: A shorter delivery time reduces farmers' WTA for the online merchant.

2.5 Risk aversion of consumers and e-commerce

Chang et al. (2005) showed that consumers' risk aversion affects e-commerce activities as follows: the higher the risk aversion, the lower the probability to shop online. This agrees with the findings of Wu and Chang (2007), who also investigated the role of risk attitude in online shopping. Their results support the idea that the risk attitudes of conventional offline buyers and online buyers are different. In addition, Swinyard and Smith (2003) delivered similar results. In the field of agricultural research, there is no study which specifically looks at the relationship between farmers' risk attitudes and the use of e-commerce. However, Carrer et al. (2017) examined, amongst other aspects, the influence of risk aversion (using production contract uptake as a proxy) on the adoption of computers by Brazilian farmers. Although they did not find a significant effect, the estimated coefficient has a negative sign, as expected. Based on this literature, we conclude the risk aversion should also play a role in farmers' internet purchasing decisions. Hence, we hypothesize that:

Hypothesis 2a: Risk aversion increases farmers' WTA for the online merchant.

2.6 Prior experiences with e-commerce

There is also a broad range of literature focusing on the effect of a consumer's internet shopping history on future purchases over the internet (Bilgihan, 2016; Brown et al., 2003; Chang et al., 2005; Farag et al., 2007; Ling et al., 2010; Shim et al., 2001; Teo and Yu, 2005). The majority of these studies found that prior online purchases can influence the willingness to buy goods online again. As an explanation for this, Perea y Monsuwé et al. (2004) argued that prior online experiences can reduce the perceived risk of a consumer. Similarly, Chen and Barnes (2007) explained that familiarity induced by experiences with online transactions impact future online purchasing behavior. Apart from that, there are also some studies concentrating on the effect of farmers' experiences on computer or internet use. In this case, off-farm work is sometimes used as a proxy for farmers' experiences with computers and the internet (Huffman and Mercier, 1991; Mishra et al. 2005; Mishra et al., 2009). For instance, Mishra et al. (2005) described that part-time farmers are more likely to use computers and the internet. In line with this, Mishra et al. (2009) found that farmers' adoption of the internet is positively affected by off-farm work and, therefore, by farmers' experiences. Taking the aforementioned studies into account, we hypothesize that:

Hypothesis 2b: First online shopping experiences reduce farmers' WTA for the online merchant.

2.7 Sociodemographic and business characteristics in e-commerce

Many studies show that personal and business characteristics affect the computer and internet use of farmers (Alvarez and Nuthall, 2006; Amponsah, 1995; Batte et al., 1990; Batte, 2005; Carrer et al., 2017; Gloy and Akridge, 2000; Huffman and Mercier, 1991; Jarvis, 1990; Mishra and Park, 2005; Ortmann et al., 1994; Putler and Zilberman, 1988; Woodburn et al., 1994). Concerning the internet purchasing behavior of farmers, some studies are available. One of these studies was carried out by Smith et al. (2004). Amongst other aspects, they explored farmers' decisions to make online purchases. Concerning business characteristics, farm size was the most influential variable in their investigation. According to the results of Batte and Ernst (2007), age of the farm operator and farm size did not have significant effects on the probability to make online purchases. Furthermore, the findings regarding the influence of education are mixed. Contrary to their expectations, farmers with post high school education were less willing to buy herbicides from an online provider, whereas post high-school education was related to a higher probability to buy machine parts online. Additionally, Briggeman and Whitacre (2008) showed that farmers that purchase inputs online tend to be more educated and that younger farmers are more likely to use e-commerce applications. Mishra et al. (2009) concentrated on internet access and internet purchasing patterns of farmers. In this study, they found that age, education, and farm size positively affect farmers' decisions to use computers. In contrast, internet purchasing patterns of farmers are neither influenced by age nor by farm size. In this regard, education has a significant influence. Taragola and van Lierde (2010) provided evidence that age negatively affects horticulturists' decision to use e-commerce applications. Furthermore, they found that higher education promotes internet use for business purposes and suggested that for larger businesses, the perceived advantages of e-commerce are greater. Based on the aforementioned findings, we hypothesize that:

Hypothesis 2c: Personal and business characteristics of the farmer influence the WTA for the online merchant.

3. Material and Methods

3.1 Data collection

For the empirical analysis, primary data was collected from German arable farmers. An anonymous online survey was developed and available for participants in February and March of 2017. Farmers were invited to participate in the survey through a reference to the study in online forums where farmers discuss several issues related to agriculture and further social media channels. The surveys of 165 farmers were included in the evaluation. The questionnaire was structured as follows: At the beginning, farmers were asked to provide general data concerning their farm operation. Secondly, we provided necessary information on the experimental setting (see Appendix). Subsequently, the DCE was conducted. Then, questions were raised to gain information on the farmers' usual input purchases and prior internet buying behavior. The risk attitude of the farmers was measured using an eleven-point risk attitude scale (Dohmen et al., 2011). The questionnaire ended with the collection of socio-demographic data.

3.2 The experimental approach

The underlying idea of a DCE is the stated preference approach, which can be attributed to Random Utility Theory. This approach allows conclusions to be drawn from previously unarticulated preferences about real choice decisions (Louviere et al., 2000). It is thereby possible to investigate the individual's preferences using an attribute-based measure in a hypothetical decision-making context (List et al., 2006). In detail, choice sets including different alternatives are presented to the participant, who is invited to choose the most preferable alternative. For each presented alternative, the attributes and their associated levels are pre-defined. Furthermore, these attributes are systematically varied in their levels, leading to different choice sets. In doing so, it is possible to detect the respective influences on the participant's choices in the DCE (Louviere et al., 2000). To investigate the preferences of German farmers regarding engagement in e-commerce, a DCE is appropriate since there is a lack of data about real internet purchases of farmers. Hence, preferences for different attributes of online merchants can be identified through an experimental design. Using this approach, initial predictions can be made about how online merchants should target their marketing in order to acquire agricultural customers.

After an introduction to the experimental procedure, the following decision situation was presented to the participating farmers: the farmers had to choose one of two merchants for the purchase of their crop protection products for one year or could decide to retain their current merchant (opt-out). Each decision situation (choice set) provided two different and mutually exclusive purchasing alternatives. These purchasing alternatives (local merchant or online merchant) were described by the following four attributes: consultation, recommendations of peers, delivery time, and price advantage. To make the choice decision as realistic as possible, attributes and their levels were chosen based on our literature review, the results of a pretest with 17 farmers, and expert discussions with both farmers and merchants. The used attributes and their levels are shown in Table 1. Following Batte and Ernst (2007), the monetary attribute (in our case, the price advantage) took possible costs for consultation and delivery into account. When there was no price advantage offered, the farmer was asked to assume that the costs are identical to his/her current merchant.

3.3 Determination of choice sets

The experimental design of the DCE was comprised of two labeled alternatives (local merchant and online merchant) and four attributes with different levels, as presented in Table 1. In order to investigate farmers' internet purchasing behavior, different choice sets had to be generated. In a full-factorial design, all possible combinations of the levels for the different attributes are considered, which leads to thousands of different choice sets. For greater practicability, the number of choice sets was reduced by choosing a so-called "efficient design". Using an efficient design, it is possible to incorporate ex-ante information and the associated uncertainty in terms of random distributions regarding the population's utility parameters. In such designs, prior parameter estimates are drawn from Bayesian parameter distributions and are therefore known as Bayesian or D-efficient designs (Rose and Bliemer, 2009). To gather ex-ante information for the final design, we conducted a pretest with 17 arable farmers. Based on these pretest results, a D-efficient Bayesian design was created using the software Ngene 1.1.2 (Choice Metrics, 2016). In this way, the number of choice sets was reduced to twelve. In the experiment, the choice sets appeared in a randomized order. One of these twelve choice sets is shown in Table 2.

Table 1: Attributes and their levels in the discrete choice experiment

Attribute	Levels	References
Price advantage[a)]	0%	(e.g., Batte and Ernst, 2007; Reib-
	5%	stein, 2002; Pretest results; Expert
	10%	discussions)
Recommendations of peers	0	(e.g., Eisenbeiss et al., 2014; Foster
	5	and Rosenzweig, 1995; Jarvis,
	10	1990; Pretest results)
	15	
Consultation	No consultation	(e.g. Doluschitz, 2002; Santos,
	E-Mail consultation	2003; Schulze et al., 2006; Pretest
	Telephone consultation	results; Expert discussions)
	Face-to-face consultation[b)]	
Delivery time	1 day	(e.g., Batte and Ernst, 2007; Ho et
	2 days	al., 2010; Pretest results; Expert
	3 days	discussions)
	4 days	

[a)] The price advantage refers to the costs for all crop protection products needed by the farmer per year.
[b)] Only appears for the local merchant since there is no face-to-face contact in e-commerce.
Source: Authors' illustration

Table 2: Example of a choice set used in the experiment[a)]

	Merchant attributes	Local merchant	Online merchant	Current merchant
?	Price advantage	0%	5%	Your experiences
?	Recommendations of peers	15	5	
?	Consultation	Telephone consultation	No consultation	
?	Delivery time	1 day	4 days	
	I choose:	O	O	O

[a)] Question marks present mouse-over-buttons which concisely repeat the information about the merchant attributes given before the experiment.
Source: Authors' illustration

Each choice set had a tabular structure. The first column showed the attributes by which the merchant was characterized. In the next two columns, the alternatives were specified by the levels of the attributes. The last column gave the opt-out alternative, which was defined as the current merchant of the farmer. For every attribute, there were mouse-over-buttons (question marks in Table 2) which ensured that the farmers had access to information on the attributes throughout the experiment (see Appendix).

3.4 Model choice for WTA estimation

In order to model consumer preferences, calculating an individual's willingness to pay (WTP) or WTA is of particular interest. Since WTP estimation can be readily extended to WTA estimation, we use WTP/WTA in the following (Rose and Masiero, 2010). With regard to the estimation of WTP/WTA, models "in preference space" can be used. In these models, the coefficients related to the choice attributes are specified to follow a specific distribution (e.g. log-normal or normal). Thus, the WTP/WTA values are derived from the distribution of the previously estimated coefficients by dividing the attribute coefficient by the price coefficient. Therefore, the WTP/WTA is given by the ratio of two randomly distributed terms. However, estimating the WTP/WTA in preference space has its shortcomings. Unfortunately, this approach often results in unrealistic and invalid distributions for WTP/WTA (Hensher and Greene, 2011; Scarpa et al., 2008). To address these weaknesses of the estimation, models in WTP/WTA space can be used. A major benefit of these models is that coefficients for WTP/WTA are directly estimated by a reformulation of the model in preference space. Hence, assumptions regarding the distributions of WTP/WTA are made directly rather than on the attribute coefficients. There is evidence that this approach produces more realistic WTP/WTA estimations than the preference space approach (Train and Weeks, 2005).

Following Train and Weeks (2005) and Scarpa et al. (2008), the idea of models in WTP/WTA space can concisely be shown. The utility of alternative *j* perceived by farmer *n* in choice situation *t* is represented by U_{ntj} and can be split into a price component (p) and non-price attributes (x):

$$U_{ntj} = -\alpha_n p_{ntj} + \beta_n' x_{ntj} + \varepsilon_{ntj} \qquad (1)$$

where α_n and β_n vary randomly across farmers and ε_{ntj} is an independent and identically distributed (i.i.d.) error term. The variance of ε_{ntj} is farmer-specific: $Var = k_n^2(\pi^2/6)$, where k_n is the scale parameter for farmer *n*. Since utility is ordinal, equation (1) can be divided by k_n in order to obtain its scale-free equivalent. Thus, behavior of U_{ntj} is not affected by this adjustment:

$$U_{ntj} = -(\alpha_n/k_n)p_{ntj} + (\beta_n/k_n)'x_{ntj} + \varepsilon_{ntj} \quad (2)$$

Then, ε_{ntj} has a constant variance $\pi^2/6$ for each farmer. Furthermore, defining the utility coefficient as $\lambda_n = (\alpha_n/k_n)$ and $c_n = (\beta_n/k_n)$, utility can be written as:

$$U_{ntj} = -\lambda_n p_{ntj} + c_n' x_{ntj} + \varepsilon_{ntj} \quad (3)$$

which is the so-called model in preference space. The WTP/WTA for an attribute is then given by the ratio of the attributes coefficient to the price coefficient calculated ex-post estimation: $w_n = c_n/\lambda_n$. Hence, equation (3) can be rewritten as

$$U_{ntj} = -\lambda_n p_{ntj} + (\lambda_n w_n)' x_{ntj} + \varepsilon_{ntj} \quad (4)$$

describing utility in WTP/WTA space. w_n is, therefore, a direct outcome of the estimation process.

4 Results and discussion

4.1 Descriptive statistics

Table 3 shows descriptive statistics of the variables used in the econometric model. Participating farmers cultivated 230.98 hectares of arable land on average, which is more than the average arable farmer in Germany with 57 hectares. The average respondent is 39 years old, while in the German farmer population, the average farmer is 53 and therefore older than the farmers in our sample. A third of those surveyed held a university degree. Therefore, the share of farmers with an academic education in our sample is higher than the German average, where only 10 % have a university degree. This might be inter alia explained by the fact that we generated our sample using an online survey. Online experiments have great advantages, since they are both low cost and able to reach many potential participants easily (Granello and Wheaton, 2004). With regards to first experiences with e-commerce, around 15% of the farmers stated that they had bought production inputs (e.g. fertilizers or crop protection products) online before. This is in line with the information of the New Media Tracker, which stated that relatively few farmers have used the internet for purchasing production inputs so far (Kleffmann Group, 2016). Finally, Table 3 provides information on the farmers' willingness to take risks. The average farmer in the sample was nearly risk neutral (6.29).

Table 3: Descriptive statistics of the variables used for interactions in the econometric model (n = 165)

Variable	Mean	SD	Min.	Max.	German average[a)]
Farm size (in hectares arable land)	230.98	343.78	7	2100	57
Age of farmer (in years)	39.00	11.95	20	71	53
Education (1 if farmer holds an university degree; 0 otherwise)[b)]	0.34	0.47	0	1	0.10
Online experiences (1 if farmer bought crop protection products and/or fertilizers online before; 0 otherwise)[b)]	0.15	0.35	0	1	0.07/0.05[c)]
Risk self-assessment of farmer[d)]	6.29	2.38	0	10	not available

a) (AgriDirect, 2013; Destatis, 2011; Destatis, 2017; Kleffmann Group, 2016).
b) For the econometric analysis, the dummy variables are effect coded: -1 and 1.
c) Crop protection products/fertilizers.
d) 0-<5 = risk-averse, 5 = risk neutral, >5-10 = risk-seeking.
Source: Authors' calculations

For greater clarity, Figure 1 provides an overview of the distribution of answers for the risk self-assessment of the participating farmers. On the one hand, there were farmers who stated that they are very willing to take risks. On the other hand, there were farmers who stated that they are very risk-averse (0 on the risk attitude scale).

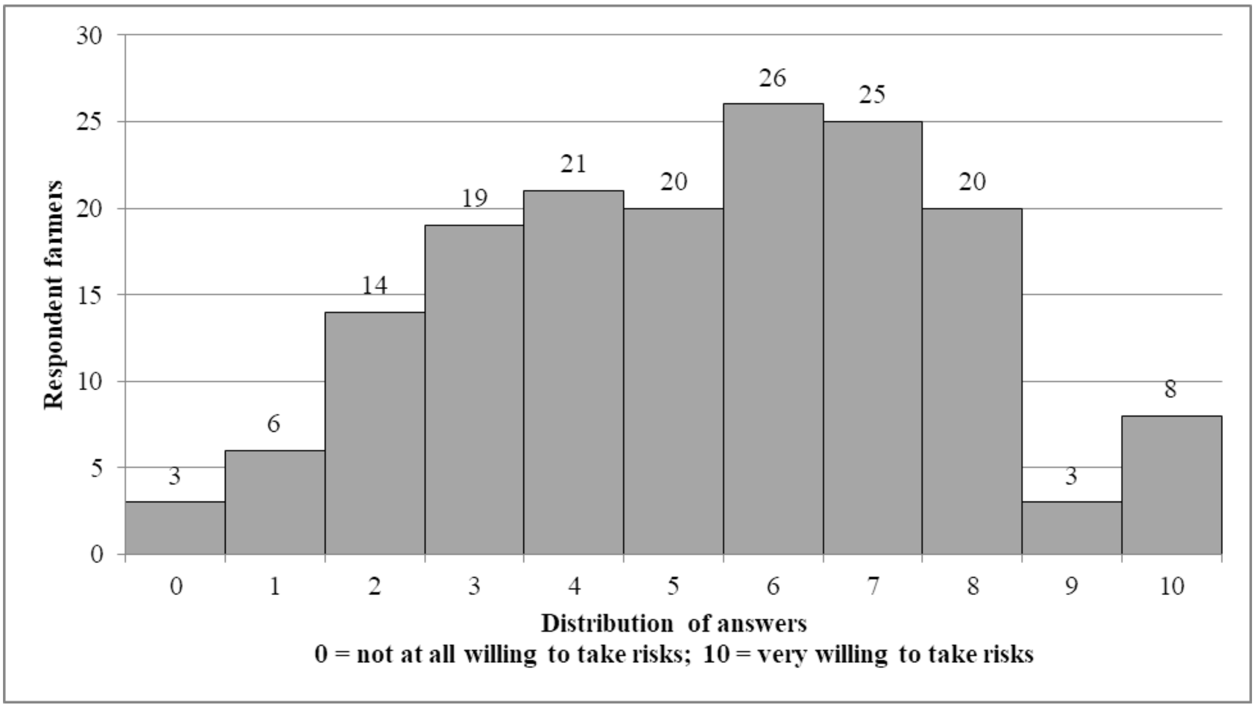

Figure 1: Distribution of answers concerning farmers' risk self-assessments (n = 165)
Source: Authors' illustration

4.2 Estimation of WTA

According to Fiebig et al. (2010) and Greene and Hensher (2010), Models in WTP/WTA space are a specified form of the generalized multinomial logit model (GMNL model). Therefore, the Stata module of Gu et al. (2013) for GMNL estimation using 1,000 Halton draws (iterations) was implemented. Table 4 presents the results of two models. First, we estimated a basic model (Model 1), which represents the WTA of the average farmer. Next, we created a more complex model by including farmer-specific variables as interaction terms with different merchant attributes in the estimation (Model 2). These interaction terms account for possible causes of the observed heterogeneity, which were characterized by significant standard deviations of the random parameter distributions of Model 1. The goodness-of-fit of the estimated models was measured using the McFadden pseudo-R^2, which was 0.36 for Model 1 and 0.37 for Model 2. According to Hensher et al. (2005: 338), a pseudo-R^2 of at least 0.3 indicates that the model fit is

Table 4: Estimation results of the GMNL model in WTA space (n = 165)[a)]

Variable	Coefficient	
	Model 1	Model 2
Merchants and attributes:		
Online merchant	-8.99 ***	-9.78 ***
E-Mail consultation[b)]	0.52	0.30
Telephone consultation[b)]	0.39	0.39
Delivery time	-2.76 ***	-2.71 ***
Recommendations of peers	0.04	0.05
Local merchant	-4.89 ***	2.50
E-Mail consultation[b)]	-0.06	0.79 *
Telephone consultation[b)]	-1.33 **	-0.81 *
Face-to-face consultation[b)]	2.27 ***	1.80 ***
Delivery time	-1.99 ***	-3.91 ***
Recommendations of peers	0.09 **	0.07
Interaction terms:		
Risk attitude × Online merchant		0.27 **
Online experience[c)] × Online merchant		3.53 ***
Farm size × Online merchant		0.05
Education[d)] × Online merchant		2.16 ***
Age × Online merchant		0.02
Risk attitude × Local merchant		0.32 *
Farm size × Local merchant		0.32 **
Education[d)] × Local merchant		-0.34
Age × Local merchant		-0.21 ***
Standard deviation (SD) of random parameters:		
SD Online merchant	7.62 ***	8.63 ***
SD Local merchant	10.26 ***	5.13 ***
SD Delivery time (Online merchant)	1.49 ***	1.56 ***
SD Delivery time (Local merchant)	2.46 ***	5.40 ***
SD Face-to-face consultation (Local merchant)	1.82 ***	1.88 ***
Scale heterogeneity:		
Tau	1.24 ***	1.33 ***
Goodness of fit:		
Log-Likelihood	-1051.95	-1031.54
AIC	2137.89	2115.10
McFadden pseudo R^2	0.36	0.37

Notes: ***p < 0.01; **p < 0.05; *p < 0.10; Number of random Halton draws = 1000.
[a)] WTA = willingness to accept; AIC = Akaike's information criterion.
[b)] Effect coded variable; base level is "no consultation".
[c)] Effect coded variable; base level is "no experience with purchasing inputs online".
[d)] Effect coded variable; base level is "no university degree".
Source: Authors' calculations

appropriate. For estimating a model in WTP/WTA space, Balogh et al. (2016) and Train and Weeks (2005) suggested that the price coefficient (in our case the coefficient for the price advantage) has to be normalized to one (for further discussion on this topic, see e.g. Scarpa et al., 2008; Scarpa and Willis, 2010). Hence, estimates allow a very convenient interpretation as they can directly be treated as WTP/WTA values. We therefore do not show the normalized coefficient for the monetary attribute "price advantage" in Table 4. For effect-coded variables, the WTA for the base level (WTA_{Basis}) was calculated as the negative sum of the estimated WTA values for the other levels of the variable. For calculation of WTA_{Basis}, coefficients which were statistically not different from zero are not considered.

4.3 Hypotheses testing

Hypothesis 1a: Farmers' WTA for an online merchant is higher than for a local merchant.

Model 1 provides estimates for the average farmer's WTA for both the online and the local merchant. In order to switch from the current merchant to the online merchant, the average farmer requires a price discount of around 9% on the annual costs for his/her crop protection products. In comparison, the WTA for the local merchant is around 5% on average. In other words, the online alternative is more strongly rejected by the farmers than the local one. Hence, we cannot reject Hypothesis 1a. Considering that 85% of the farmers in our sample did not buy inputs online before, this result is plausible. Our results are in close agreement with the findings of Batte and Ernst (2007), who suggested that farmers require 10% lower prices to incentivize the purchase of herbicides online. Thus, one possible strategy for online merchants could be to offer price discounts in order to motivate farmers to make initial purchases. Nonetheless, online merchants should not only focus on price policy. This became clear once the remaining hypotheses were tested.

Hypothesis 1b: Recommendations of peers reduce the farmer's WTA for the online merchant.

The estimated coefficient for the variable "Recommendations of peers" was 0.04 (Model 1). Although the coefficient had the expected positive sign (interpreted as a decrease in WTA), it was not statistically significant. We therefore reject Hypothesis 1b. In contrast, there was a positive significant effect of recommendations of peers on the WTA for the local merchant. Nonetheless, this effect was rather small. Every additional recommendation led to a decrease of 0.09 percentage points in the WTA. For instance, ten recommendations for the local merchant reduced the WTA of the average farmer by 0.9 percentage points. A possible explanation for this could be that only 8% of the farmers in our sample indicated that they have discussed their current merchant with peers. We therefore conclude that there is not intensive exchange of information regarding prior experiences with merchants among German farmers. Hence, new e-commerce retailers, in particular, should invest in trust-developing measures to strengthen or build a reputation, such as cooperating with partners who are already integrated in an electronic marketplace (Grabner-Kraeuter, 2002). As a German example, early e-commerce platforms such as *agrando.de* and *agra2b.de* both aim to improve the procurement of agricultural inputs by bringing merchants and farmers together. According to our results, this approach seems to be promising for the success of e-commerce in agriculture.

Hypothesis 1c: The more personal the consultation offered by the merchant, the lower the farmers' WTA for the online merchant.

Model 1 shows that the offered communication medium for consultation does not affect the average farmer's WTA for the online merchant. As expected, the estimated coefficients for "E-Mail consultation" and "Telephone consultation" are positive (interpreted as a decrease in WTA), but are not significant. Thus, we reject Hypothesis 1c. Furthermore, it is striking that offered consultation significantly influences farmers' WTA for the local purchase. If the local merchant provides communication via telephone, farmers request a higher price advantage on average compared to the base level of no communication. Compared to the case of no communication, a face-to-face relationship between the local merchant and the average farmer leads to a decrease of the WTA by 3.21 percentage points (WTA_{Basis} = - (-1.33+2.27) = - 0.94; 3.21 = 2.27 - (-0.94)). One possible explanation for this could be that the average farmer requires an intimate business relationship when switching from his or her current merchant to another local one. In line with this, 75% of the participating farmers stated that they were offered a face-to-face consultation by their current merchant if needed. Altogether, results indicate that traditional communication media for consultation in e-commerce are not relevant for farmers. By implementing more interactive media, such as online chats or real-time feedback via video telephony, online merchants could offset the missing face-to-face contact (Basso, 2001). Hence, the choice of communication media for consultation should be strategically considered by online merchants in order to build a trusting and sustainable relationship.

Hypothesis 1d: A shorter delivery time reduces farmers' WTA for the online merchant.

Model 1 indicates that the delivery time plays an important role in farmers' merchant choice. Delivery times influence the average farmers' WTA for both online and local merchants significantly. Hence, we can accept Hypothesis 1d. According to the results of Model 1, the average farmer requests a price advantage of around 2.76% for an online purchase if the delivery time increases by one day. Similarly, for the local merchant, an increase in delivery time by one day leads to an increased WTA by around 1.99 percentage points. This finding indicates that farmers' reactions are more sensitive when longer waiting times are expected in the e-commerce setting. This agrees with results of prior studies, which underlined the importance of delivery time for online shopping decisions (see, for instance, Batte and Ernst, 2007; Briggeman and Whitacre, 2008). Hence, online merchants of agricultural inputs should attach great importance to delivery service in order to take farmers' time constraints into account. Overnight delivery, as is offered by many online shops, could also be contemplated by online merchants of agricultural products.

Hypothesis 2a: Risk aversion reduces farmers' WTA for the online merchant.

The interaction variable "Risk attitude × Online merchant" provides information regarding the extent to which the WTA for the online merchant is related to farmers' risk attitude. According to the estimates of Model 2, the more risk-averse the farmer, the higher the WTA for an online purchase. In other words, the positive coefficient shows that the WTA decreases by 0.27 if the farmer rates his/her risk tolerance as higher. To give an example, a rather risk-seeking farmer (8 on the risk attitude scale) has a decreased WTA of 2.16 percentage points (= 8 × 0.27) for the online merchant. In comparison, a rather risk-averse farmer (2 on the risk attitude scale) has a 1.62 percentage point higher WTA for buying crop protection products online (= 8 × 0.27 - 2 × 0.27). Thus, Hypothesis 2a can be accepted. Moreover, the risk attitude of farmers significantly impacts the WTA for the local merchant. The estimated coefficient is similar to the changes in WTA for the online merchant (-0.32). Altogether, these findings are in line with prior results in the field of risk attitude and e-commerce adoption (see, for instance, Chang et al., 2005; Wu and Chang, 2007). The positive effect of farmers' risk attitude on the WTA for the online merchant is a further indication of the importance of building trust in an e-commerce setting. Therefore, online merchants should consider this result in their marketing efforts concerning trust-building.

Hypothesis 2b: First online shopping experiences reduce farmers' WTA for the online merchant.

The interaction term "Online experience × Online merchant" provides evidence for the relationship between prior online purchases and future e-commerce activities of farmers. Hence, a farmer with prior e-commerce activities has a 7.06 percentage points lower WTA for the online merchant compared to a farmer without online purchasing experiences (WTA_{Basis} = -(-3.53); 7.06 = 3.53-(-3.53)). We therefore cannot reject Hypothesis 2b. This result is in line with the findings of other studies which investigated the effect of experiences on e-commerce or computer adoption behavior (see, for instance Mishra et al., 2009; Mishra and Park, 2005; Shim et al., 2001). Due to the fact that, as of yet, only a small share of German farmers have bought production inputs online (Kleffmann Group, 2016), we suggest that online merchants should implement marketing measures in order to alleviate the initial doubts of inexperienced farmers. In this respect, guarantee policies can be combined with quality labels of trusted authorities. E.g., the Trusted Shops certificate provides a money-back guarantee for the consumer (Grabner-Kraeuter, 2002). Along these lines, this result suggests that first impressions greatly influence later behavior. Therefore, this result further indicates that retailers should strive to achieve customer satisfaction in order to build loyalty. Hence, Hypotheses 1b and 1c, which both focus on the effect of service quality on farmers' online purchasing behavior, are supported too.

Hypothesis 2c: Personal and business characteristics of the farmer influence the WTA for the online merchant.

Model 2 indicates that there is evidence to support Hypothesis 2c. The interaction term "Education × Online merchant" is highly significant. Hence, in comparison to the base level of "no university degree", the estimated coefficient shows that if the farmer holds a university degree, the WTA for the online merchant is 4.32 percentage points lower (the calculation is the same as before). This finding is in line with the aforementioned studies focusing on the effect of farmers' education on computer and internet adoption. Surprisingly, neither farm size nor age significantly affects farmers' WTA for the online merchant. Nonetheless, this is in line with the findings of Batte and Ernst (2007), who did not find significant effects for these variables. Thus, Hypothesis 2c can be partially confirmed. Interestingly, we found that age and farm size do influence farmers' WTA for the local merchant. With each year of advancing age, the WTA increases, whereas farm size reduces the WTA for the local merchant. However, the positive effect of farmers' education on the adoption of e-commerce is an important finding of our analysis. As a practical implication, online merchants should make the purchasing procedure as convenient as possible and provide assistance to address less-educated farmers, who have most likely had fewer experiences with the use of internet applications for business purposes. For instance, Chinese farmers are offered e-commerce trainings (AGRA-EUROPE, 2017). In terms of education policy, e-commerce trainings could be integrated into the agricultural apprenticeship.

5. Concluding remarks

The Digital Agenda driven by the European Commission aims to achieve nationwide coverage of high-speed internet for member countries by 2020. This improvement in internet infrastructure is promising regarding farmers' ability to enter electronic markets for business purposes. However, the majority of German farmers currently do not buy production inputs online. Against this background, we provided a first investigation of German farmers' WTA for e-commerce by utilizing a DCE about online purchase of crop protection products. By referring to literature in the field of marketing and agriculture in particular, we derived research hypotheses related to e-commerce behavior. WTA estimates showed that farmers are willing to switch to an online merchant if they are offered a significantly lower price. However, word-of-mouth-reputation and consultation offered via traditional media do not influence farmers' WTA for an online merchant. In contrast, delivery time significantly affects farmers' WTA for an online merchant. Additionally, risk aversion increases the WTA, whereas prior online shopping experiences and education reduce the WTA for online purchasing. Surprisingly, age and farm size do not impact farmers' WTA in the e-commerce setting. In summary, most of our hypotheses could be confirmed by the results and, hence, can be used as guidelines for choosing marketing strategies in agricultural e-commerce. We recommend that online merchants of agricultural inputs focus foremost on building trust, service quality and timely delivery. We see further potential in offering e-commerce trainings and price discounts to motivate initial purchases, since farmers who have gained some e-commerce experience have lower WTA. Furthermore, our results provide an interesting recommendation for education policy. E-commerce trainings could be integrated into farmers' apprenticeships. Although the results are quite logical, these are valuable insights into German farmers' e-commerce behavior since there was only anecdotal evidence explaining the failure of online merchants in German agriculture before.

Additionally, the results demonstrate the need for further research on this topic, since e-commerce is clearly multifaceted. On the one hand, farmers' acceptance of labels as a basis for trust in e-commerce could be analyzed in future work. On the other hand, online selling behavior of farmers could also be an interesting field to investigate, especially when considering direct marketing. Due to the fact that there is no data on farmers' actual online purchases or sales, surveys and experimental approaches are appropriate. If data on real e-commerce behavior becomes available in the future, it would be useful to validate first experimental results with empirical data.

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Appendix: Information on the Discrete Choice Experiment

[Could appear as online supplemental material]

"Please imagine that you have to decide today from which merchant you will buy all crop protection products needed on your farm this year. In the following, you will be asked twelve times which merchant you prefer. In each of the twelve decision situations, two different merchants can be chosen. Please consider each decision situation independently of the others. We are interested in your personal opinion. Therefore, there are no "wrong" answers. Within the experiment, you will always be given the possibility to choose your current merchant if you do not want to switch to one of the alternative merchants. The different merchants are characterized by the following four attributes, with are described in detail according to their characteristics:

1) *Price advantage*

   The merchants can offer a price advantage. This price advantage can vary. If there is no price advantage offered, please assume that the price is equal to the price offered by your current merchant.

2) *Recommendation of peers*

   For the merchants, the recommendations of your peers are available. For instance, think of discussions with farmers at regular meetings or in your neighborhood. The recommendations can vary.

3) *Consultation*

   The merchants can offer different consultation concerning, e.g., product information and the purchase procedure. This consultation can be provided by different communication media. There are no further costs for the consultation services offered.

4) *Delivery time*

   In order for you to be able to plan ahead, the expected delivery time is shown for each merchant. For the delivery service, there are no additional costs. The delivery time can vary.

The experience from previous similar surveys is that people often respond in one way, but act differently in reality. Therefore, please make your choices as if you really have to decide from which merchant you would like to buy your crop protection products. That is why it is particularly important that you deal with the purchasing alternatives in each of the 12 decision situations."

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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine schlagkräftige Einheit mit international beachteten Forschungsleistungen.

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