How does the Risk Attitude affect the Bidding Behavior of Farmers? Results of an Experimental Auction

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Abstract

Auctioning off goods is a widespread practice in the agricultural sector. The revenue equivalence theorem predicts that independent of the type of auction, the revenues are identical under fulfillment of specific conditions. One of these conditions is that bidders must be risk neutral; this condition, however, often fails in reality. An experiment was carried out with farmers to investigate how the bid amount is influenced by the individual risk attitude. In the experiment, farmers were able to buy a good with a private value in four different auctions types. Results indicate that the revenues in auctions are affected by the risk attitude of the bidders. Moreover, the influence of the risk attitude depends on the auction type.

Key Words

Eckel and Grossman lottery; risk attitude; revenue equivalence theorem; Vickrey theorem

1 Introduction

Auctions play an important role in buying and selling goods in the agricultural sector, e.g., breeding animals, such as cattle (ROBINSON and CHRISTLEY, 2007; COATNEY et al., 2012), horses (STOCK et al., 2006), hogs, sheep and goats (BOLTE et al., 2008). Feeder-calves are also frequently auctioned in the United States (SCHULZ et al., 2015). Additionally, the auctioning off of agricultural machines (RITCHIE BROS. AUCTIONEERS, 2013), agricultural enterprises and farmland is a common practice (MCAFEE and MCMILLAN, 1987; KLEMPERER, 1999; HUETTEL et al., 2013).

For the process of auctioning off goods, there are four well-known and commonly used auction types in the agricultural sector: first, the Dutch auction which is where the auctioneer begins with a high bid that is then gradually lowered, until the first bidder is willing to pay the called price. This auction type is used to sell perishables and flowers, for example (ROCKOFF and GROVES, 1995). Second, the first price sealed bid auction in which bids are made in private, with the bidder who offered the highest bid receiving the good. This auction type is common for auctioning off farmland (HUETTEL et al., 2013). Third, the English auction, in which bidders outbid one another with the highest bidder receiving the good. The English auction is frequently used in the agriculture sector to sell breeding animals (COATNEY et al., 2012) or machinery (RITCHIE BROS. AUCTIONEERS, 2013). Finally, the second price sealed bid auction where bids are made in private, and the bidder offering the highest bid receives the good, but pays the amount of money offered by the second highest bidder (WOLFSTETTER, 1996). This type of auction is also used to sell farmland, e.g. in the eastern states of Germany (HUETTEL et al., 2013). All of these different auction types, however, have one fundamental characteristic in common: the price to receive the good results from the competition of the bidders (CASSADY, 1967).

VICKREY (1961) predicted that independent of the type of auction, the obtained revenues are equal based on several assumptions. VICKREY (1961) assumes independent private values for the auctioned good. Furthermore, the bidders must be risk-neutral, as well as knowing their personal valuation of the good being auctioned off. However, the bidders do not know the valuation placed on the good by the other bidders, whereby, the valuation of all bidders descends from the same interval of a probability distribution. Furthermore, each bidder knows the total number of bidders and makes no attempts to collaborate with other bidders to adjust their personal valuation with regard to the prices (VICKREY, 1961). VICKREY's findings are commonly referred to as the revenue equivalence theorem.[1]

Since the publication of VICKREY's theorem, many studies have examined the revenue equivalence theorem, and have determined that the revenue equivalence theorem often does not hold in reality. A laboratory experiment conducted by KAGEL et al. (1987) with student participants, shows that the revenues of second price sealed bid auctions are higher than the

[1] For more detailed information on the revenue equivalence theorem, please refer to VICKREY (1961).

revenues of English auctions. Another laboratory experiment using student participants and conducted by COX et al. (1983) indicates higher revenues of first price sealed bid auctions, in comparison to Dutch auctions. These studies have all attained results which demonstrate that VICKREY's revenue equivalence theorem does not hold, since VICKREY's assumptions might be unrealistic. In reality, entrepreneurs in general and farmers in particular are risk averse on average (MAART-NOELCK and MUSSHOFF, 2014). Furthermore, most auctions cannot clearly be characterized as private value or common value auctions (LAFFONT, 1997).

The present experiment takes a closer look at the question if the revenue equivalence theorem holds for farmers in auctions. Furthermore, the influence of risk attitude of the participants regarding the bidding behavior, on the background of the revenue equivalence theorem is analyzed. This will allow for more detailed statements to be made regarding the influence of risk attitude on the bids in different auction types. The experiment is conducted with farmers instead of student participants, as it was the case for many other studies which questioned the revenue equivalence theorem, because students tend to behave differently in comparison to other groups of participants (BURNS, 1985; BARR and HITT, 1986; HAIGH and LIST, 2005; MAART-NOELCK and MUSSHOFF, 2014; BOCQUEHO et al., 2014). Thus, the generalizability, as well as the validity of experiments conducted with students would thus be questionable (BURNS, 1985). The objective of the present evaluation is to analyze the auction behavior of entrepreneurs, in this case farmers. It is revealed in the literature that results cannot be directly transferred from one occupational group to another (YITSHAKI and KROPP, 2016; BRUSH et al., 2000; EGAN et al., 1997). In addition, differences between the value orientation of farmers and the overall population are found (BAUR et al., 2016). Summing up, it is necessary to conduct the auction experiment with farmers to understand the relation between bids and risk attitudes of farmers.

With this in mind, the current experimental auction has been carried out in the field, with farmers selling a homogeneous good with a private value. Our aim is to evaluate if VICKREY's revenue equivalence theorem holds for farmers. Additionally, factors influencing the bids in auctions are examined. In particular, the influence of risk attitude on bidding behavior is analyzed. Furthermore, other factors that might have an influence on the bid amounts of the participants are investigated. A homogeneous good with a private value has been chosen to compare the respective auction revenues directly with one another. Hence, this experiment extends the existing literature with respect to the following points: First, this is the first paper that analyzes if the revenue equivalence theorem is violated for the occupational group of farmers. Second, the auction is conducted in the field, as is common in the agricultural sector, while the majority of previous experiments related to the validity of the revenue equivalence theorem have been conducted in the controlled environment of a laboratory (COX et al., 1983; KAGEL et al., 1987; KAGEL and LEVIN, 1993). Third, no existing studies have been found where each participant took part in each of the four different auction types; however, this within subject design further increases the statistical power and the validity of the results due to repeated measurements. Fourth, the experimental procedure has been developed to allow for better control over framework conditions, e.g., the group size of bidders along with personal data of the participating farmers.

The remainder of this article is structured as follows: the hypotheses are derived from the existing literature (Section 2). Sections 3 and 4 explain the experimental design and the approach to data analysis. The description of the results and the discussion follow in Section 5. The article ends with a conclusion and outlook of future opportunities (Section 6).

2 Derivation of Hypotheses

The revenue equivalence theorem predicts that all four auction types, Dutch auction, first price sealed bid auction, English auction and second price sealed bid auction, will result in the same amount of revenues for the auctioneer (VICKREY, 1961). In the second price sealed bid auction, the successful bidder pays the bid amount of the second highest bidder. However, specific conditions must be fulfilled so that the revenue equivalence theorem holds.

The bidders have to be risk-neutral and know their personal valuation of the good being auctioned off, but not the valuation placed on the good by the other bidders. However, the valuation of all bidders is descended from the same interval of a probability distribution. Each bidder knows the number of bidders, and makes no arrangements to other bidders to adjust their personal valuation with regard to the prices (VICKREY, 1961).

In reality, however, these assumptions often fail. Laboratory experiments (KAGEL et al., 1987; KAGEL and LEVIN, 1993; COX et al., 1983) have shown that the revenue equivalence theorem does not hold, as at least one assumption of the revenue equivalence theorem is not fulfilled by the participants in realistic settings. No studies regarding this theorem have been conducted with farmers until now. In different experiments it was examined that farmers are on average risk averse (RILEY and SAMUELSON, 1981; MASKIN and RILEY, 1984; MATTHEWS, 1987; MAART-NOELCK and MUSSHOFF, 2014). Therefore, we validate that the revenue equivalence theorem does not hold. Therefore, the following hypothesis is derived:

H1: The revenue equivalence theorem does not hold for farmers in experimental auctions.

One assumption of the revenue equivalence theorem is that the bidders must be risk neutral; this assumption, however, often fails in reality as stated above. However, there are presently no known studies which experimentally identify the influence of risk attitude on bidding behavior in the four auction types that were conducted in the experiment. In addition, information on the influence of risk attitudes in the context of the revenue equivalence theorem is rare.

However, first indications on the influence of risk attitudes on other auction types can be gathered from the literature. CHEN et al. (2017) analyze theoretically the bidding behavior in all-pay auctions. In this special type of auction, all players have to pay their bids whether or not they win the bid. CHEN et al. (2017) find two opposing behavioral patterns: on the one hand, more risk-averse participants bid higher than less risk-averse participants and win with higher ex-ante probability. On the other hand, they drop out bidding. Furthermore, BRUNNER et al. (2014) focus on premium auctions. In these auctions, the highest losing bidder receives a predefined amount of money from the seller. BRUNNER et al. (2014) observe that in an English premium auction, revenues are higher for risk-loving than for risk-averse bidders. HU et al. (2011) compare behavior in standard English and English premium auctions. They find that the inclusion of a premium leads to a decrease of the expected revenue when bidders are risk averse.

These studies indicate that risk attitude has a differing influence on various auction types. Since these studies are based on auction types other than those which were used in the conducted experiment, results are not directly transferable. Behind this background, the influence of risk attitude is investigated in the current study and the following hypothesis is derived:

H2: Deviations from the revenue equivalence theorem depend on the varying influence of risk attitude of the farmers on different auction types.

Furthermore, little evidence can be found in the literature for additional factors which may influence the revenues of agricultural auctions. It is possible, for example, that socio-demographic and socio-economic factors may exist which influence bidding behavior, yet are not referred to as necessary conditions in the revenue equivalence theorem. Therefore, the following hypothesis is derived:

H3: Deviations from the revenue equivalence theorem depend on socio-demographic and socio-economic factors.

3 Experimental Design

The present experiment was designed as an extra-laboratory experiment (CHARNESS et al., 2013). It was conducted with farmers as a non-standard subject pool, and it took place in the field. This is advantageous since, if a specific demographic group should be investigated, it is sensible to conduct the experiments where this group can be found. In addition, an advantage of extra-laboratory experiments is the possibility to replicate the experiment.

Before the experiment started, the participating farmers were aware that they were taking part in an experiment and that their behavior would be analyzed. The experiment consists of two parts (see Appendix). First, the participating farmers attended an experimental auction. Second, the farmers answered a personal questionnaire related to personal characteristics and their socio-economic parameters; they were also expected to participate in an Eckel and Grossman lottery (ECKEL and GROSSMAN, 2008) to determine their risk attitude.

3.1 Design of the Experimental Auction

The experimental auction had a within subject design with repeated measurements. Each participant took part in each of the four incorporated auction types, and the order of the various auctions was randomized. Hence, each auction occurred at each stage of the auction series. Due to this total randomization, problems with the order effect were avoided (MITCHELL and JOLLEY, 2013); the order effect is the effect of the

different auction types on each other when run in sequential order. Furthermore, problems with the starting point bias are also avoided (BAZERMAN and SAMUELSON, 1983); this is the effect of the first auction influencing the following auction. Overall, due to the experimental design, directly comparable bid results are achieved. Furthermore, the rules of the experiment were kept as simple as possible to aim for transparency and understanding of the rules for each participant (DEPIPER et al., 2013).

To ensure total randomization during the experiment, the experimenter received a leaflet that indicated the order of the auctions. Furthermore, for the sake of simplicity as well as for better comparability, envelopes containing a €10 banknote with a 50% probability of occurrence were auctioned off.[2] Therefore, a selection bias (HECKMAN, 1979), which potentially occurs when using a specific agricultural good which attracts only a portion of the farmers, was avoided. Additionally, agricultural goods such as animals or machines are too expensive and difficult to handle in an experimental situation, and have thus been excluded. We have chosen an amount of €10 to be sure that each participant had enough money to bid according to one's individual preferences. As in real auctions, the quality of the auctioned good was unknown but became apparent when the transaction has been completed (BRANNMAN et al., 1987; MCAFEE and MCMILLAN, 1987). A 50% probability was used to simplify the calculation of the expected value as the pretest had revealed problems for the participants when calculating the expected value for more complex probability distributions.

In order to attract participants, each farmer received a representation allowance of €10, which covered the opportunity costs of participation. The study was planned with a playing period of 20 minutes, so that the representation allowance corresponded to an average hourly wage of €30.[3] The group size was fixed at five farmers per group to account for findings of BAZERMAN and SAMUELSON (1983) that the group size of bidders influences the average winning bid in auctions. By ensuring a group size of exactly five participants, the influence of the group size to the bidding behavior is constant. Once five farmers committed to participate in the study, the group was established, and the experiment began.

At the beginning of the experiment, the group of farmers was informed that they would take part in an auction and that they were given a detailed explanation of the rules by the experimenter. The group was informed that four envelopes were available, one for each of the four consecutive auctions, whereby two of them contained money (50% probability). Each successful bidder had to pay for the purchased envelope with his own money. To make sure that the participants bid individually, the experimenter monitored the group to ensure that participants were not working together. For the sake of simplicity, the bids could only vary in increments of €0.50. When the Dutch auction was carried out, the experimenter started with €10.00 with the value gradually being decreased by €0.50 increments until the first bidder called 'mine' and accepted the price. When carrying out the first price sealed bid and the second price sealed bid auctions, the participants received a leaflet on which they wrote down their bid. Thereby, care had to be taken to ensure that the participants wrote down their bids in secrecy. Afterwards, the leaflet was handed back to the experimenter; thus, the auctions were based on sealed bids and participants were unable to see the bids made by other participants. In both auctions, the bidder submitting the highest bid received the envelope; however, in the second price sealed bid auction, the bidder submitting the highest bid was only required to pay the bid of the second highest bidder. All bidders were notified of the value of the successful bid. The English auctions started with a bid of €0.50 and the experimenter asked the participants if they were willing to pay this price. Farmers who were willing to pay the called price raise their hands. The ex-

[2] This envelope is supposed to be a good with a private value. Indeed, the envelope has objectively the same expected value for every participant of €5, but the subjective valuation of money has to be considered. Money is characterised by decreasing marginal utility (LAYARD et al., 2008) and each Euro that somebody receives has a different subjective value for different persons depending on personal circumstances (KAHNEMAN and TVERSKY, 1984). For example, BRANDSTÄTTER and BRANDSTÄTTER (1996) show that the subjective valuation of money depends on net income as well as on the attitude against money. Also, BOYCE and WOOD (2011) emphasise that the marginal utility of money varies between different persons.

[3] We are aware that a "house money effect" can be caused, according to THALER and JOHNSON (1990), with the paid representation allowance at the beginning of the experimental auction. Losing some of the prior money gain does not hurt as much as "losing one's own cash" (THALER and JOHNSON, 1990). Since each participant receives the same amount of representation allowance, all participants are consequently biased in the same manner.

perimenter gradually raised the bid by €0.50 increments until only one bidder was willing to pay the actual price.

The respective successful bidder received his envelope at the end of the experiment, and had to pay the effective bid to the experimenter. Therefore, the participants did not know during the experimental auction which envelopes contained a €10 note and which were empty. In the case that the bid value in the closed sealed bid auctions was identical for two participants in one group, both participants received one envelope; this means that an additional envelope that had a 50% probability of containing money came into play. It was not possible that two bids in the open bid auctions were identical.

3.2 Personal Questionnaire and Eckel and Grossman Lottery

To investigate the revenue equivalence theorem and control for the influence of socio-demographic and socio-economic characteristics, a personal questionnaire was used to collect data relating to these factors for each participant. Since the participants' prior experience might influence their bidding behavior (WILCOX, 2000), the participants were asked whether they typically use auctions to purchase or buy goods. Furthermore, we asked the farmers which of the auction types, if any, they were familiar with before they participated in the experiment. Moreover, the relationships between farmers within a group were also recorded, i.e., what, if any, level of acquaintance existed between the farmers. Naturally, participants who were previously acquainted with one another had more information about these bidders than others (ALBRIGHT et al., 1988). Additionally, the group dynamics could be affected by the previous acquaintances of the participants, which might in turn affect the individual bids (SCHWEIZER and UNGERN-STERNBERG, 1983).

In order to discover the risk attitude of the participants, an incentivized Eckel and Grossman lottery (EGL; ECKEL and GROSSMAN, 2008) with modifications according to REYNAUD and COUTURE (2012) was carried out. This lottery was decided upon primarily because it is easy for participants to understand (DAVE et al., 2010). In the EGL, the participants were asked to choose one out of nine different gambles that they would be most likely to engage in. The participation in the lottery was not associated with costs, but the outcomes varied between the nine gambles. The varying payments affected the expected outcome value and the variance between the gambles, thus, each subsequent gamble became more risky. Risk attitude was expressed by the ECKEL and GROSSMAN lottery-value (EGL-value). Gambles chosen between 1 and 5 indicate risk aversion, while those chosen between 7 and 9 indicate risk-seeking behavior. The decision for a gamble of 6 indicates a risk-neutral decision-maker.

The participating farmers were informed that one out of 50 participants would be randomly chosen to receive a payout. The amount of money that the randomly-chosen participant received, depended on the individual decision in the EGL. The gamble that the participants had chosen was carried out, and the payout depended on the outcome of that chosen gamble.

4 Approach to Data Analysis

With our data analysis we aim to verify our hypotheses. The choice of data analysis is based on the structure of the data. Since each group of participants takes part in the four different auctions, repeated observations occur and the data cannot be seen as independent. Therefore, a mixed model is estimated, with revenues in auctions as the dependent variable (y) of groups i and observations j (FAHRMEIR et al., 2013):

$$y_{ij} = \beta_0 + \beta_1 x_{ij1} + \ldots + \beta_k x_{ijk} + \gamma_{0i} + \varepsilon_{ij} \qquad (1)$$

The population intercept is depicted by β_0 and the population slope parameters are depicted by $\beta_1, \ldots, \beta_k$ of covariates $1, \ldots, k$ with $x_{ij1}, \ldots, x_{ijk}$. The error term ε_{ij} is i.i.d. $\varepsilon_{ij} \backsim N(0, \sigma^2)$. The groups are each a sample of a larger population, therefore, it is assumed that i.i.d. $\gamma_{0i} \sim N(0, \tau_0^2)$ and that ε_{ij} and γ_{0i} are independent. Mixed models account for correlations between observations of the same group, and also model the unobserved heterogeneity that is not accounted by the covariates included in the model. The regression coefficients are correct in that they demonstrate correct standard errors, confidence intervals and tests (FAHRMEIR et al., 2013).[4]

The variables that are included in the final model explaining the bid values are automatically selected using the Akaike Information Criterion (AIC). In the first step, all variables that were supposed to be relevant for answering the hypotheses were included in the model. Afterwards, the variable selection proce-

[4] The assumptions for estimating mixed models are fulfilled in the sample. The residuals are normally distributed and the linearity of the residuals is given. Additionally, homoscedasticity of the variance of the residuals can be assumed.

dure occurred on iterative bases where the covariates are considered, that significantly improve the AIC of the model.[5] Thereby, an analysis of variance (ANOVA) is carried out after each extension of the model. The additional variable is only kept when the new model is superior.

5 Results and Discussion

5.1 Descriptive Statistics

The experimental auction was carried out at nine informational events which were organized by German agricultural companies in the fall of 2013 in central Germany. Agricultural firms use these events as an opportunity to present new plant varieties or new technology and machinery, as well as to provide information for farmers. Being more specific, we have chosen informational events of the KWS and the Chamber of Agriculture of Lower Saxony, as well as from "Maschinenring". These events have been selected since they were all located in central Germany and took place during a small period of time. The experimenter visits these field days, and when the official part of the field days ended, asked the farmers to participate in the experiment.

At these events, roughly 520 farmers were randomly asked to participate in the experiment. In total 240, approximately 45%, of all of the approached farmers were willing to participate. Thus, the experiment was conducted with 48 groups consisting of five participants each. On the one hand, the role of the experimenter is to be the auctioneer and auction the envelopes, and on the other hand to control the framework conditions of the experiment. Thereby the experimenter is not allowed to influence the participating farmers. The average time for carrying out the experiment was 19 minutes.

The analysis is based on the revenues of all conducted experimental auctions of the four auction types. As the focus is on explaining the revenues of the auctions, only the successful bids are included in the analysis. When we conducted the open bid auctions, we were only able to match the winning bid to the winning bidder. Altogether, 192 auctions were carried out for the experiment (48 groups • 4 auctioned envelopes per group). In nine of the auctions, however, two farmers bid the same amount of money, therefore receiving one envelope each. Furthermore, in three of the auctions, three bidders bid the same amount of money and received one envelope each. Therefore, the observations increased to 208 successful bids which were analyzed. Table 1 depicts the socio-demographic and the socio-economic characteristics of all the successful bidders.

Table 1. Socio-demographic and socio-economic characteristics of the successful bidders[a]

Characteristic	Mean	Standard deviation
Male participants	97.11 %	-
Age in years	39.67	15.65
Years of school education[b]	10.65	1.97
Farmers with a university degree	27.40 %	-
Completed agricultural vocational	78.37 %	-
Experience with auctions	27.27 %	-
Knowledge of auction types		
Dutch auction	35.10 %	-
First price sealed bid auction	73.56 %	-
English auction	77.88 %	-
Second price sealed bid auction	19.81 %	-
Farm manager[c]	54.81 %	-
EGL-value[d]	3.93	2.57
Farm size in ha	161.89	293.67
Farm income as mainstay	73.08 %	-
Farm type		
Cash crop	49.04 %	-
Dairy	15.38 %	-
Finishing	5.77 %	-
Others	29.81 %	-

[a] n = 208
[b] Calculated according to OECD (1999).
[c] The 45.19% of the participants who are not managing an agricultural enterprise work on a farm.
[d] 1-5 = risk averse, 6 = risk neutral, 7-9 = risk seeking
Source: own calculation

The age of the farmers ranges between 17 to 75 years, while farm sizes vary between 3 and 2,300 ha of cultivated farmland. The participating farmers indicated that the English auction is the most well-known auction type, although the first price sealed bid auction is also fairly well known. For buying products in real life, 18.75% of the farmers regularly use some type of auction, while 18.27% of the farmers reported selling products in auctions. The average revenue for all four auction types is depicted in Table 2. It is revealed that the average revenues are the highest for the first price sealed bid auction, whereby the standard deviation is also the highest.

The EGL-value shows that the participating farmers are risk averse on average. It can be seen in

[5] The models have been estimated with the software R using the packages 'Hmisc' by HARELL and DUPONT (2014), 'lmerTest' by KUZNETSOVA et al. (2014), 'mult comp' by HOTHORN et al. (2008), 'nlme' by PINHEIRO et al. (2014) and 'RLRsim' by SCHEIPL et al. (2008).

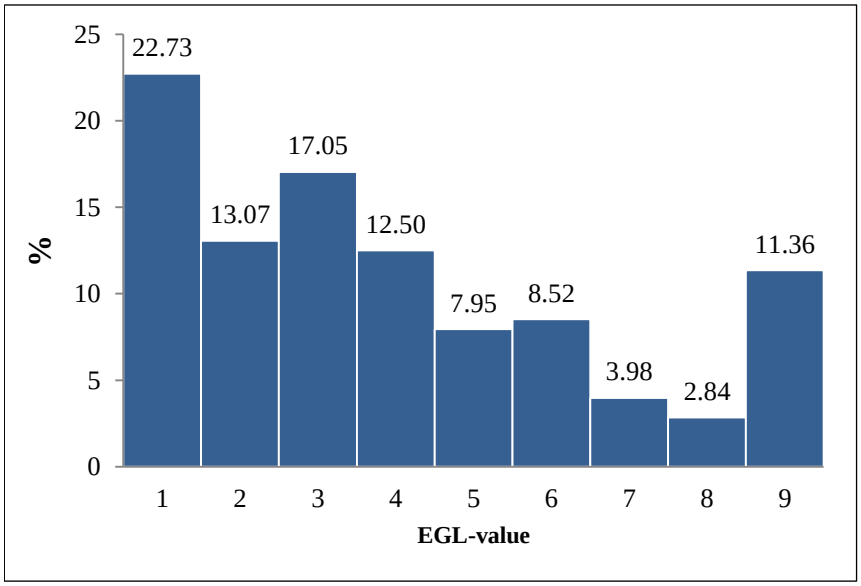
Table 2. Overview of the revenues in € for the four auction types[a]

Auction type	Mean	Standard deviation	Minimum	Maximum
Dutch auction	5.43	1.82	2.00	10.00
First price sealed bid auction	6.32	2.14	2.50	10.00
English auction	4.85	1.97	1.00	10.00
Second price sealed bid auction	5.37	2.04	1.50	9.50

[a] n = 208
Source: own calculation

Figure 1 that 73.3% of all participants can be classified as risk averse, whereby only 18.18% of the participants can be classified as risk loving. Risk neutral participants account for 8.52% of the sample. This result is not surprising as MAART-NOELCK and MUSSHOFF (2014) show that the majority of the German farmers in their sample are also risk averse.

Figure 1. EGL-value of the successful bidders[a]



[a] n = 208
Source: own calculation

5.2 Hypotheses Testing

To answer the hypotheses, we estimate a mixed model to explain the revenues obtained in auctions with the covariates EGL-value, farmers' previous experience with auctions and the four different auction types, whereby the English auction serves as the reference. Furthermore, interaction terms for the auction type and the EGL-value are included in the regression model. With the inclusion of the interaction terms, it can be determined whether the risk attitude of the participants influences the revenues of the auction types. Other socio-demographic and socio-economic covariates such as gender, age, years of education, farm size and whether the farm is the main source of income for the farmer, were not chosen in the variable selection procedure based on the AIC. The restricted likelihood ratio test indicates that the random effect parameter of the group of farmers is significant (p-value<0.0001). The final model is depicted in Table 3.

The estimation results show that when Dutch auctions or first price sealed bid auctions are carried out, the revenues are on average €2.22 and €2.09 higher respectively, compared with English auctions. The coefficients for both of these types are highly statistically significant. However, if second price sealed bid auctions are carried out, the revenues are on average €0.68 higher, but do not significantly differ from English auctions. To prove whether the differences between the average revenues of the four auction types are significant, a post hoc test (Tukey test) with variation of the reference category is done (Table 4). The Tukey test is used to compare the means of more than two groups, with testing for the present experiment being done pairwise. This test confirms that the average revenues of the first price sealed bid auction differ statistically significantly, from both the English and the second price sealed bid auctions. The Tukey test also confirms that the average revenues of the Dutch auctions significantly differ from the average revenues of both the English and the second price sealed bid auctions. However, the average revenues of the first price sealed bid and the Dutch auctions do not differ statistically significantly. Furthermore, the average revenues of the second price sealed bid and the English auctions also do not differ statistically significantly. It can there be concluded that the revenue equivalence theorem does not hold for the specific occupational group of farmers and, therefore, *hypothesis 1* which assumes that the theorem does not hold *can be accepted*.

Table 3. Results of the estimation of a mixed model, dependent variable 'amount of bid'[a]

Covariate	Coefficient	t-statistic
Constant	3.34	6.77 ***
Second price sealed bid auction	0.68	1.20
Dutch auction	2.22	3.75 ***
First price sealed bid auction	2.09	3.59 ***
EGL-value[b]	0.24	2.68 **
EGL-value • second price sealed bid auction	-0.05	-0.46
EGL-value • Dutch auction	-0.43	-3.29 **
EGL-value • first price sealed bid auction	-0.19	-1.57
Experience with auctions[c]	-0.79	2.91 **
Gender[d]	-	-
Age in years	-	-
Years of school education	-	-
Acquaintance	-	-
Farmland in ha	-	-
Farm income as main source of income	-	-
AIC	725.02	

Covariates for which no coefficient and t-statistic are given were included in the variable selection, but are not considered in the final model, because their influence does not significantly improve the AIC of the model.
[a] n = 208; *** = p-value < 0.01, ** = p-value < 0.05, * = p-value < 0.1
[b] 1-5 = risk averse, 6 = risk neutral, 7-9 = risk seeking
[c] 1 = experience with auctions; 0 = no experience with auctions
[d] 1 = male; 0 = female
Source: own calculation

Table 4. Results of the Tukey test for analyzing differences between the average revenues of the four auction types[a]

	Dutch auction	First price sealed bid auction	English auction	Second price sealed bid auction
Dutch auction	-	0.13 (0.23)	2.22 (3.75) ***	-1.54 (-2.84) *
First price sealed bid auction		-	2.09 (3.59) **	-1.41 (-2.59) *
English auction			-	0.68 (1.20)
Second price sealed bid auction				-

[a] n = 208; *** = p-value < 0.01, ** = p-value < 0.05, * = p-value < 0.1
Source: own calculation

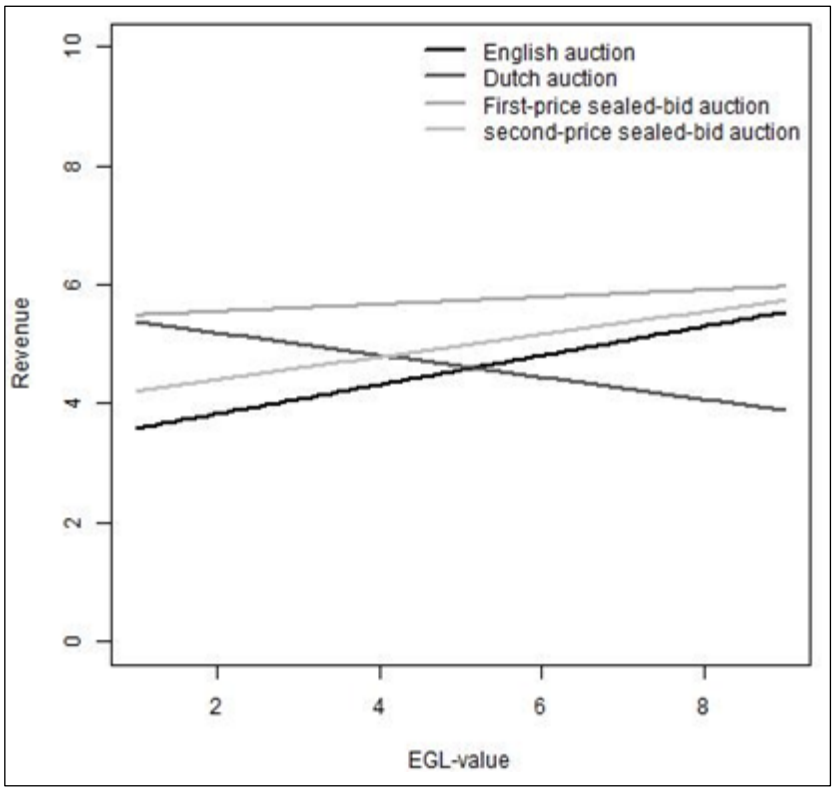
Thus, it can be concluded that under the specific conditions of the experiment, the Dutch and the first price sealed bid auctions do not statistically significantly differ from one another, and that the English and the second price sealed bid auctions also do not significantly differ from one another. It is noteworthy, that in the literature these auction types are often summarized as pairs (KLEMPERER, 1999). Moreover, MILGROM and WEBER (1982) found identical results with their theoretical model. Thus, it can be concluded that VICKREY's predictions for the process of bidding in the Dutch and the first price sealed bid auction pair, as well as in the English and the second price sealed bid auction pair, are applicable to farmers; however, the revenue equivalence theorem still does not hold. It is possible that this is due to other assumptions of the revenue equivalence theorem, which fail in the experimental context with regards to the condition of risk-neutral bidders. VICKREY (1961) assumes that all bidders have to be risk neutral in order for the revenue equivalence theorem to hold.

With regard to the regression results of Table 3, we analyzed the influence of risk attitude. The results indicate that risk attitude significantly influences the revenues in auctions. Higher EGL-values lead to higher revenues in auctions. Thus, with increasing risk seeking behavior, obtained revenues increase. The interaction term, however, indicates that when the revenues are generated in a Dutch auction, the positive effect of the EGL-value becomes negative. The interactions of EGL-value and first price sealed bid, or EGL-value and second price sealed bid auction have no significant influence on the revenues. Hence, our results reveal that the risk attitude of farmers affects the revenues of the various auction types differently.[6]

Figure 2 shows a more detailed view of the effect of the risk attitude on the revenues in the four different auction types. The figure depicts the effects which are presented in the estimation. It can be seen that English and the second price sealed bid auction are similar in the trend of their respective lines. However, although the Tuckey test indicates no significant difference between the

[6] It is not assumed that participants adapt their own bidding behavior to that of the other group members. Since each auction type is only carried out once, it is not possible to learn about the bidding behavior in one specific auction type. Additionally, differing auction types complicate learning about the bidding behavior or risk attitude of the other participants.

Figure 2. The influence of the risk on the bids



Source: own calculation

mean of the bids in Dutch and first price sealed bid auctions, the lines show that the bids are affected by the EGL-value in different directions. While the bids in first price sealed bid auctions slightly increase, the bids in Dutch auctions decrease with higher EGL-values. With the revenue equivalence theorem, it is expected that the revenues are the same for all four auction types for risk-neutral people. The four lines depicting the four auction types therefore should cross at an EGL-value of six, as this value indicates risk-neutral behavior. Figure 2, however, indicates that the lines do not cross and, therefore, the revenues differ. That the lines do not cross at the EGL-value of six may occur due to the fact that most of the participants were risk averse. Thus, there are more observations for risk-averse farmers than for risk-neutral farmers.

For hypothesis 2, we can conclude that risk attitude affects the bids dependent on the auction type. The higher the EGL-value, the higher the bids are in the English, the first price sealed bid and the second price sealed bid auction. In contrast, the bids decrease with increasing EGL-value for the Dutch auction. Hence, the risk attitude can partly explain deviations from the revenue equivalence theorem. *Thus, hypothesis 2 can partly be accepted.*

The study by RILEY and SAMUELSON (1981) indicates that risk attitude does not affect the revenues in English and second price sealed bid auctions; however, risk attitude does affect the revenues of Dutch and first price sealed bid auctions. Their results, however, are based on analytical deviations and are not proven with the true behavior of decision makers. With the results obtained in the current experiment, existing findings can be complemented. In particular, a slight, albeit and not significant influence of the risk attitude is emphasized that can be shown with respect to English and second price sealed bid auctions. However, similar to RILEY and SAMUELSON (1981), the current findings indicate a significant influence of the EGL-value for the bids in Dutch auctions. An additional result of our analysis is that the farmers' previous auction experience significantly influences the revenues. Participants with prior bidding experience bid on average €0.79 less than farmers without bidding experience. Other socio-demographic factors such as gender, age or years of education have no significant influence on the auction revenues.

We can, therefore, conclude for *hypothesis 3* that bidding experience has influence on the bids in auctions, however, no statistically significant influence of socio-demographic characteristics is detected, and therefore, the hypothesis *cannot be fully accepted*.

6 Conclusion and Outlook

Auctions play an important role in buying and selling goods; this is especially true for agricultural goods, such as livestock, machinery or farmland. Four different auction types are commonly used: the Dutch auction, the first price sealed bid auction, the English auction and the second price sealed bid auction. In consideration of specific conditions under the revenue equivalence theorem, each of the aforementioned auction types generates the same revenues for a homogenous good. In reality, however, several studies have

shown that the assumption of same revenues made by the revenue equivalence theorem fails. With the presented experimental auction, an attempt to analyze whether the revenue equivalence theorem is applicable for agricultural decision makers is made. Additionally, risk attitude and its effect on the revenues of the auctions are analyzed. The influence of socio-demographic and socio-economic variables and their influence with regard to the revenues of auctions are controlled for in the results. In total, 48 groups of five farmers each participated in a series of four auctions for envelopes which have a 50% probability of containing a €10 banknote.

The results reveal that the revenues vary significantly between the four auction types. However, the revenues of the Dutch and the first price sealed bid auctions as a pair, and the English and the second price sealed bid auctions as a pair, do not differ significantly. The bids can be partially explained by the risk attitude of the participants. With participants' increasing risk seeking behavior, the revenues in the English, first price sealed bid and second price sealed bid auctions rise, and the bids in Dutch auction decrease. Thereby, the risk attitude of the participants influences the auction types differently. Furthermore, our results indicate that farmers who have previous experiences with auctions pay less than farmers with no auction trading experience. As a result of this, sellers receive more money by selling their goods to inexperienced farmers, a factor which is not possible to guarantee in practice. Furthermore, sellers should use Dutch and first price sealed bid auctions when possible in order to achieve higher revenues due to the revenues being significantly higher, while risk-averse buyers should participate in English and second price sealed bid auctions in order to pay the lowest price.

In the interpretation of the results, it needs to be kept in mind that these results are based on experimental data, and it is possible that farmers will behave differently in reality, primarily due to dealing with higher values than €10. To further validate the consistency of buying decisions and bid values, further studies are necessary. It would be beneficial for the experiment to be repeated with a more detailed questionnaire or with the use of data from real auctions, such as e.g. breeding animals, in future studies. In addition, learning effects in bidding behavior should be analyzed. Moreover, the transferability of experimentally obtained results from one group to another, as well as the factors that might restrict that transferability should be investigated in future research.

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Appendix

First Section (experimental auction)

Instructions for the experimenter
These points are made step by step by the experimenter.

1. The experimenter invites farmers to participate in the experiment.
2. When five farmers are willing to participate in the experiment, the representation allowance is paid. The farmers are required to sign a document that have they obtained their €10.00.
3. The participants are informed by the experimenter that an auction is to be carried out, and they are then introduced to the rules of the experiment. The participants are informed that we have prepared four envelopes which may contain €10.00 or €0.00. There is a 50% chance that an envelope contains €10.00 and there is a 50% chance that the envelope is empty (two envelopes contain €10.00 and two envelopes are empty). Each participant has to choose a name that he wants to use during the experiment. This name does not have to be their real name, but has to remain the same throughout the experiment. The name is used solely to assign the bids to the participants. The bids for one envelope are free, but they can only change in increments of €0.50. Furthermore, the experimenter explains that the participants must actually pay their bids in the event that they are the most successful bidder. The payment is performed at the end of the experiment to ensure that no farmer opens the envelope before the experiment is completed. Therefore, the participants do not know which envelopes contain €10.00until the end of the experiment.
4. The experimenter takes a prepared folder with the necessary leaflets and envelopes to conduct the experiment. On the cover sheet of each group, the experimenter has to note the date. Furthermore, the experimenter has to carry out the auctions in the order which is written on this sheet. The folder contains the four prepared envelopes, the sheets to note the bids and the personal questionnaires.
5. When the Dutch auction is carried out, the experimenter explains the auction type. Afterwards, the experimenter starts with a price of €10.00 and decreases in €0.50 increments. The first participant who says “mine” is the successful bidder and receives at the end of the experiment one envelope. The experimenter writes down the successful bid and the (invented) name of the participant on the leaflet.
6. When the first-price sealed-bid is carried out, the experimenter explains the auction type first. Afterwards, the experimenter hands out a leaflet to each participant of the group. The participants have to write down their (invented) names. Then the participants must write down their bid on a leaflet. The experimenter collects the leaflets and identifies the successful bidder and the corresponding bid. In the event that two participants bid the same amount of money, both participants receive one envelope at the end of the experiment; this is an additional envelope which has a 50% chance of containing €10.00.

7. When the English auction is carried out, the experimenter explains the auction type. Then the experimenter starts with a bid of €0.50 and asks the participants if they are willing to pay this price. The participants must raise their hands when they would bid the called price. The experimenter raises the price until only one participant is willing to pay the actual bid. The experimenter writes on the leaflet the successful bid and the (invented) name of the participant. The successful bidder receives one envelope at the end of the experiment.
8. When the second-price sealed-bid auction is carried out, the experimenter explains the auction type first. Afterwards, the experimenter hands out a leaflet to each participant of the group. The participants have to write down their (invented) names along with their bid. The experimenter collects the leaflets and identifies the successful bidder and the corresponding bid, as well as the second highest bid which is the value that the highest bidder has to pay. In the event that two participants bid the same amount of money, both participants receive one envelope at the end of the experiment; this is an additional envelope which has a 50% chance of containing €10.00.
9. Points 5 through 8 may appear at random, i.e., the auction types must not be carried out in this particular order.

Second Section (personal information)

After finishing the experimental auction, the experimenter hands out the personal questionnaire along with the Eckel and Grossman lottery to the participants. The participants receive the following instructions:

Finally, we would like to ask you some questions regarding your personal details. All results of this survey will be presented anonymously, with no possibility of being able to draw any inferences of the actual persons or farms providing the information. […]

We offer you nine different gambles. Please decide the one gamble in which you are most likely to participate. Select the gamble of your choice with an "x" in the box to the right of the table. The chance to receive either payoff 1 or payoff 2 is 50% in each of the nine gambles; however, the amount of money varies. One participant out of every 50 is randomly drawn and their chosen gamble is carried out.

Once the participants have finished the questionnaire and the lottery, they have to pay for their envelopes. For this purpose, the experimenter has a money bag containing change. After the implementation of the sale, the experiment is finished.

	Payoff 1 Chance 50%	**Payoff 2 Chance 50%**	**Please choose your preferred gamble**
Gamble 1	€40.00	€40.00	
Gamble 2	€32.00	€51.00	
Gamble 3	€24.00	€64.00	
Gamble 4	€16.00	€78.00	
Gamble 5	€12.00	€86.00	
Gamble 6	€8.00	€91.50	
Gamble 7	€6.00	€92.90	
Gamble 8	€4.00	€93.40	
Gamble 9	€1.00	€93.50	