Received: 27 April 2021 | Revised: 23 November 2021 | Accepted: 3 December 2021

DOI: 10.1111/1477-9552.12477

JAE Journal of Agricultural Economics

ORIGINAL ARTICLE

Lower price increases, the bounded rationality of bidders, and underbidding concerns in online agricultural land auctions: The Ukrainian case

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Abstract

Auction theory suggests that bidders follow a dominant strategy that is to submit the highest bid equal to the bidder's true valuation in an ascending price auction with independent and private values. Bidders in real-world auctions may deviate from this strategy, resulting in either underbidding—submitting bids lower than the valuation—or overbidding—bidding an amount in excess of the real value. This study utilises data collected from online agricultural land lease auctions in Ukraine that took place between October 2018 and September 2019 to analyse the occurrence of minimal price increases, which may indicate underbidding. It investigates if factors—auction and property characteristics—that typically explain deviations from the dominant strategy—can also explain bidding behaviours in land lease auctions. The estimation using a heteroscedastic probit model reveals that underbidding could reasonably be attributed to low competition, insufficient time to place a subsequent bid, very small bid increments, and cumbersome entry fees.

KEYWORDS

agricultural rental prices, bidding behaviour, online land lease auction, underbidding

[Corrections made on 18th January 2022, after first online publication: Citation and reference listing (Econometrica, 50, 1982, 1089) has been removed in this version.]

JEL CLASSIFICATION
C01; C21; D44; Q12; Q24

1 | INTRODUCTION

Agricultural land rights are often transferred from the state to private holdings via auction (Hartvigsen, 2014). Several important issues surrounding the bidding on agricultural land sale auctions have been analysed by economists. Among the first, Colwell and Yavaş (1994) investigated a special form of farmland sale auctions, when large plots are first broken into small parcels and each parcel is auctioned separately, and then they are subsequently reassembled and auctioned as a whole parcel. Later, Hüttel et al. (2013) investigated if an auction mechanism used in eastern Germany during land privatisation significantly affected the price of farmland sold. Croonenbroeck et al. (2020) investigated asymmetries among foreign and local bidders that may result in non-competitive price formation. In the most recent study by Seifert and Hüttel (2020), bidder valuations were tested for the presence of a common component that may affect bidding behaviour and auction revenues. Bidders were assumed to either have access to commonly known pricing information from the secondary market or reliable publicly available statistical information about land prices.

Although the above-mentioned studies have covered several important issues related to bidding on farmland sale auctions, none of them investigated bidding in land lease auctions. The need to study land lease auctions separately is motivated by the fact that they entail several characteristics that may affect bidding behaviour not characterised by land sale auctions. Grenadier (1995: 299) referring to Miller and Upton (1976) suggests that 'leasing an asset is a purchase of the use of the asset over a specified period of time. Thus, leasing provides a mechanism for the separation of ownership from use, with the lessee receiving the benefits of use and the lessor receiving the value of the lease payments plus the residual value of the asset.' Based on this approach, the first obvious distinctive feature of land tenancy compared with land sales is the contract term: In contrast to land sale auctions that are used to determine a one-time transaction price, land lease auctions are used to determine not only a spot price but also a sequence of future payments (Hüttel, Ritter, et al., 2016) that may affect the behaviour of both bidders and landowners. Landowners who wish to lease a parcel via auction will find it very important to identify the least capitally constrained tenant to ensure that the tenant will be able to pay the agreed-upon rental payments despite any possible production variations—especially if their access to credit and insurance is limited (Deininger & Feder, 2001). Besides, landowners will find it important to ensure that the tenant cultivates the plot in a profitable and sustainable way, invests in land preservation, and the residual value of the plot at the end of the term of the tenancy agreement remains high. Second, compared to land sales, rental markets are associated with positive externalities by facilitating the acquisition of agricultural knowledge by the tenant and adaptation to changing labour availability (Deininger & Feder, 2001). They may increase bidders' certainty in land valuations. The third distinctive feature is either the presence or absence of a secondary market. Unlike land sale auctions, where non-farmers may purchase a plot with the intent of reselling (Seifert & Hüttel, 2020), subleasing plots may not be allowed. On the one hand, it imposes an information constraint on bidders in lease auctions: They cannot formulate their valuations based upon resale pricing. On the other hand, non-farmers will no longer be interested in leasing land via auction, and tenants are more likely to rent a plot for cultivation. Hence, bidders are expected to derive their land valuations exclusively from their expected returns from agricultural activities. Last but not least, land plots are rarely perfect substitutes, as the location, size and productivity may vary (Hüttel, Ritter, et al., 2016). So, farmers who often lease additional plots to expand their existing farm are likely to be interested in a particular plot located nearby. For them, not winning a specific plot may be more consequential than for non-farmers, who purchase land to resell it.

This paper analyses the agricultural land lease auctions that took place in Ukraine between October 2018 and September 2019. The auctions use an ascending price online auction scheme with a reserve price and an entry fee. Online auctions usually share important features of an English auction (Garratt et al., 2012) and are equivalent to a second-price auction (SPA) under the independent private values paradigm (IPVP; Milgrom, 1989). It means that each potential bidder is assumed to have a privately and independently drawn valuation of an auctioned good which is equal to the maximum amount they are willing to pay (Krishna, 2010). The seller uses an auction to identify the bidder with the highest valuation (Paarsch & Hong, 2006). The bidder's dominant strategy is to bid their own private valuation (Milgrom & Weber, 1982). If a seller sets a minimum bid and a non-refundable entry fee, potential bidders will then find it optimal to participate only if the difference between their true valuation and the minimum bid compensates for the entry costs (McAfee & McMillan, 1987b; Tan & Yilankaya, 2005).

The empirical evidence from experimental and real auctions shows that bidders may often depart from the dominant bidding strategy (Kagel & Levin, 1993). In the experiments described in the studies by Kagel and Levin (1993) and Garratt et al. (2012), all of the bidders study-wide were pre-assigned their private valuations before the auction began. If bidders failed to follow the dominant strategy during an auction, it can be assumed that bidding errors occurred. Bidding errors in real-world auctions were considered mostly under the common values paradigm (CVP; Bajari & Hortacsu, 2003a, 2003b). That means that the value of the object was assumed to be the same for all bidders (Paarsch & Hong, 2006: 26). In these cases, the winning bids were analysed in light of posted—‘take-it-or-leave-it’—pricing (Paarsch & Hong, 2006: 55) of the product in question or the comparative value of a similar good (Bajari & Hortacsu, 2003b). The related studies suggest that bidding errors may occur in both directions, such as overbidding—bidding an amount that is higher than the actual willingness to pay—and underbidding—bidding a very low amount compared to the valuation (Malmendier & Lee, 2011). In online auctions, the share of bidders who overbid and the share of those who underbid may reach about 40% each, or bidding errors of one or the other kind may prevail (*ibid*.).

Economists have found few factors that influence a bidder's decision to behave in compliance with the dominant strategy. Cooper and Fang (2008), Garratt and Wooders (2010), Garratt et al. (2012), and McGee (2013) investigated the capability of bidders to apply a dominant strategy derived from the knowledge they gained from past auction outcomes. However, they found that the scope of this effect is limited.

The factors leading to deviation from the dominant strategy are more numerous. For example, Wolf et al. (2005) suggest that bidders may develop a personal affinity to an auctioned good the longer they participate and subsequently overbid. A competitive auction environment is considered as one that makes bidders more prone to overbidding rather than underbidding (Cooper & Fang, 2008; Hou et al., 2009; Hüttel et al., 2013). Non-refundable entry costs can often be seen as ‘sunk’, which may lead to a sunk cost fallacy (Athey & Haile, 2007; Augenblick, 2016; Camerer & Weber, 1999; McAfee et al., 2010), where bidders are less willing to exit a situation as their financial commitments increase (Augenblick, 2016; Camerer & Weber, 1999). Hickman et al. (2017, 2012), Hickman (2010), and suggest that due to incremental bidding, online auction participants may shade their valuations instead of revealing them. Malmendier and Lee (2011) expected that bidding errors could also be explained by intrinsic lot characteristics, but found narrow empirical evidence supporting this hypothesis.

There are several additional factors leading to bidding errors in real estate auctions. Dotzour et al. (1998) attributed overbidding to the information constraints that bidders face and suggested that bidders may overbid for property if they are unaware of the prices and/or availability of other comparable properties being offered for sale. Gwin et al. (2005) showed that bidders consistently overbid, if they want to secure the land for development. Chang et al. (2007) suggest that overbidding can happen when a developer wants to obtain property in a specific geographical location where they already have an ongoing project. Tse et al. (2011) found that any sort of increasing uncertainty motivates bidders to reduce their bids.

The publicly disclosed auction data from agricultural land lease auctions in Ukraine reveals that deviations from the optimal bidding strategy in the form of very low price offers—such that the difference between the minimum bid and the winning bid was less than the actual entry costs—were observed in almost one half of the successfully completed auctions. The actual observed bidding behaviour deviations from the theoretically rational one imply that bidders in these auctions entered the auction with either a very low willingness to pay and/or some factors exist, such as auction design problems or property particularities, that discourage bidders from submitting higher bids. This paper investigates if the common causes of underbidding in SPAs may be helpful in explaining low winning bids in land auctions. The effects of these causes on the propensity to underbid were analysed by means of several specifications of a heteroscedastic probit model.

We use the IPVP for the following reasons: First, it is assumed that farmers' valuations are based on their estimated earnings from land cultivation—which differ for each farmer. Furthermore, the information about other bidders' valuations conveys limited information about property value. Second, the subleasing of a rented plot may not be allowed by rental agreements, thereby ruling out the possibility of further rent and any referential price the property may have on the secondary real estate market. Finally, there are very few reliable sources of statistical information in Ukraine on aggregate level rental pricing, which could have been used by bidders as a reference to form their valuations, and this information is not necessarily available to all bidders (Kvartiuk et al., 2020).

We contribute to the discussion about agricultural land lease auction efficiency. For farmers, underbidding may increase their risk of not winning the property (Seifert & Strecker, 2003), where there may be no other suitable plot. In addition, finding a substitute may be associated with further search costs. The farmer subsequently might need to rent several remote plots to expand production, and this may increase land cultivation costs (Hüttel, Ritter, et al., 2016). For landowners, underbidding is also problematic resulting in revenue losses (Krishna, 2010). Any problems that may prevent the landowner from identifying the bidder with highest valuation, including those associated with land auction design, may affect the efficiency of allocation (*ibid.*).

The remainder of this paper proceeds as follows: Section 2 describes the theoretical background related to rational bidding behaviour in an ascending price auction under the IPVP with a minimum bid and an entry fee corresponding to the Ukrainian land lease auctions. Section 3 provides an institutional background related to online land lease auctions and describes the auction data. It presents the methodology, core empirical results and discussion. Section 4 concludes.

2 | THEORETICAL BACKGROUND: DOMINANT BIDDING STRATEGY AND THE OPTIMALITY OF PARTICIPATION

2.1 | Bidding behaviour in a SPA

As mentioned above, the online agricultural land auctions in Ukraine have adopted an open ascending price auction scheme with a predetermined reserve price, entry fee and incremental bidding. At least two well-known models for ascending price auctions exist, namely the clock model of Milgrom and Weber (1982) and an incomplete model of English auctions of Haile and Tamer (2003) that extends its arguments. They provide a useful framework for the present analysis. The Milgrom-Weber clock model assumes a 'button' auction: An auction process is conducted by an auctioneer who begins the auction by announcing a minimum bid, which is then raised by bidders. After each round the bidders must confirm that they are still participating. When the price exceeds their valuations, they drop out of the auction. The bidding continues as long as at least two actual bidders are participating and closes when one of the two remaining bidders drops out. The remaining bidder wins the auctioned lot. An open ascending bid (or English) auction and a sealed-bid second-price (or Vickrey) auction are considered to be strategically equivalent if bidder valuations are assumed to be private and independent (The reasoning for why the IPVP is appropriate is provided in Appendix SA). The dominant strategy of the bidder i is to bid b_i that is equal to the bidder's valuation v_i (Krishna, 2010). It can be formally expressed as follows:

$$b_i = \beta\left(v_i\right) = v_i, \quad i = 1, \cdots, N \tag{1}$$

(Paarsch & Hong, 2006).

Given these bids, bidder's payoffs are:

$$\Pi_i = \begin{cases} v_i - max_{j \neq i} b_j \text{ } if \text{ } b_i > max_{j \neq i} b_j \\ 0 \text{ } if \text{ } b_i < max_{j \neq i} b_j \end{cases} \tag{2}$$

where $max_{j \neq i} b_j$ $(j = 1, \cdots, M)$ denotes the highest bid submitted by other bidders (Krishna, 2010).

They can be described as follows. If a bidder i submits the highest bid, then their profit will be $v_i - max_{j \neq i} b_j$. If they do not win the auction, the profit will be zero. The bidder i wins, if all other bidders submit lower bids. In an exceptional case $b_i = max_{j \neq i} b_j$ the object or property goes to each winning bidder with equal probability (*ibid*.).

Haile and Tamer (2003) extended the clock model, allowing for a free-form bidding process: Bidders are not required to indicate if they are still active during the auction and may submit a bid larger by one bid increment or place a jump bid. The model is based on two assumptions about bidders: First, they do not place bids above their valuations and second, they do not allow a competitor to win at a price they would still be willing to pay. Both assumptions are consistent with the dominant strategy of 'button' and second-price auctions (Paarsch & Hong, 2006). However, according to the model of Haile and Tamer (2003), the second-highest bid may not necessarily be equal to the second-highest valuation. Instead, the second-highest valuation may be bounded by the winning bid plus one bid increment. If the latter were not true, some other competitor whose valuation is the second highest, would have beaten the existing highest bid (Paarsch & Hong, 2006).

It is implied in the first assumption of the extended model that bidders do not overbid. The second assumption is motivated by the idea that bidders observe and respond to the current bid with a higher bid of their own (McAfee & McMillan, 1987) and they do not miss opportunities to make a profit (Haile & Tamer, 2003). Therefore, they will not underbid if it leads to losing the auction. If they do, the object may then go to the bidder with a lower valuation, thus affecting the efficiency of allocation. Moreover, it does not cost bidder i much to bid a bit higher because the winning price is determined by the last bid of the nearest competitor (Paarsch & Hong, 2006). This provides additional arguments that underbidding is not optimal.

2.2 | Exclusion principle

McAfee and McMillan (1987) suggest that the optimal selling mechanism for the owner of an item is to sell it to the bidder with the highest valuation, if this valuation is above a set cut-off price. The cut-off price should be strictly above the seller's own valuation that is revealed through the minimum bid (also called a positive reserve price) $r > 0$. A bidder with value v_i that is lower than the minimum bid r will not find it worthwhile to participate (and often they are not allowed), because if they win, it is not possible to make a positive profit from the auction. Therefore, it is usually assumed that only those potential bidders who had valuations exceeding the reserve price participate. The bidders' equilibrium strategy becomes (Krishna, 2010; Paarsch & Hong, 2006)

$$\beta\left(v_i\right) = v_i \; if \; v_i \geq r \tag{3}$$

The exclusion of bidders with low values has implications upon the efficiency of an auction. If the seller attaches no value to the object, that is, $r = 0$, the object will be sold to the bidder with the highest value thereby ensuring efficient allocation (Krishna, 2010). A positive reserve price $r > 0$ leads to a trade-off that the seller must confront: the higher reserve price will increase revenue when only one bidder participates and will also raise the probability that the object remains unsold, if no registered bidder has a valuation that exceeds the reserve price $v_i > r$ (Haile & Tamer, 2003).

The auctioneer may also charge a non-refundable entry fee e. Similar to a bidder with value v_i that is below the positive reserve price ($v_i < r$), a bidder with a value below an entry fee ($v_i < e$) will also not find it worthwhile to participate (Krishna, 2010). Moreover, if an auctioneer uses both instruments—a reserve price and an entry fee—the bidder's strategy becomes

$$\beta\left(v_i\right) = v_i \; if \; \left(v_i - r\right) \geq e \tag{4}$$

According to Equation (4), a bidder i, who bids their valuation, will find it worthwhile to participate only if the difference between the winning bid and minimum bid can at least cover the entry fee (Krishna, 2010; McAfee & McMillan, 1987b; Menezes & Monteiro, 2005; Tan & Yilankaya, 2005).

Although bidders are supposed to stick to the dominant strategy, their deviations from it are often referred to in economic literature as bidding errors (McGee, 2013, Garratt & Wooders, 2010, Garratt et al., 2012, Cooper & Fang, 2008). Potential bidding errors and factors that influence their occurrence are described in Section 3.1.3.

3 | EMPIRICAL ANALYSIS

3.1 | Description of land auctions and the auction data

3.1.1 | Electronic land auctions in Ukraine

Land privatisation in Ukraine started after the dissolution of the Soviet Union. The distribution of the state-owned agricultural land was done by granting land certificates in the 1990s. It facilitated the transfer of about 31 million hectares (ha) or three quarters of all farmland to private ownership. In 2001, a moratorium on land sales restricted the private landowners' right to sell the farmland they received. Absent a land sales market, land relations have developed on a lease/rental basis. The transfer of land rental rights for privately owned land was conducted through private negotiations. Their details were neither systematically collected nor publicly disclosed. Rental rights for agricultural state-owned land could only be transferred via a traditional English auction, according to the 2012 Land Code. It was intended to improve transparency of state-owned land rental process. The auctions gradually gained in popularity and in 2018, the Ukrainian State Service for Geodesy, Cartography and Cadastre (also referred to as the State GeoCadastre) conducted around 1500 successful auctions (Kvartiuk et al., 2020).

One of the Ukrainian decentralisation reforms launched in 2014 aimed at increasing the efficiency of managing state-owned land. Responsible regional and/or community agencies were given the right to manage local state- or community-owned land. An online auction project to facilitate the transfer of land rental rights from the state and communities to private hands was launched in October 2018 (Kvartiuk & Herzfeld, 2019; The Cabinet of Ministers of Ukraine, 2017). This project aimed to replace the traditional English auction scheme, to prevent corruption, and to gain experience in auctioning farmland electronically (The Cabinet of Ministers of Ukraine, 2017). The publicly disclosed auction data has become a unique source of information about state-owned land transaction prices in Ukraine (Kvartiuk et al., 2020). The online auctions will also be used in the future for the transfer of state-owned land rental rights as well as the sale of privately owned agricultural land after the ban on selling land was lifted in July 2021 (The Verkhovna Rada of Ukraine, 2020).

The online auction process proceeds in several stages. It starts when the auctioneer receives documentation with the property description from the regional or community agency that owns the parcel and is interested in renting it out. In these documents the contact information of the landowner, property characteristics (its dimensions, land use designation, location, cadastre number, normative appraisal, contract term, rental agreement draft, etc.), and auction-specific characteristics (the minimum bid, bid increment, entry fee) are detailed. The auctioneer announces an auction after the receipt of the documents and publishes an announcement on the OpenMarketLand webpage, an online auction platform run by the state enterprise 'The system of electronic trade of seized property' in partnership with the State GeoCadastre. Regional, district and community agencies also publish announcements on their webpages. Potential bidders have to register within 30 calendar days and may inspect the property. During the registration, paying an entry fee is required. The amount is calculated at 50% of the state determined subsistence-level income on the publication date of the land auction announcement and may not exceed it. Potential bidders acquire the status of a bidder after they successfully register. Each lot is auctioned separately (The Cabinet of Ministers of Ukraine, 2017).

The auction starts at the prescheduled announced date and is conducted within one business day. The first bid placed (price offer) must be equal to or higher than the reserve price. The landowners are free to set the reserve price at an amount they consider appropriate. As an unofficial rule, the reserve price is calculated at 8–10% of the normative land appraisal.[1] Each subsequent bid must be raised by at least one minimal bid increment. The bid increment amount is usually 0.5% of the reserve price. The bidding ends when no bidder is willing to increase the price within the set time interval (after three minutes have passed) after the auction begins. If a subsequent bid higher than the previous one (or the reserve price) is placed, the auction is extended for an additional three minutes. Such auctions are termed 'soft close' (Duffy & Ünver, 2008). If no further bid is submitted, the bidding closes and the winning bid is published on the webpage. The winner is obligated to sign the protocol electronically within 15 min after the auction closes. If they do not sign the protocol within a specified period, the highest bid is cancelled by the system and the auction may be resumed. An unsold plot may be auctioned repeatedly (The Cabinet of Ministers of Ukraine, 2017).

The successful auction results were published on the OpenMarketLand website. The published information includes the land- and auction-specific information received from the landowner before the auction, as well as the winning bid. The auction is considered successful, if it is concluded with a signed land rental agreement. It is considered a failure if no rental agreement is signed. The private information about bidders and winners and the final concluded

[1]Normative valuations are derived in accordance with the prescribed procedure in the Ukrainian Legal Code 'On Land Evaluation' of 11 December 2003, and with the Decree of the Cabinet of Ministers of Ukraine 'On approval of the methodology of normative monetary valuation of agricultural land' of 16 November 2016. The valuation represents capitalised income from the plot, determined according to established and approved norms (The Cabinet of Ministers of Ukraine 2016). One may reasonably suggest that normative appraisals are considered public information that may be used by bidders to form their valuations. However, the methodology of normative land appraisals was adopted to calculate land prices not formed by market forces. Therefore, the appraisal may not necessarily reflect the economic value of a certain plot (Kvartiuk et al., 2020). The appraisals are calculated based upon a relatively old economic land assessment conducted in 1988 (The Cabinet of Ministers of Ukraine 2016). The methodology is based on assigned rental income, which is generated only through the production of cereals and overlooks many other factors, such as the selling price of cereals, production cost per hectare, profitability, technological innovations and so on (*ibid*.). The appraisals may be used by bidders to get an impression of the plot's land cultivation productivity and profitability, but they can hardly be used by farmers when forming their private land valuations, because in real life farmers will not use the same technology and grow the same products.

agreement details may not be published (The Cabinet of Ministers of Ukraine, 2017). The results from the successful electronic land auctions that took place between October 2018 and September 2019 are described below.

3.1.2 | Data and descriptive statistics

The initial sample collected consisted of 2670 successful auctions. To increase the homogeneity of the data, outliers below the 5th percentile and above the 95th percentile were removed to drop the unusually small and large per-hectare prices. These adjustments led to deleting 265 observations. Six winning bids below the reserve price were also removed. They were likely documented by mistake.

The auction data contains plots with different land use designations, namely arable land, grassland and farmland used for other purposes. Arable land constitutes the largest share of auctioned agricultural land (about 84% of plots rented). Nearly 10% of the rented plots were grassland. About 6% of auctions had rental preconditions that the land be used for organic agriculture, gardens or reserves. To further increase homogeneity of the data, only arable land plots and grassland were selected. This resulted in deleting 152 further observations. The final sample consists of 2247 observations with 90% representing arable land. All bids are in Ukrainian currency, hryvnia (UAH). At the time of data collection, €1 corresponded to approximately UAH 30 (The National Bank of Ukraine, 2019).

Every observation in the sample includes the information about the winning bid, number of actual bidders, reserve price, entry fee, bid increment, average time spent by each bidder, month the auction took place, location, plot area, land use designation, contract term, and if a plot is auctioned for the second time (see Table 1). A maximum of 12 bidders participated in an auction. The average number of actual bidders fluctuated between two and three bidders per auction, tending to decrease to two bidders at the end of the observed period—which is the minimum number of bidders required for an auction to take place according to the respective law. In a repeated auction only one actual bidder is required for a plot to be rented out (The Cabinet of Ministers of Ukraine, 2017). The average land lease per-hectare price amounts to approximately 3303 UAH/ha. It ranges from 79 UAH/ha to 33,985 UAH/ha. The per-hectare minimum bid varies between 23 UAH/ha and 11,293 UAH/ha with a mean value of approximately 1461 UAH/ha. The average participation costs amounted to 965 UAH and ranged between 800 UAH and 1003.5 UAH. The amount of bid increment varies between 0.12 UAH/ha and 56.48 UAH/ha with an average value of 7.31 UAH/ha. On average, each bidder spent approximately 7.43 min in auction. Twenty-nine auctions or about 1% of the sample were repeated auctions. Leased plots are on average 16.6 ha. Their area ranges from 0.6 to 159 ha. The majority of the land lease contracts auctioned had a 7-year term. Forty-nine successfully concluded contracts were 10-year rental agreements. All contracts may be extended up to 50 years—the maximum allowable land lease term according to the Land Code (The Verkhovna Rada of Ukraine, 2002).

Table 2a shows the growing number of successful auctions over time. A testing phase was conducted during the first months of the project's implementation. It was used mainly for technical optimisation, and it allowed the auctioneer, landowners and bidders to gain experience. The number of successful auctions per month increased from 9 in October 2018 to 404 in September 2019. This tendency holds for both groups of considered land.

The territory of Ukraine consists of several physiographic regions: Forest-Steppe and Steppe (including Donbas), Polissia, the Carpathian Mountains, and the Crimean Peninsula.[2] The topsoil, climate and vegetation vary regionally. Table 2b illustrates the absolute number of

[2]The sample includes no observations from the Crimea.

TABLE 1 Descriptive statistics and definition of variables ($N = 2247$).

Variable	Notation	Mean	Std. Dev.	Min	Max	Remarks
Per-hectare winning bid, UAH/ha	price_ha	3303.23	3171.23	78.93	33,985.48	
Number of actual bidders	nr_bidders	2.89	1.32	1.00	12.00	
Per-hectare reserve price, UAH/ha	reserve_price_ha	1461.47	1172.20	23.00	11,292.76	Also called here a minimum bid
Entry fee, UAH	entry_fee	964.72	27.78	800.00	1003.50	Also called here entry/participation costs
Minimum bid increment, UAH/ha	increment_ha	7.31	5.87	0.12	56.48	
Average time spend by each bidder, minutes	duration_min	7.43	13.18	0.27	153.50	
Repeated auctions	repeated	0.01		0.00	1.00	Dummy variable = 1 if a plot is auctioned for the second time
Contract term, years	length	7.07	0.438	7.00	10.00	
Plot area, ha	area_ha	16.61	15.73	0.65	158.69	
Grassland	grassland	0.10		0.00	1.00	Dummy variable = 1 if a plot is grassland
Month	month			1.00	12.00	The variable indicates the respective month from October 2018 to September 2019, when auctions took place
Physiographic regions	natural_area			0.00	6.00	The variable indicates the respective physiographic region to which the plot belongs (see Table 2b and Table B1 and B2 in Appendix SB).
Underbids	underbid	0.46		0.00	1.00	Dummy variable = 1 if a winning bid is below the equilibrium bid level
Underbids	underbid_2	0.44		0.00	1.00	Dummy variable = 1 if a winning bid plus one increment is below the equilibrium bid level

Source: Author‘s representation based on OpenMarketLand data (2018–2019).

TABLE 2A Number of plots rented via online auction per month for two groups of land (N = 2247)

	Arable land			Grassland		
Month	**Freq.**	**Percent**	**Cum.**	**Freq.**	**Percent**	**Cum.**
Oct.–Dec. 2018	156	7.72	7.72	9	4.00	4.00
Jan. 19	74	3.66	11.37	4	1.78	5.78
Feb. 19	78	3.86	15.23	1	0.44	6.22
Mar. 19	283	14.00	29.23	37	16.44	22.67
Apr. 19	185	9.15	38.38	23	10.22	32.89
May 19	233	11.52	49.90	15	6.67	39.56
Jun. 19	238	11.77	61.67	23	10.22	49.78
Jul. 19	190	9.40	71.07	13	5.78	55.56
Aug. 19	246	12.17	83.23	35	15.56	71.11
Sept. 19	339	16.77	100.00	65	28.89	100.00

Source: Author's representation based on OpenMarketLand data (2018–2019).

TABLE 2B Number of plots rented via online auction per physiographic region for two groups of land (N = 2247).

	Arable land			Grassland		
natural_area	**Freq.**	**Percent**	**Cum.**	**Freq.**	**Percent**	**Cum.**
Forest-Steppe	774	39.03	39.03	69	31.51	31.51
Donbas	103	5.19	44.23	35	15.98	47.49
Steppe	649	32.73	76.95	102	46.58	94.06
The Carpathians	83	4.19	81.14	2	0.91	94.98
Western Polissia	271	13.67	94.81	2	0.91	95.89
Central Polissia	24	1.21	96.02			
Eastern Polissia	79	3.98	100.00	9	4.11	100.00

Source: Author's representation based on OpenMarketLand data (2018–2019).

successful auctions per physiographic region. The majority of successful auctions took place in the Forest-Steppe and Steppe regions. They have the largest area of available agricultural land and the best soil quality. The auctions that took place in Central and Eastern Polissia represent the smallest share.

Many auctions concluded with the price equal to or just above the reserve price: In about 46% of all auctions[3] bidding ended where the difference between the bid and the reserve price was less than the entry fee. It clearly contradicts the dominant strategy and the threshold that determines the optimality of participation (Equation 4 above). The losing bidders in these auctions entered the auction with either a very low willingness to pay and/or some other factors that may be associated with auction design or land characteristics prevented the bidders from revealing their valuations and led to bidding errors.

[3]If the highest possible valuation of the second highest bidder reaches the amount of the winning bid plus one bid increment (Haile and Tamer 2003), the participation threshold does not hold in about 44% of the auctions.

3.1.3 | Hypotheses and empirical model

A typical measure of bidding errors is the propensity to overbid or underbid (Feng et al., 2016). To examine the occurrence of underbidding in the present case, a variable 'underbid' was created and was given the value of 1 if the winning bid exceeded the reserve price by less than the entry fee and a value of 0 if otherwise. The propensity to underbid was further modelled as a function of auction characteristics and property attributes. The auction characteristics include entry fee, number of bidders, bid increment value, the average time a bidder spent in the auction, and if the auction was repeated, along with contract and property characteristics, such as contract term, month, plot area, land use designation, and location. Equation 5 is, therefore, our empirical model:

$$underbid = f(entry\_fee, nr\_bidders, increment\_ha, duration\_min, repeated, length, month, area\_ha, grassland, natural\_area) \tag{5}$$

There are many studies that investigate the effect of participation costs on bidding behaviour, but there is no consensus of what outcomes should be expected. Despite entry costs that are often seen as sunk and not relevant to rational decision making (McAfee et al., 2010), several papers (see, e.g., Augenblick, 2016; Camerer & Weber, 1999) contend that they have an effect on bidders' behaviour in a way that players become less willing to exit a situation as their commitments increase—even if these investments no longer seem worthwhile. In turn, Phillips et al. (1991) suggest that bidders may also ignore sunk costs or they may value an item less as the amount of sunk costs increase. Therefore, it seems reasonable to analyse the effect of higher participation costs on the propensity to underbid.

Greater competition in ascending price auctions with private values is often associated with overbidding (Bajari & Hortacsu, 2003b; Paarsch, 1992). When facing greater competition, bidders may offer a price that exceeds their valuation of property and overpay (Hou et al., 2009; Hüttel et al., 2013). Hence, we include the number of bidders as a reflection of the competition for the plot.

According to Haile and Tamer (2003), bidders in ascending price auctions may deviate from bidding their true valuations by one bid increment. This deviation may be more pronounced if bid increments are large. In line with this, Hickman et al. (2017) and Hickman (2010) claim that due to incremental bidding, participants in online auctions may engage in bid shading similar to those in first-price auctions. In the present case, bid increments vary from auction to auction and in some instances were quite large, therefore it may be expected that larger bid increments prevent bidders from revealing their true property valuations and this may lead to underbidding.

The time bidders spend in auction may have an effect on their behaviour, but this effect is ambiguous. On the one hand, the longer bidders stay in an auction, the more likely they are to submit a higher bid, possibly due to attachment or endowment that they develop in the course of bidding (Wolf et al., 2005). On the other hand, a long bidding process may be associated with bidders increasing monitoring costs, which may make them less willing to switch auctions in order to avoid new search and entry costs. Bidders may also subtract these costs from their willingness to pay for an item (Bapna et al., 2009; Goes et al., 2012). Therefore, the variable reflecting average time spent by each bidder in auction[4] is entered into the model to investigate if the propensity to underbid decreases or increases when bidding lasts longer.

Both learning and gaining auction experience are often assumed to be remedies for bidding errors. Yet there is still room for ambiguity. On the one hand, Wilcox (2000) claims that bidders may still make systematic bidding errors even after many repetitions. On the other hand, Zhang

[4]The average time was used, because the land auctions under consideration are not 'button' auctions, so one cannot know how much time exactly bidders spent before they dropped.

et al. (2019) claim that participants may discover the dominant strategy through their prior observations. In line with this premise, it seems reasonable to suggest that participants in a repeated land auction[5] will be more likely to follow the dominant strategy, because they may at least obtain some information about the auction procedure and the competition for the specific plot during the initial auction, and they may more accurately bid for the same plot the second time. The repeated auctions dummy variable was added to control for this effect in the model.

Physical features, such as quality of an auctioned item can also explain bidding errors. Namely, higher item quality may motivate bidders to overbid rather than underbid (Malmendier & Lee, 2011). Thus, the 'natural_area' variable indicating the physiographic region to which the plot belongs was entered into the model to control for the effect of the location and characteristics of the plot. This includes factors such as soil quality, the availability of infrastructure, and the role agriculture plays in the regional economic structure which may have an impact on bidders' willingness to pay (Hüttel et al., 2013; Nilsson & Johansson, 2013). The topsoil in the Forest-Steppe region is mainly represented by black soils (Fatieiev & Paschenko, 2003) that are the most productive and most expensive. This region was used as a reference category in the models, expecting that the willingness to pay for land located in this region is higher than in other regions and underbidding is less likely to occur. Compared to the Forest-Steppe region, other regions are expected to have lower land prices due to the following reasons. Namely, the Steppe region is the warmest among all regions, has overall good conditions for agriculture, but mainly sod-carbonate soils. The Donbas region has large agricultural areas and black soils (Fatieiev & Paschenko, 2003), but heavy industry (coal mining, chemical and metallurgical processing sites) dominates in the structure of regional economy (Yakovliev & Chumachenko, 2017), making agriculture a less attractive economic sector. Western Polissia is characterised by high humidity and poor soils due to insignificant nutrient reserves. The basis of the Central Polissian geostructure is formed by crystalline rocks, which participate in soil formation. Here sod-podzolic, sod mid-podzolic, light gray and gray forest soils predominate. Eastern Polissia is characterised by the combination of sod-podzolic soils and black soils. The Carpathians are a mountainous region with brown forest soils (Fatieiev & Paschenko, 2003). Therefore, Western, Eastern, Central Polissia and the Carpathians are less suitable for agriculture.

Many studies are dedicated to estimating the effect of plot size on pricing, yet this relationship is ambiguous (Hüttel, Ritter, et al., 2016). Land cultivation and farming activities may be better facilitated if one large plot is at the farmer's disposal, thus reducing transaction and machinery costs and resulting in a willingness to pay more for land (see, e.g., Hüttel et al., 2013; Hüttel, Ritter, et al., 2016). But larger plots may conversely be in lower demand due to budget constraints (Xu et al., 1993). Land prices may also be independent from plot sizes (Maddison, 2000). It seems reasonable to control for the effect of plot size too, but its exact effect is to be determined.

Several papers (Grenadier, 1995; Gunnelin & Söderberg, 2003; Hüttel, Ritter, et al., 2016) have explored the role lease contract lengths play in the price formation process. Expectations about future rents may respond to changing market conditions (Gunnelin & Söderberg, 2003). To incorporate farmer expectations regarding future transformations, Gunnelin and Söderberg (2003) and Hüttel, Ritter, et al., 2016) analysed contracts negotiated at the same time of year over a period of several years and modelled price as a function of term structure (an interaction between the contract length and year, when the contract was concluded). However, our data only covers one year, so we can only control for contract length. In addition, the effect of time on the occurrence of very low winning bids is captured by the monthly dummy variables. Auctions that took place during the testing phase between October and December 2018 were chosen as a reference due to a small number of observations in the first months. Gunnelin and Söderberg (2003) and Hüttel, Ritter, et al., 2016) report case-specific results, therefore, it

[5]Bidders learn that the plot is auctioned for the second time in the auction announcement.

is difficult to predict expected positive or negative effects associated with the lease length and time of contract conclusion.

To check the robustness of the results, different model specifications and samples were used. Model 1.1 was estimated using the sample of winning bids. Model 1.2 accounted for arable land only. In Model 2.1 the variable 'underbid_2' replaced the variable 'underbid', where the definition of an underbid is increased by one auction increment. It was modelled as a function of the same dependent variables. Model 2.1 was estimated using the full sample. To additionally check the robustness of our estimated coefficients, the alternative specifications of the regression model (Models 3.1–4.1) were also estimated without the variable representing the number of participating bidders. All models use the cluster-robust (district-level) variance-covariance matrix. The data includes observations from 373 out of 490 Ukrainian districts (without cities).

A non-constant variance across observations (heteroscedasticity) may affect the consistency of the maximum likelihood estimators of probit model parameters (Holden, 2011). Therefore, both models were estimated by means of heteroscedastic probit regression. In comparison with a conventional probit model, this model allows the scale of the inverse link function to vary from observation to observation as a function of the independent variables. The presence of heteroscedasticity was tested by a likelihood-ratio test, as suggested by Harvey (1976). Both models were estimated by maximum likelihood.

3.2 | Estimation results and discussion of potential causes of underbidding

Table 3 presents the average marginal effects of Models 1.1–2.1. The respective coefficients are presented in Table C1 of Appendix SC. The estimation results of the model's alternative specifications that do not account for the number of bidders as an explanatory variable are presented in Table D1 and D2 in Appendix SD. Jointly, the estimated coefficients of all models are significant according to the Wald test. The likelihood-ratio test of heteroscedasticity is also significant and therefore a heteroscedastic probit model is appropriate.

The marginal effects of entry costs, competition, bid increment, and the average time bidders spent in auction on the propensity to underbid are also shown in Figure C1a–d in Appendix SC for both the beginning and the end of the observed period. Auctions at the beginning of the pilot project are characterised by a slightly higher occurrence of underbidding when compared with the last month. Greater competition (the number of bidders) significantly decreases the propensity to underbid. It approaches zero if the number of bidders increases to eight (Figure C1b in Appendix SC). This finding met the expectations and is in line with related studies (see, e.g., Cooper & Fang, 2008; Feng et al., 2016; Hou et al., 2009; Kagel & Levin, 1993; McGee, 2013) that demonstrate that auctions with higher competition are more prone to overbidding—diminishing the chance of underbidding. Larger minimum bid increments tend to decrease the propensity to underbid, though the marginal effect is barely identifiable. Underbidding is not observed, when the per-hectare bid increment is greater than 200 UAH (Figure C1c in Appendix SC). This finding is in line with the studies by Hickman (2010) and Hickman et al. (2017) which suggest that incremental bidding may affect bidding behaviour in online auctions. Furthermore, it was found that underbidding is less likely when bidders spend more time in an auction. In particular, if the average time each bidder participates in an auction increases to 15–20 min, the likelihood of underbidding approaches zero (Figure C1d in Appendix SC). Thus, the possible negative effect of higher monitoring costs as described in Bapna et al. (2009) and Goes et al. (2012)—that bidders would subtract from their valuations and bids—was not found. Instead, bidders who spent more time in an auction were more inclined to win the property in question, possibly to avoid renewed auction-related costs of search, entry and monitoring. Besides, greater entry fees slightly increase the propensity to underbid (Model 1.2). This finding contradicts the expectation that higher entry costs may compel bidders to

TABLE 3 Estimated marginal effects for the main model and its alternative specifications.

	Model 1.1 (main)		Model 1.2		Model 2.1	
	Marg. Effect	Std. Err.	Marg. Effect	Std. Err.	Marg. Effect	Std. Err.
Dependent variable	*underbid*		*underbid*		*underbid_2*	
entry_fee	0.00	(0.00)	0.00*	(0.00)	0.00	(0.00)
nr_bidders	−0.13***	(0.01)	−0.13***	(0.01)	−0.13***	(0.01)
increment_ha	−0.00*	(0.00)	−0.00*	(0.00)	−0.01***	(0.00)
duration_min	−0.06***	(0.01)	−0.06***	(0.01)	−0.06***	(0.01)
repeated	−0.02	(0.05)			−0.01	(0.06)
length	−0.02	(0.02)	−0.02	(0.02)	−0.02	(0.02)
Monthly variables						
Oct.-Dec.18	Reference		Reference		Reference	
Jan.19	−0.14*	(0.07)	−0.14*	(0.06)	−0.14*	(0.07)
Feb.19	−0.05	(0.05)	−0.06	(0.05)	−0.04	(0.05)
Mar.19	−0.11***	(0.03)	−0.13***	(0.03)	−0.11***	(0.03)
Apr.19	−0.11***	(0.03)	−0.12***	(0.03)	−0.10**	(0.03)
May.19	−0.17***	(0.03)	−0.17***	(0.03)	−0.17***	(0.03)
Jun.19	−0.07*	(0.03)	−0.07*	(0.03)	−0.07*	(0.04)
Jul.19	−0.09*	(0.04)	−0.09*	(0.04)	−0.08	(0.04)
Aug.19	−0.05	(0.04)	−0.06	(0.04)	−0.05	(0.04)
Sept.19	−0.08*	(0.04)	−0.08*	(0.04)	−0.08	(0.04)
area_ha	−0.01***	(0.00)	−0.01***	(0.00)	−0.01***	(0.00)
grassland	−0.00	(0.03)			0.00	(0.03)
Natural area						
0 Forest-Steppe	Reference		Reference		Reference	
1 Donbas	0.03	(0.04)	0.04	(0.04)	0.02	(0.04)
2 Steppe	0.01	(0.02)	−0.00	(0.02)	0.01	(0.02)
3 Carpathians	−0.01	(0.06)	−0.02	(0.06)	0.00	(0.06)
4 Western Polissia	0.08*	(0.04)	0.08*	(0.04)	0.09*	(0.04)
5 Central Polissia	0.05	(0.07)	0.04	(0.07)	0.05	(0.06)
6 Eastern Polissia	0.09***	(0.03)	0.07**	(0.03)	0.09**	(0.03)
N	2247		2022		2247	

Note: Standard errors in parentheses.
Significance levels: $^*p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

submit higher bids (McAfee et al., 2010). Instead, larger entry fees in land lease auctions make bidders more attentive to costs (Figure C1a in Appendix SC).

Contract terms were found to have an insignificant effect on the propensity to underbid. Therefore, there is no sufficient evidence to conclude if farmers were either more interested and/or willing to pay more for longer-term contracts.

The estimation also shows that the intrinsic features of the land auctioned may partly explain the propensity to underbid. First, when compared with the Forest-Steppe region, where the soils are the most productive and agriculture is an attractive economic activity, auctions that took place in Western and Eastern Polissia were more prone to underbidding. This confirms that better lot quality may motivate bidders to overbid rather than underbid (Malmendier &

Lee, 2011). Second, bidders tend to underbid less if a larger plot is being auctioned. Larger plots are more convenient and efficient to cultivate, as many land market studies claim (see, e.g., Hüttel et al., 2013; Hüttel, Ritter, et al., 2016) that may explain this result. Overall, this finding is also in line with the ideas described in Malmendier and Lee (2011), which suggest that item characteristics can explain the occurrence of bidding errors.

4 | CONCLUSION

This study contributes to a scarce body of literature related to the occurrence of bidding errors in agricultural land auctions. Among the first to analyse the issue are Seifert and Hüttel (2020), who examined the occurrence of overbidding in agricultural land sales auctions in eastern Germany under the assumption that bidders derive their valuation from some commonly known pricing information. The present study adds further evidence from the land lease auctions in Ukraine that employ the ascending price rule. It assumes that land valuations are private and independent—due to scarcity of reliable statistical rental rate information available to farmers for deriving their land valuations.

A close look at the publicly disclosed data from the 2018–2019 online agricultural land auctions in Ukraine indicate that winning bids of almost one-half of auctions exceeded the reserve price by less than the entry fee. Assuming that the winning bid represents the second-highest bidder's true valuation of the plot, the losing bidders in these auctions entered the auction with either a very low willingness to pay and/or some factors prevented them from revealing their valuations, if these valuations were higher. This led to underbidding and consequently revenue losses for the landowners. This motivated the need to examine which factors—auction and property characteristics—could lead to this situation. The selection of factors was based on the theoretical and empirical evidence related to the occurrence of bidding errors in SPAs that are thought to be equivalent to an ascending price auction under the IPVP. It examined the effects of the causes that lead to bidding errors in agricultural land lease auctions for the first time.

The analysis confirms that parameters of auction design affect bidding behaviour, and if not optimally set, they may lead to bidding errors that affect the plot rental rate as well as subsequent rental payments. The estimation results show that highly competitive auctions are not prone to underbidding, but over the studied period there were few highly competitive auctions observed. As a revenue-maximising landowner may want to attract more actual bidders and facilitate more competitive bidding, this may be achieved by improving the information provided about the auctions to potential interest groups. If a landowner wants to ensure the cultivation of a plot, and revenues are of secondary importance, then they may decrease the reserve price. Lowering reserve prices will likely allow bidders with lower valuations to enter the bidding, which should enhance competition, but may not necessarily have a positive price effect, especially if the second highest bid that determines the winning bid was placed by a bidder with a low valuation. Another suggestion may be to standardise the reserve price amounts. So far, there is no legally determined method for setting reserve prices and the majority of landowners calculate it by themselves, generally being around 8%–10% of the normative land appraisal. This may serve as a good indication of land quality for bidders, on the one hand. This may also be difficult for bidders to rely on if landowners do not follow this unwritten rule. Standardising reserve prices in the documentation regulating the auction procedure may improve the transparency of the auctions process. Entry fees may also dissuade participants from entering if the price is deemed high and bidders are not sure about their chances of winning (Reiss & Wolak, 2007). Hence, a higher number of bidders can enter an auction if an entry fee is smaller. In addition, larger entry fees decrease a bidders' willingness to pay more for land. Therefore, an auctioneer seeking to maximise revenue may charge entry fees that decline in correlation with the magnitude of the bid placed—helping to motivate higher bids and de-emphasising the effect entry fees have on bidding behaviour (Maskin & Riley, 1984; Matthews, 1983, 1984; Wilson, 1992).

To further facilitate competitive bidding, the timing of bids and bid increment amounts may be amended. Underbidding does not occur if the time each bidder participates in an auction averages to 15–20 min. However, this time exceeds the average time spent by actual bidders in the sample by 2–3 times. The auctioneer should consider that bidders may have no prior experience and may need some time to learn the auction rules and the bidding strategy (Duffy & Ünver, 2008). So, in order to prevent early auction closure, the timing between placing their bids may be extended. Long bidding may also be a result of very small bid increment amounts that bidders use to raise their bids. The estimation results reveal that underbidding does not occur if the size of the bid increment is above 200 UAH/ha—substantially exceeding the average amount observed. Bidders and landowners may find it useful if the auctioneer increases the bid increment amount.

The limitations of this study reside mainly in the estimation technique utilised and the amount of auction data available. The reduced-form estimation by means of a heteroscedastic probit model allowed for the factors that influence the occurrence of bidding errors to be analysed. The calculation of optimal entry fee amounts and bid increment sizes used to achieve higher land auction efficiency goes beyond this paper. Second, the auction data used in the present study does not provide sufficient means to conduct a detailed demand side analysis, because the identities of bidders and winners are confidential. Thus, it is not possible to analyse if the same bidders took part in repeated auctions and if any learning effects took place. Third, the publicly disclosed auction data allowed accounting for many important factors that impact the occurrence of bidding errors. However, this list of factors is not complete. Last but not least, absent the personal information about bidders, they were all treated as symmetrical and homogeneous. However, in farmland auctions asymmetric bidder structures and different bidder types depending on their values and risk preferences may also be assumed (Croonenbroeck et al., 2020; Ivanova-Stenzel & Salmon, 2011; Menezes & Monteiro, 2000; Palfrey & Pevnitskaya, 2004). Therefore, some follow-up research may be done in the future if additional data becomes available.

ACKNOWLEDGEMENTS

I thank Dr David Harvey, JAE Editor in Chief, two anonymous reviewers, and Dr Ramona Teuber for their insightful comments and suggestions that in my opinion significantly improved the paper.

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How to cite this article: Myrna, O. (2022) Lower price increases, the bounded rationality of bidders, and underbidding concerns in online agricultural land auctions: The Ukrainian case. *Journal of Agricultural Economics*, 73, 826–844. Available from: https://doi.org/10.1111/1477-9552.12477