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Agricultural Land Markets – Efficiency and Regulation

Farmland Values and Bidder Behavior in First-Price Land Auctions

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Abstract

Within this paper, we aim to investigate asymmetries among bidders in land auctions that may entail non-competitive prices. Using representative data for Eastern Germany including winning bids, bidder characteristics, and land amenities, we pursue a structural approach to derive distributions of latent land values for different bidder groups. By applying nonparametric techniques, we cannot find evidence for asymmetric bidder structures while differentiating between legal entities, tenancy status, and nationality of bidders. Our findings challenge the hypothesis that land privatization via auctions discriminates against certain buyer groups—an argument that is often used to justify stricter regulation of agricultural land markets.

Keywords: First-Price Sealed Bid Land Auctions; Structural Estimation; Buyer Heterogeneity

JEL codes: C57, D44, Q12, Q15

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1 Introduction

Land ownership rights are often transferred by auctions, given the virtue of the auction mechanism to allocate land efficiently. Consensus exists that land market auctions yield higher sales prices in comparison to search markets due to higher transparency and competitive pressure among buyers (e.g., Chow, Hafalir, and Yavas 2015, or Bulow and Klemperer 1996). The auction mechanism appears particularly attractive if land is sold by public purse, and for this reason many Eastern European countries with a history of economic transition and land reforms privatize or redistribute land via first-price sealed bid auctions (Hartvigsen 2014). Since 1997, it has even become obligatory—in line with European Union (EU) law—to rule out any publicly allotted allowances from the market mechanism if the public hand acts as a seller (Official Journal of the European Union No. C 209).

Efficiency in the sense of maximizing revenues from land sales or allotting land to owners with the highest willingness to pay is not the only objective that land markets should pursue, at least from a policy perspective. Policy makers and other stakeholders are also interested in a "sound" distribution of land property rights, a prevention of dominant market positions and a diversity of legal forms and production systems. As a matter of fact, the share of farmland owned by farmers is constantly decreasing in most developed economies (e.g., Deininger et al. 2011). Though usually associated with developing countries, land-grabbing has been shown by van der Ploeg, Franco, and Borras (2015) to occur on a broad scale in the global north and the EU as well. Not surprisingly, a heated policy debate has emerged regarding whether land markets in their present state can actually cope with these issues in a satisfactory way or whether regulations should be tightened (Kay, Peuch, and Franco 2015). Sometimes the debate about land market regulations, particularly regarding ownership restrictions, is embedded in more general discussions on how sustainable agriculture should be organized (e.g., Brady et al. 2017). Proponents of small-scale, family-based, and regional agricultural production are concerned about the possible economic dominance of large-scale, potentially industrialized agricultural structures. To ensure viability of the former, these groups often propose allowing privileged access to land markets or restricting ownership (see e.g., Lawley (2018), who investigates the land ownership restriction act in Canada). In the EU, various measures have been proposed and in some member states already imposed to achieve the aforementioned objectives, for example, giving priority to farmers in the case of land purchases or relieving young farmers' access to land by facilitating farm succession and start-ups. At the same time, the restriction of market access for agents treating land as an investment asset without possessing any farming interests (so-called non-agricultural or financial investors) is being debated, even though this is not in line with EU treaties.[1]

Against this background, it is desirable to understand whether using land auctions as specific market institutions facilitate the aforementioned policy goals, or if the resulting land allocation favors or discriminates certain farm types in terms of their legal form, their size, or the provenance of the bidders. For example, are large scale industrialized farms more successful in acquiring land from auctions than small family farms, or do foreign investors offer systematically higher bids than domestic farmers? Nevertheless, why should bids and hence valuations of land systematically differ

[1] A detailed analysis of newly-established land market regulations to ensure limited access to investors (both foreign and domestic) in the group of Eastern European Member States can be found in Ciaian et al. (2017).

among bidder groups? Clearly, these differences should be related to expected income streams generated by farmland investments. One might argue that larger farms generate higher incomes while benefiting from economies of scale. Likewise, non-agricultural investors may face lower financial constraints compared with farmers, and thus lower costs of capital. Local farms and farm-investors might, however, be better informed about the potential income generated from the land, which could possibly lead to different (higher or lower) valuation for given land characteristics (e.g., soil quality) compared to non-farm investors. Local farmers instead of bidding for land to use it and not with the intention to rent it out, might have a higher willingness to pay (WTP), particularly if it comes to auctions for land that is already under their usage, or for a parcel surrounded by own parcels without any infrastructure to access the land. In the latter case, high transaction costs for disentangling the field and further losses besides using the field area such as increased production costs might increase the WTP of farms compared to investors. Even collusion between local farmers might be possible, which comes even at a disadvantage to non-farm investors, possibly leading to lower prices. This phenomenon has been reported to affect equilibrium prices in auctions (Banerji and Meenakshi 2004), though thus far not in the land markets context.

Whether these arguments are valid or not in reality is an empirical question. Unfortunately, there is only sparse empirical evidence on the dominance of certain buyer groups in land auctions. Hüttel et al. (2013) show that realized land prices are higher in land auctions in Eastern Germany when the share of agricultural bidders is low. Yet, higher land prices could likewise be realized if the winning bidder was a resident with knowledge about local land development plans and infrastructure. Curtiss et al. (2013) report higher prices if investors are involved in the transaction, particularly in transition economies in which market entry is not highly regulated.

With this paper, we aim to analyze whether buyer groups differ systematically in their valuation distributions leading to different bidding behavior in land auctions. Knowledge about buyer asymmetries is relevant for two reasons. First, one can verify whether bidders representing certain farm types are dominant and have the potential for crowding out competitors, which would undermine the aforementioned diversity goal, at least on a local scale. Second, bidder asymmetries may entail market inefficiencies with non-competitive prices (Klemperer 1999). As such, first price auctions might then not lead to an efficient allocation of the land. That is, the land will not be in the hand of those with the highest valuation. The reason is that weakness of bidders leads to a more aggressive bidding strategy that may even prevent other bidders from participating, and the final winning bids are not fully competitive anymore. Moreover, the revenue equivalence principle no longer holds under asymmetry, and the question arises regarding which auction format will maximize sellers' profits.

To identify potential bidders asymmetries in land auctions, we use a comprehensive data set from the land privatizing agency in Eastern Germany (Bodenverwertungs- und -verwaltungs GmbH; BVVG), over the period 2007–2015. The BVVG sells land in first-price sealed bid auctions with public tenders. We analyze these auction data using a structural estimation approach, which relies on the hypothesis that the observed bids are the equilibrium bids of the auction model considered, in our case a first price sealed bid auction (c.f. Paarsch and Hong 2006).[2] At equilibrium, a bidder's strategy maps the private valuation of the item into a bid. Structural estimation of auction data (SEAD) targets recovering the (unobserved) distribution of the bidders' valuations from the

[2] Overviews on structural estimation of auction data are provided by Perrigne and Vuong (1999) or Hickman, Hubbard, and Sağlam (2012).

observed distribution of bids. That is, the aim is to investigate the data-generating process directly (Hendricks and Porter 2007). Therefore, the structure of the auction is used to map the theoretical equilibrium bid functions and their distribution into econometric models. Hence, the probability law of the valuations of potential bidders, that is, the primitives of the underlying theoretical auction model, can be identified (Perrigne and Vuong 1999). Reduced form models used as an alternative approach to analyzing auction data basically include auction-specific variables such as the number of bidders or the bidder type, into a hedonic price regression rather than using the equilibrium bids as a mapping from observed bids to unobserved bidder valuations (Hong and Shum 2000). Thus, reduced form models can only provide the average mark up in bids possibly attributed to a specific bidder group, which would not be sufficient for our research question. Another advantage of SEAD is that the theoretical auction model imposes restrictions that can be tested, such as monotonously increasing bid functions or a markdown of valuations in first-price sealed bid auctions. Hence, theoretical results serve as a basis for testing the validity of the auction model under consideration, which is crucial since any data would otherwise support the price data (Athey and Haile 2007).

In our empirical analysis, we explore asymmetries within three pairs of bidder groups in land auctions in Eastern Germany. Based on a rich data set, we classify the groups by their legal form, their tenancy status, and the involvement of foreign investors, respectively. Regarding legal status, we differentiate between natural persons (single farms, private partnerships) and legal entities (co-operatives, limited liability companies, and joint stock companies). The distinction between natural persons and legal entities is more than a formal one. While corporations and cooperatives are in most cases direct successors of the formerly agricultural cooperatives of the GDR, newly established and re-established family farms were typically founded as natural persons.[3] In a simplistic manner, these two groups represent opposed principles of organizing agricultural production. Legal entities stand for industrialized agriculture; they are, on average, much larger than single farms, employ foreign workers, and operate with a larger share of leased land. In contrast, natural persons are smaller in size, centered around a family (a household) and typically strive to transfer the farm to the next generation.

The distinction between former tenants and other bidders is motivated by informational gains that the former group may have when bidding for land. Practical experiences that former tenants have gained facilitate a realistic and more precise valuation of the tendered land plots. It is, however, unclear if former tenants submit systematically higher bids than their competitors do. The third classification aims to identify land speculators. Though we cannot clearly measure the motivations that drive bidders in land auctions, it seems very likely that speculation is an important motivation if foreigners are involved in the buyer consortium. Thus, it is interesting to test whether (local) farmers' willingness to pay for land is lower compared to foreign investors. Our findings do not support asymmetric structures and thus challenge the hypothesis that land privatization via auctions discriminates certain buyer groups and the argument to justify stricter regulation of agricultural land markets.

The remainder of the article is structured as follows. We start with presenting the background of the land privatization process and the auction design in Eastern Germany. In the next section, we describe the data and provide descriptive evidence on potential asymmetric bidder structures. In the subsequent section, we outline the theoretical framework, the independent private value model from which we derive optimal bidding strategies for asymmetric bidders. Next, we detail our

[3] German Democratic Republic, today Eastern Germany from October 3rd, 1990, onwards.

empirical strategy, including the empirical identification of the model and the non-parametric estimation of the distribution of land valuations. In the following section, we discuss our empirical results, and in the final section, we present conclusions.

2 Background: Privatization and Land Auctions in Eastern Germany

In Eastern Germany, the legal foundation of land reform after 1989 was comprised of the Agricultural Adjustment Law (*Landwirtschaftsanpassungsgesetz*), the Law Governing Unsolved Property Issues (*Gesetz zur Regelung offener Vermögensfragen*), and the Reunification Treaty (*Einheitsvertrag*). For about 55% of the agricultural and forest land, ownership rights were restituted without the involvement of Germany's privatization agencies. Former owners who had been expropriated between 1945 and 1949 were not restituted, although they were potentially eligible; this included other citizens of the GDR involved in the agricultural sector (Hartvigsen 2014). As a direct successor of the federal privatization agency (Treuhandanstalt, founded in 1990), in 1992 the BVVG (Bodenverwertungs- und –verwaltungs GmbH) was founded with the target of privatizing the agricultural and forest land over a longer period. Until claims for restitution were decided, BVVG rented out the land based on long-term lease contracts in the first years. One major reason here was the uncertainty and the wish to avoid a large-scale privatization, where price drops in the land market were expected. Based on the Land Purchase Program (1994) and the Privatization Principles (Privatisierungsgrundsätze) since 2007, where our data set starts, land is either directly sold to eligible persons ("Direktvergabe") at a "fair" market value, which typically refers to a local reference value ("Vergleichspreissystem"), or sold by public authorities through tenders (first-price sealed bid auctions) with public calls. These transactions make up a considerable local market share. To illustrate their local importance, in Saxony-Anhalt for instance, BVVG had a market share of roughly 20% in the period from 1995 to 2010 (BVVG 2010). BVVG's privatization practice, that is, selling the land on behalf of the Federal Ministry of Finance, but also the respective German privatization policies in general have been criticized as major contributors to soaring land prices (Wolz 2013). In particular, possibly higher prices realized within auctions compared to those from negotiated sales as shown by (e.g., Fluck, John, and Ravid 2007) have been used as an argument to question the auction mechanism as being optimal for privatization by the public purse. As a response, and in order to increase market transparency, BVVG regularly publishes achieved prices and some basic lot characteristics such as type of land and region on their website.[4]

Auctions are typically used by many post-communist countries to privatize formerly state-owned land (c.f. Hartvigsen 2014) as, for instance, recommended in earlier studies (e.g., Braun 1998) as a prerequisite for a successful economic transition.[5] Whether the auction mechanism really ensures market efficiency, whether inefficient ownership structures occur because of asymmetric buyer structures, and whether such ownership structures go along with policy aims of a favorable farming structure have to the best of our knowledge not been analyzed thus far. More recent studies rather examine the implications of lagging privatization and deal mainly with the role of investors in land markets, often labeled as "land grabbing" (e.g., Visser and Spoor 2011; Kerven et al. 2016). Also in Eastern Germany, non-farmers' and investors' market participation has been critically debated. In this regard, BVVG's activities in publishing the auctions' results, which was originally intended to

[4] See http://www.bvvg.de/INTERNET/internet.nsf/HTMLST/SERVICE (in German, last accessed Nov-5th, 2017).

[5] Comprehensive overviews about transition-related land reforms and other privatization challenges in post-communist countries can be found, for instance, in Lerman, Csáki, and Feder (2004). Also, an excellent brief overview is given by Sedik and Lerman (2008).

improve market transparency, were often used as arguments for why BVVG auctions in particular contribute to soaring prices in Eastern Germany. Given that these land auctions are generally open, it is often conjectured that because of the published auction results, market entry might be eased; particularly non-agricultural buyers motivated by capital investments in times of low interest rates might be attracted. Soaring auction prices due to increased competition could then be interpreted by the market in general as an indicator of positive future price developments (Tse, Pretorius, and Chau 2011). First empirical investigations support this argumentation (e.g., Hüttel, Wildermann, and Croonenbroeck 2016). Empirical evidence, however, still lags behind because of the difficulty of identifying a "non-agricultural buyer" or "investor" not directly related to the local farming business, but also because of the heterogeneity of this group regarding their scale of investment, regional involvement, and the origin of their capital (cf. Tietz, Forstner, and Weingarten 2013).

In the auction literature a considerably different size of the bidders (Laffont, Ossard, and Vuong 1995) or differences in capacity constraints (Jofre-Bonet and Pesendorfer 2003), both of which result in differences in financial limits, have been reported to lead to asymmetric bidder structures. Different levels and quality of information also foster potential asymmetries in bidder structures (Hendricks and Porter 1992; Hendricks, Porter, and Wilson 1994). These arguments all hold for the land market. Land may be acquired with intentions to simply farm it, but also to enlarge equity or to grow. The latter argument also holds for larger agribusiness firms or GDR-LPG-successors.[6] Another intention may be to rent the land out as in the case of farmer investors, that is, treating the land as an investment asset. These intentions can be traced back to different types of buyers with different capital sources and financial restrictions. This observed asymmetry has often been used in debates over why particularly local and privately organized (and likely smaller) farms could be "priced out" of the market. Two facts, however, weaken this argumentation. First, even bidders within the group of farmer-bidders may naturally differ since land utilization options and potential benefits from scale economies remain farm-specific, as do productivity and cost structure. That is, within the farmer group we also observe asymmetries on potential bidders; unfortunately, our data set does not allow us to investigate this asymmetry. We can, however, distinguish by legal form, which allows us to investigate whether potential bidders with legal forms typically chosen by newly- and re-established farms (mainly privately organized) value land differently than potential bidders from the group of legal entities and cooperatives, typical forms of (larger) successor-farms.

Second, while potential returns from using the land might strongly depend on the type of land, it is the final productivity and managerial ability of the user that generates profits from the land. As such, farmer bidders can rely on experience and may be better informed, particularly if it comes to former tenants of the lot or BVVG. Local and experienced farms may also be better informed regarding transaction costs, for instance in case of not winning the auction (losing the land), as well as revenue losses from losing production capacity. These costs may involve mapping the auctioned plot from a potentially larger lot under usage, but also to ensure access some infrastructure (paths, roads) might need to be (re-)established. Such asymmetries have often been reported in transition-related land markets, where this may even lead to bargaining power of the buyer (e.g., Curtiss et al. 2013). We will investigate this kind of asymmetry by using observed tenancy status (i.e., the buyer was a former tenant at BVVG or not) and whether a foreigner obtains the winning bid, which we use as an indication for investment activities.

[6] The acronym LPG stands for *Landwirtschaftliche Produktionsgenossenschaft*, that is, an agricultural cooperative that was a typical farming organization in the German Democratic Republic.

The direction of effects, however, is not that clear in advance. Informational asymmetry might trigger or compensate for differences in the cost structure and financial restrictions. For instance, a credit-constrained farm with better information might have a higher valuation compared to non-constrained investors or larger firms; this farm might not participate in the auction even though the estimate of future returns for this farm might be higher. It could also be that anticipating potentially stronger bidders in the auction, for instance without financial limitations or larger firms with considerable benefits from scale economies, the perceived weaker bidder might bid more aggressively to compensate for disadvantages (Flambard and Perrigne 2006). As a result, it is possible that market outcomes will be inefficient, that is, the bidder with the highest valuation will not win, and the auction results are then neither competitive nor do they result in equilibrium prices. This may in turn lead to wrong market signals.

Another related question is whether the resulting distribution (independent of the efficiency question) meets policy perspectives, visions, and aims regarding ownership and farming structure. The BVVG sells on behalf of the Federal Ministry of Finance with the aim to privatize efficiently. The Federal Ministry of Food and Agriculture and other stakeholder groups in the farming lobby, however, typically state visions regarding a diverse ownership and farming structure, and target at fostering local farmers. Within this debate, investors' participation and market asymmetries were often used as arguments for proposing intense regulation in Germany, for example ownership restrictions or eligibility for participation in these auctions to ensure diverse ownership structures. However, empirical evidence thus far is lacking. In order to investigate empirically whether and how asymmetric bidder structures possibly dominate these land auctions, a differentiation between potential buyers by investors (local, domestic, and foreigners) and farmers would not suffice. The first step must be to investigate whether systematic differences between different buyer groups in these land auctions exist.

3 Data and Descriptive Statistics

The data set at hand covers all BVVG auctions from January 3, 2007 to July 17, 2015 for all eastern federal states of Germany. We exclude transactions where churches, municipalities, and others such as non-profit organizations were involved since these are uninformative for our questions (in sum, 455 transactions were excluded in this step), while tenders with only forest, recreation, and areas for natural reserve were already excluded by BVVG. From these remaining 12,250 transactions, we consider only competitive ones, that is, with at least two bidders. Excluding incomplete observations, BVVG identified outliers, and those with only minor holdings or building land (arable and grassland amounts to zero) provides the final sample with 9,781 observations that are rather uniformly distributed by the years (see table A1 in the appendix).

For each transaction the winning bid, the total number of bidders, the exact date of the auction, as well as the location, land characteristics (plot-specific) including a soil quality index[7], lot size, number of parcels, and type of usage are available. The average winning bid, that is, the average

[7] The soil quality index (points) refers to an official index in Germany constructed to unify pedologic, scientific, and (agro-)economic considerations within one measure for arable land ("Ackerzahl") and grassland ("Grünlandzahl"). These values range across Germany, where the lowest measured value is 7 and the highest ever measured value is 104. In our data set both are available, though to ease the analysis of mixed lots, we unify these measures into one and assign the shares of the respective land type on the total lot size as weights. The higher the index is, the higher is the quality of the land and the higher is the potential yield from using the land.

price of all plots gathered in one transaction, amounts to 1.18 Euros per square meter over the entire period. Transaction prices range from 0.03 to 9.51 Euros, which suggests a significant heterogeneity of the auctioned lots. Average size is about 8.34 hectares, with a maximum of 631.6 hectares (see table A2 in the appendix for descriptive information of transaction shares). The share of arable land ranges from zero to one, though with more than 50% at the mean. Most important for our research question (the analysis of bidder asymmetries) the data set contains bidder characteristics that allow us to differentiate by legal status, whether the buyer was a former tenant (not necessarily on the same plot) and whether a foreigner was involved in the buyer consortium. Tables 1-3 display descriptive statistics for these bidder groups.

Cooperatives win in 9% of the transactions considered, incorporated enterprises win in 22% of the transactions, and civil law associations together with single firms are victorious in 68% of the transactions. In terms of auctioned area, the relation changes slightly: corporations and cooperatives buy 34% of the land while single firms and partnerships buy 64%. Auctioned lots of legal entities are, on average, larger (9.498 versus 7.566 hectares) though they also involve a higher number of parcels. Interestingly, the number of bids is around 4 in both groups while the average distance is larger in the group of natural persons (see table 1).

Table 1: Summary Statistics of Winning Bids by Legal Status

Legal entities (2,916 transactions)

	Mean	Std. dev.	Skewness
Winning bid [Euros per m^2]	1.206	0.802	1.809
Number of bids per transaction	3.949	2.442	2.524
Distance buyer to plot [km]	24.814	82.851	4.788
Lot size [hectare]	9.498	20.779	13.278
Share arable land [0,1]	0.650	0.393	-0.720
Average soil quality index	42.200	16.506	1.179
Number of parcels	7.922	13.220	7.853

Natural persons and private partnerships (6,417 transactions)

	Mean	Std. dev.	Skewness
Winning bid [Euros per m^2]	1.168	0.853	1.851
Number of bids per transaction	4.017	2.451	2.344
Distance buyer to plot [km]	80.945	145.665	1.925
Lot size [ha]	7.566	19.769	19.069
Share arable land [0,1]	0.538	0.439	-0.214
Average soil quality index	41.470	15.694	1.135
Number of parcels	5.226	8.478	8.676

Source: BVVG 2007-2015.

Second, we consider differences between groups by using the information whether the buyer was former tenant of BVVG. Over the period studied, former tenants won 27% of the auctions, though not necessarily of the lot being auctioned. This sums up to a share of 30% of the auctioned land (table 2).

Table 2: Summary Statistics of Winning Bids by Tenant Status

Non-tenants (7,021 transactions)

	Mean	Std. dev.	Skewness
Winning bid [Euros per m^2]	1.201	0.873	1.870
Number of bids per transaction	4.062	2.513	2.399
Distance buyer to plot [km]	75.270	141.838	2.127
Lot size [hectare]	8.043	21.854	17.697
Share arable land [0,1]	0.553	0.437	-0.277
Average soil quality index	41.659	15.848	1.129
Number of parcels	5.469	9.340	10.919

Former tenants (2,663 transactions)

	Mean	Std. dev.	Skewness
Winning bid [Euros per m^2]	1.130	0.752	1.661
Number of bids per transaction	3.828	2.247	2.240
Distance buyer to plot [km]	30.915	88.875	3.378
Lot size [hectare]	9.108	19.769	14.222
Share arable land [0,1]	0.614	0.403	-0.566
Average soil quality index	41.718	16.017	1.201
Number of parcels	7.643	12.071	5.541

Source: BVVG 2007-2015.

Table 3 reveals that our sample contains 99 transactions with international bidders (1% of the cases and the land auctioned). Foreigners (or in participation) have, however, bought on average, larger lots, though also with a larger number of parcels at a comparable quality and a lower share of arable land compared to the other transactions. Potential asymmetries may in this case arise from differences in financial capacity, and potential constraints might be lower in the case of investors. As such, we would expect differences here, though the low number of observations by group might be a challenge.

Table 3: Summary Statistics of Winning Bids by Foreigner Involved

Foreigners involved (99 transactions)

	Mean	Std. dev.	Skewness
Winning bid [Euros per m^2]	1.080	0.642	5.392
Number of bids per transaction	3.263	1.882	2.293
Distance buyer to plot [km]	79.375[8]	85.170	0.215
Lot size [hectare]	15.105	28.695	6.430
Share arable land [0,1]	0.427	0.424	0.208
Average soil quality index	36.530	11.308	0.484
Number of parcels	8.232	20.741	8.162

National buyers (9,582 transactions)

	Mean	Std. dev.	Skewness
Winning bid [Euros per m^2]	1.183	0.844	1.766
Number of bids per transaction	4.005	2.449	2.378
Distance buyer to plot [km]	63.038	130.967	2.391
Lot size [hectare]	8.266	21.207	17.210
Share arable land [0,1]	0.572	0.429	-0.361
Average soil quality index	41.728	15.926	1.148
Number of parcels	6.044	10.043	8.429

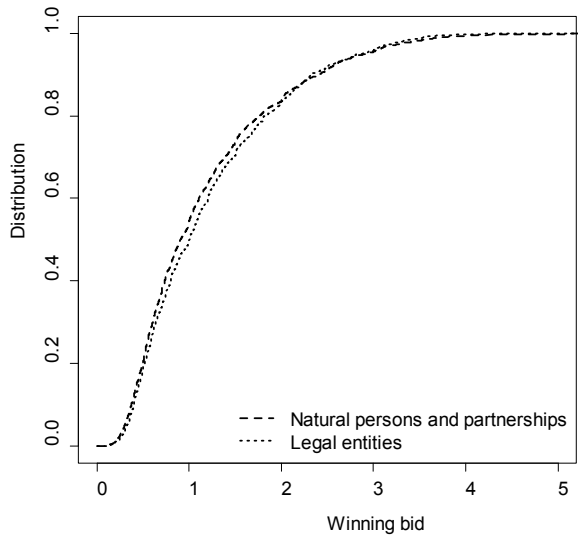
Source: BVVG 2007-2015.

To get a first impression of potential asymmetries among these bidder groups, we proceed in two steps: first, we compare the distributions of the winning bids and second, we test for differences in hedonic price regressions as suggested by Flambard and Perrigne (2006).

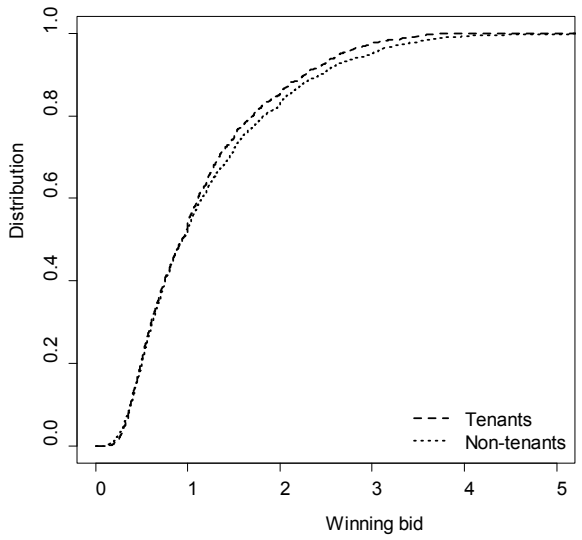
Inspecting the winning bid's cumulative density functions, in case of asymmetries one group should first-order stochastically dominate the other. That is, the strong bidders (e.g., advantages in the cost structure) are more likely to win the auctions and should dominate the weak bidders (e.g., cost disadvantages lead to lower returns from owning the land). In panel a) of figure 1, the CDF of the winning bids (given in Euros per square meter) suggests some range where legal entities dominate. Similarly, we investigate whether the CDFs of the winning bids differ if a former tenant was involved in the transaction (see panel b) of figure 1) and whether a foreigner participated (see panel c) of figure 1). While nearly no difference can be observed in the lower range of the observed bids between tenants and non-tenants, in the upper range non-tenants seem to dominate. Comparing transactions where domestic bidders win with those where foreigners were part of the winning consortium, in the lower ranges no differences are visible, while in the upper range some dominance by domestic buyers could be observed. This contradicts the often-stated apprehension that foreign investors price farmers out of the market. However, given the heterogeneity of the tendered land plots and the considerable price impact of land characteristics, differences among bid distributions must be interpreted with caution.

[8] This information is only available for 5 transactions.

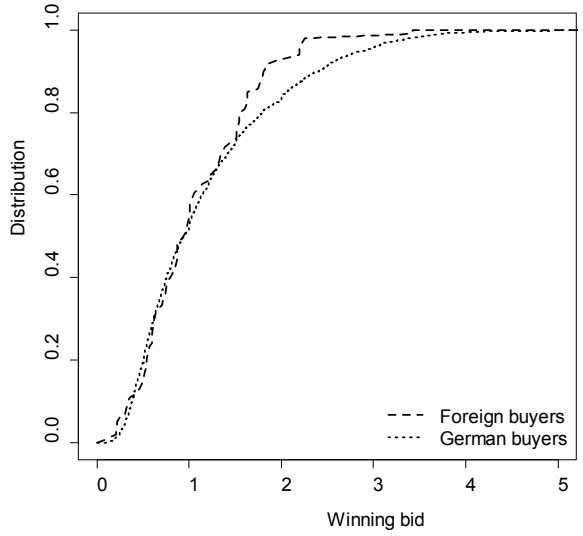
Figure 1: Cumulative distribution functions (CDF) of the winning bids in €/m² by a) legal form, b) tenancy status and c) foreigner participation



a) Legal form



b) Tenancy status



c) Foreigner participation

In a second step, we regress the log of winning bids on plot and auction characteristics, that is, lot size, soil quality, distance lot-buyer, number of bidders, and number of parcels, and include time dummy variables. We run these regressions separately for each bidder type except the distinction by foreigner participation because of the low number of observations. A Chow test reveals that the estimated coefficients for number of bids, distance, and soil quality, as well as dummy variables for 2007, 2012, 2013, and 2015 differ significantly by natural persons and legal entities. This finding indicates that the valuation of land attributes differs among legal forms. Quality and dummy variables for 2008, 2013, and 2014 also differ when distinguishing between former tenants and non-tenants. To verify these initial findings we proceed with investigating potential asymmetries using a structural approach for asymmetric bidder structures in first-price auctions.

4 Independent Private Values Auction Model with Asymmetric Bidders

In this paper, we make use of the independent private value (IPV) paradigm. In the case of the land market under study, the valuation of land can be assumed to be private for each bidder. Private land values can be justified because bidders' expected development of future income streams, either from using or renting out the land, depends on expected returns from farming but also on individual knowledge, ability, their overall net income flow, wealth status, as well as their time and risk preferences, which are all based on private information. This also holds for potential cost of not winning the auction that also remain private. In the case of renting out the land as potentially targeted by investors, the information on expected returns also depends on potential tenants' behavior, in particular on their expectations, both of which remains private for the bidders. In contrast, a common value might exist because the real net present value of the land investment remains unobserved and land can be sold after the auction.[9] Land investments are, however, typically long-term investments with the intention to store and increase either wealth or a production base, and less likely with the intention to re-sell it. This argument is supported by the low overall mobility of farmland in Germany, where 0.7% of the total utilized agricultural area was transacted in 2015 (Destatis 2015). In addition, even though BVVG publishes the results of the auctions, the valuation can be argued to be private and independent because forming the bid is based on expected future returns of the land investment, and publishing might ease market entry and hence lead to increased competition, while information on how to estimate the returns will remain private.

In the independent private values' setting, n bidders are assumed to be risk-neutral and compete for a plot of land with the goal to maximize utility, denoted by $U_i = U(v_i)$. This function is assumed to increase in v_i, denoting bidder i's private information. Under independent private values, environment uncertainty arises from the fact that the value for competing bidders is unknown. That is, the other bidders' valuation remains uninformative for the bidder (e.g., Perrigne and Vuong 1999) and utility reduces to $U_i = v_i$. Each bidder is assumed to have an individual expectation of the value of the land, V, which can be interpreted as the present value of future returns from utilizing the land, or renting it out as would be the case for investors. The exact present value is typically unknown and hence V is modelled as a random variable, with realizations v_i reflecting the valuations of the bidders. That is, bidders draw their private values independently from the common distribution function that reduces to n dimensions in $F_V(v)$ and density $f_V(v)$. For further details we refer to Milgrom and Weber (1982).

The bidders are further assumed to estimate the relationship between their bid and the probability of winning the auction, and to behave incentive-compatible (bidder rationality). Since BVVG proceeds upon a non-binding reserve price, it follows that $p_0 = \underline{v}$, where $\underline{v}$ denotes the lower bound of the distribution domain.

Following the idea of incomplete information games under bidder symmetry, that is, *ex ante*, the bidders are identical and the equilibrium of the symmetric game will be restricted to be symmetric as well. That is, each bidder uses the *same* strategy $\sigma(\cdot)$ that maps each private value to the bid s_i

[9] The common value environment is the other extreme in the auction literature to the independent private values framework. Under pure common values, the value of the auctioned item is the same for all bidders, though unknown to the bidder. Given the arguments presented in the text, a clear distinction in the land markets context is difficult and we cannot rule out that land markets might obey a common component or affiliated values. We argue that a common component would be more relevant if the intention to re-sell the land would be more pronounced in land markets, and as such continue using the IPV model.

directly returned from $\sigma(v_i)$. We define random variable S with its realization s_i representing the bid. Since strategy $\sigma(\cdot)$ returns a bid and depends on the private value v_i, it follows that its inverse maps from the space of bids into the values such that $v_i = \sigma^{-1}(s_i)$. For $n \geq 2$, at the Bayesian Nash equilibrium each bidder chooses her bid to maximize expected profits with the equilibrium strategy as a unique solution of the following first-order differential equation:[10]

$$1 = [v_i - \sigma(v_i)](n-1)\frac{f_V(v_i)}{F_V(v_i)}\frac{1}{\sigma'(v_i)} \tag{1}$$

subject to the boundary condition $\sigma(\underline{v}) = \underline{v}$ and the solution is given by

$$s_i = \sigma(v_i, F_V, n) \equiv v_i - \frac{1}{[F_V(v_i)]^{n-1}}\int_{\underline{v}}^{v_i}[F_V(u)]^{n-1}\,du. \tag{2}$$

While the symmetry assumption seems to constitute a reasonable starting point, we argue that the competitors among land within BVVG auctions are not *ex ante* identical per se. As indicated by the empirical assessment of the data set, we thus follow upon a more general model setup that allows us to acknowledge the asymmetries among bidders. Symbol n_j now denotes the number of potential bidders by type, with $j = 0{,}1$ indicating the respective bidder group with $n = n_0 + n_1$.

Following the notation of Perrigne and Vuong (1999), group 1 could be better informed regarding usage possibilities of the land compared to subgroup 0 denoting all other bidders. Bidders of type 1 draw independently from their private values distribution $F_1(\cdot)$ and bidders of type 0 from their distribution $F_0(\cdot)$ with $\boldsymbol{F}(\cdot,\ldots,\cdot) = F_1^{n_1}(\cdot)F_0^{n_0}(\cdot)$.

It is assumed that these distributions are common knowledge with a common support $[\underline{v}, \bar{v}]$. The equilibrium strategies $\sigma_1(\cdot)$ and $\sigma_0(\cdot)$, respectively, are given by the following differential equations:

$$\begin{aligned}
\sigma_1'(v_{1i}) &= (v_{1i} - s_{1i})\left[(n_1 - 1)\frac{f_1(v_{1i})}{F_1(v_{1i})} + n_0\frac{f_0(\sigma_0^{-1}(s_{1i}))}{F_0(\sigma_0^{-1}(s_{1i}))}\frac{\sigma_1'(v_{1i})}{\sigma_0'(\sigma_0^{-1}(s_{1i}))}\right] \\
\sigma_0'(v_{0i}) &= (v_{0i} - s_{0i})\left[(n_0 - 1)\frac{f_0(v_{0i})}{F_0(v_{0i})} + n_1\frac{f_1(\sigma_0^{-1}(s_{0i}))}{F_1(\sigma_1^{-1}(s_{0i}))}\frac{\sigma_0'(v_{0i})}{\sigma_1'(\sigma_1^{-1}(s_{0i}))}\right]
\end{aligned} \tag{3}$$

subject to boundary conditions $\sigma_1(\underline{v}) = \sigma_0(\underline{v}) = \underline{v}$ and $\sigma_1(\bar{v}) = \sigma_0(\bar{v})$. For existence and uniqueness of the equilibrium, we refer to Maskin and Riley (2000).

Note that this system of differential equations is complex and intractable for simulation-based empirical investigation. Thus, we follow the indirect structural empirical approach introduced by Guerre, Perrigne, and Vuong (2000), which relies on non-parametric estimation techniques. Applying this empirical approach has the advantage that the equilibrium strategy does not need to be computed.

[10] For all these steps we refer to Krishna (2009).

5 Empirical Strategy: Structural Analysis of Land Auction Data

In what follows, we first present the idea of non-parametric identification, followed by the estimation procedure.

5.1 Non-Parametric Identification of the Asymmetric IPV Model

Identification in the estimation of auction models can be reduced to the question of whether, for a given equilibrium, a bijective relationship exists between the unobserved distributions of the bidders' valuations and the observed bids exists (Hendricks and Porter 2007). That is, the question is whether $F_1(\cdot)$, $F_0(\cdot)$, n_0 and n_1 can be identified from the observed bids and the number of actual bidders. The core assumption upon which non-parametric identification relies is that the observed winning bids are assumed to be the equilibrium bids, and the number of potential bidders is equal to the number of actual bidders.

Guerre, Perrigne, and Vuong (2000) provide the basic insight that bidders' latent valuations can be expressed as a function of the bids and the joint distribution of competing bidders. Define $G(s_i) = F\left(\sigma_0^{-1}(s_i)\right) = F(v_i)$ as the equilibrium distribution of the bids and $g(s_i)$ as the corresponding density, then substituting into the differential equation (3) yields

$$\begin{aligned} v_{1i} &= \xi_1(s_i) \equiv s_{1i} + \frac{1}{(n_1 - 1)\, g_1(s_{1i})/G_1(s_{1i}) + n_0\, g_0(s_{1i})/G_0(s_{1i})} \\ v_{0i} &= \xi_0(s_i) \equiv s_{0i} + \frac{1}{n_1\, g_1(s_{0i})/G_1(s_{0i}) + (n_0 - 1)\, g_0(s_{0i})/G_0(s_{0i})}. \end{aligned} \tag{4}$$

Herein, ξ_1 and ξ_0 are the inverse bid functions that map bids into values. Since bids, bid distribution, bid densities, the number and the identity of bidders are observable, equation (4) enables the identification of latent private values**.** In fact, Laffont and Vuong (1996) show that the asymmetric IPV model is identified if the functions $\xi_1(s_i)$ and $\xi_0(s_i)$ are strictly increasing in the bids (s_i). The intuition is that $F(\cdot)$ is identified from $G(\cdot)$ since observed bids are linked to private values by a strictly increasing equilibrium strategy.

(Athey and Haile 2002, 2116) assert that identifying the asymmetric IPV model is even possible from a single bid as long as the identity of the bidder is observed in first-price auctions. Since we observe the transaction price as well as the legal form of the winning bidder, his status as former tenant and his origin, our data set provides sufficient information to empirically identify the auction model and to assess potential asymmetries among bidder groups.

5.2 Estimation procedure

The nonparametric approach proposed by Guerre, Perrigne, and Vuong (2000), hereafter denoted by GPV, evaluates the sample analog of equation (4). The estimation proceeds in two steps: First, estimate the distributions $G(\cdot)$ and densities $g(\cdot)$ non-parametrically using kernel estimation. Second, based on equation (4) calculate pseudo valuations $\hat{v}_i$ and estimate the empirical distributions $\hat{F}(v)$ from these pseudo values. This approach, though data-intensive, exhibits two main advantages: it is computationally simple as no explicit expression of the optimal bid function

is required. Moreover, it avoids parametric assumptions about F, which is convenient because theory offers little guidance on the functional form of the distributions of the valuations. In our application we have to take into account three peculiarities which require some modifications of the aforementioned procedure, namely missing information of the composition of bidders types in an individual auction, incomplete bid data, and heterogeneity of the sold land plots. In what follows, we discuss how we deal with these issues.

Tables 1-3 reveal that the auctioned land plots are rather heterogeneous. Quality, size, and usage of the land (e.g., arable land or grassland) not only systematically differ by auction and group, though these strongly determine the usage possibilities and hence the productivity from the land and thus shape the bid. As shown by Athey and Haile (2002, 2117), the model is still identified and the GPV-approach can be extended to acknowledge each auction item to have different characteristics. To remove object heterogeneity, we follow (Athey and Haile 2007) and assume an additive structure of valuations

$$V_{it} = \Gamma(z_t) + a_{it} \tag{5}$$

where z_t denotes the observed attributes of the auction t, $\Gamma(\cdot)$ is a function to be estimated and a_{it} are bidder-specific private values. Haile, Hong, and Shum demonstrate that additive separability is preserved in equilibrium. This allows us to control for the effect of covariates by running a regression in the sense of a hedonic approach of observed bids as

$$s_{it} = \gamma + \Gamma(z_t) + \epsilon_{it} \tag{6}$$

with constant term γ and error term ϵ_{it}. Here, we use a linear function $\Gamma(\cdot)$. With estimates $\hat{\Gamma}(z_t)$ at hand, homogenized bids s^h can be calculated as follows:

$$s_{it}^h = s_{it} - \hat{\Gamma}(z_t - \bar{z}) \tag{7}$$

where $\bar{z}$ is the mean of all plot characteristics over all auction cases. That is, homogenized bids refer to a fictive land plot with average values of attributes. Homogenized bids replace actual bids in all subsequent estimation steps.

Calculations of valuations via equation (4) requires information on the composition of bidder groups in an auction, that is, the number of potential bidders in each group n_0 and n_1. Moreover, a sufficiently large number of auctions with the same absolute number of bidders is needed for a reliable nonparametric estimation of the bid distributions and densities. As Tables 1 through 3 document, the number of bidders, and thus competitive pressure, varies considerably around an average value of about 4. We account for this in a way similar to the heterogeneity of land characteristics. That is, we include the number of bids in the hedonic regression equation (7) and calculate homogenized bids for an auction with an average number of bids, that is, 4. Then we impose the simplifying assumption that the relative size of bidder groups is the same for all auctions, and estimate the relative size by the share of won auctions. After rounding this leads to $n_0 = 3$ for the group of natural persons, non-tenants and domestic buyers, respectively, while $n_1 = 1$ for legal entities, former tenants, and foreign buyers, respectively.

Though all bids are observable in a first-price auction, only the winning bids w_j are available in our data set. Fortunately, Paarsch (1989) shows that even though $\sigma_j(v_i)$ is nonlinear in v_i, it is possible to identify value distributions $F_V^j(v_i)$ with its density $f_v^j(v_i)$ from winning bids w_j. Estimators for the distribution of winning bids, $G_W^j(w_j)$, and density $g_W^j(w_j)$, respectively, for both bidder groups are obtained by

$$\hat{G}_W^j(w_j) = \frac{1}{T_j}\sum_{t=1}^{T_j} 1\left(W_{jt} \leq w_j\right) \tag{8}$$

and

$$\hat{g}_W^j(w_j) = \frac{1}{T_j}\sum_{t=1}^{T_j} \frac{1}{h} k\left(\frac{W_{jt} - w_j}{h}\right) \tag{9}$$

with T_j as the number of auctions, h denotes the bandwidth parameter and k the kernel function. We use Epanechnikov kernels as these provide compact support. Optimal bandwidth selection is performed via cross-validation following Guidoum (2015); these are shown in table A4 in the appendix.

The estimates of the distributions and densities of winning bids are then used to generate estimates of maximal valuations, $\hat{V}_{max}$ via equation (4). With these pseudo values at hand, we can estimate the distribution of highest valuations denoted by Y as follows:

$$\hat{F}_Y^j(y_i) = \frac{1}{T_j}\sum_{t=1}^{T_j} 1\left(\hat{V}_{\max_t} \leq y_i\right). \tag{10}$$

Finally, the bidder group-specific distributions of values are calculated as (Paarsch and Hong 2006, 104):

$$\hat{F}_V^j(v_i) = \hat{F}_Y^j(v_i)^{\frac{1}{n}} = \frac{1}{T_j}\sum_{t=1}^{T_j} 1\left(\hat{V}_{\max_t} \leq v_i\right)^{\frac{1}{n}}. \tag{11}$$

In order to obtain an estimate of the empirical probability density function of v, we use numerically pointwise consistent gradients of $\hat{F}_V^j(v_i)$. The probability density of Y is then estimated by

$$\hat{f}_Y^j(y_i) = \frac{1}{T_j}\sum_{t=1}^{T_j} \frac{1}{h} k\left(\frac{y_i - \hat{V}_{\max_t}}{h}\right) 1\left(W_{min} + h \leq W_{jt} \leq W_{max} - h\right) \tag{12}$$

where W_{min} and W_{max} denote the lowest and highest observations of winning bids across t. From $\hat{f}_Y^j(y_i)$, the estimation of the probability density of values is given by

$$\hat{f}_V^j(v_i) = \frac{1}{n}\hat{F}_Y^j(v_i)^{\frac{1}{n}-1}\hat{f}_Y^j(v_i). \tag{13}$$

These calculations are carried out for each pair of bidder groups, that is, legal versus natural persons, tenants versus non-tenants, and German versus foreign buyers. We finally compare the densities by buyer groups and test whether different bidder groups have different distributions of their valuations by pairwise two-sample Kolmogorov-Smirnov-tests (e.g., Marsaglia, Tsang, and Wang 2003; Chernomaz and Yoshimoto 2017).

6 Results

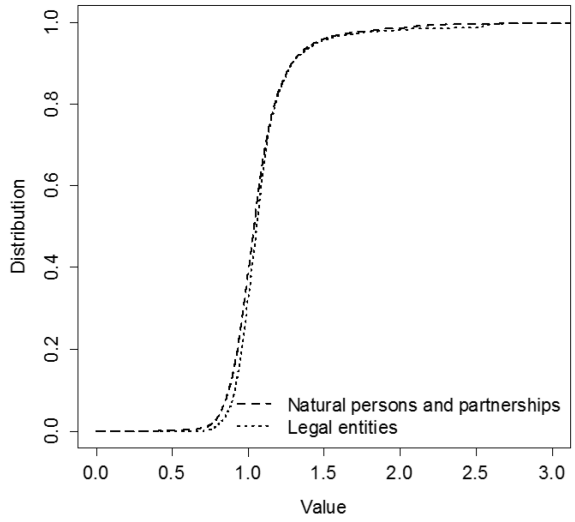
Before we turn to the final results of the SEAD model, that is, the bidder-specific distributions of land valuations, we present the results of the hedonic regression that are used to remove heterogeneity in the tendered land plots according to equation (6). The R^2 of 0.919 documents that only little variability remains in the adjusted, homogenized bids (table A3). Moreover, the signs of the estimated coefficients are plausible and in line with other empirical studies about the impact of land attributes on land prices. As expected, land quality, the share of arable land, and plot size have a positive effect on the transaction price, while the number of plots have a negative impact. The year dummies reflect the steady increase of the general land price level observed in Germany between 2008 and 2015. The positive coefficient of the number of bidders confirms theoretical predictions for the IPV auction model.

The estimated value distributions $\hat{F}_V^j(v_i)$ for each pair of the buyer groups are depicted in figure 2, while the summary statistics of the pseudo-values (table A5), their density plots (figure A1), as well as the CDFs of homogeneous winning bids (figure A2) are presented in the appendix. Comparing the distributions of winning bids (figure 1) and the distributions of the homogenized winning bids (figure A2) visualizes the effect of the bid adjustment (equation 7). The CDFs of homogenized bids are steeper and show less variability since they refer to a hypothetical land plot with average values of attributes. Moreover, contrasting the CDFs of homogenized winning bids and bidders' valuations shows that the latter is dominated by the former, which is due to bid shading (eq. (4)).[11]

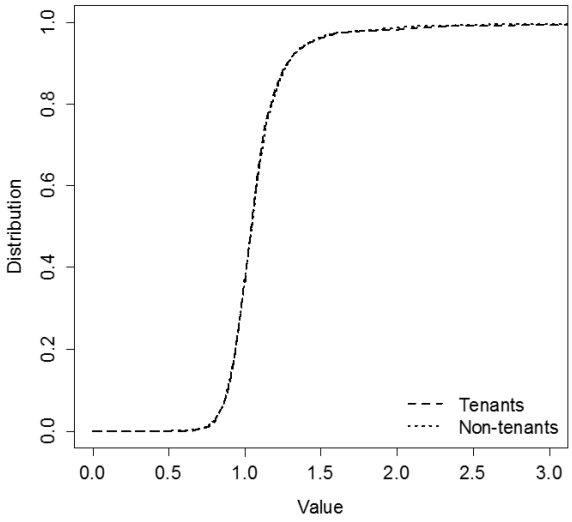
Turning to the bidder asymmetries with regard to the legal form of bidders, figure 2a shows that the value distribution of legal entities slightly dominates that one of natural persons over a large range of values. A two-sample Kolmogorov-Smirnov test confirms that the value distributions differ significantly at any level (p-value: 0.0000). The difference between the means of the CDFs, however, is rather small and amounts to 300 Euros per hectare, that is, a mark-up of about 2.6%. This finding may indicate that legal entities in eastern Germany yield higher marginal returns from utilizing land compared to natural persons. Higher returns may stem from benefits from size (economies of scale) since cooperatives are, on average, considerably larger than private (mainly family) farms. In 2014/15, the average size of legal entities was about 1,125 ha in eastern Germany while private farms classified as larger according to the Federal Ministry's statistic used an average of 178 ha (Germany). Moreover, legal entities may face lower financial restrictions, which might also relate to the opportunities of investors' participation. Particularly the legal form of a cooperative or corporate may offer such opportunities for investors. However, single farms and private persons' partnerships draw from distributions with slightly lower valuations, and this group wins 74% of the auctions (64% of the auctioned land). Comparing homogenized winning bids and values for both groups reveals that natural persons bid a bit more aggressively, on average: the discount on valuations amounts to 1.3% compared with 0.9% for legal entities.

[11] The difference between winning bids and values appears rather small (about 1%). Note that bid shading is more pronounced since it refers to optimal bids, which are smaller than winning bids.

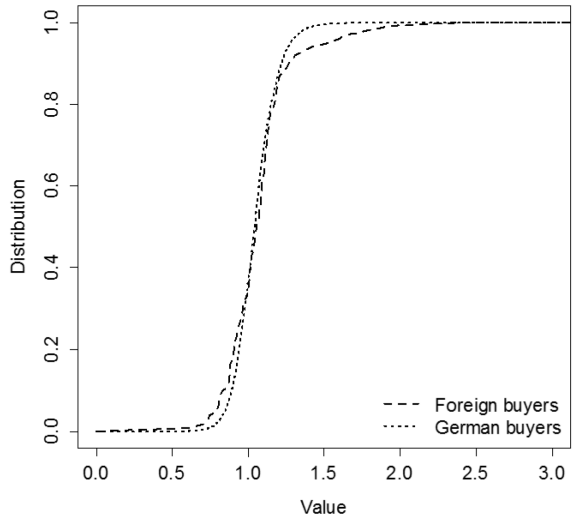
Figure 2: CDF of valuations in €/m²
by a) legal form, b) tenancy status and c) foreigner participation



a) Legal form



b) Tenancy status



c) Foreigners involved

The distribution functions of valuations for former tenants and non-tenants displayed in figure 2b reveal that apart from the very left tail, both CDFs are strikingly similar. In fact, the p-value of two-sample Kolmogorov-Smirnov-test is 0.406, that is, we cannot reject the null that both distributions are identical. Accordingly, tenants and non-tenants seem to have the same valuation of land, where former tenants win in 28% of the cases (30% of the auctioned land in hectares). However, some caution is needed here. First, the groups of tenants and non-tenants are heterogeneous and can interfere with the classification according to legal form and farm size. Thus, asymmetries related to different causes may offset each other. Second, potential informational advantages of former tenants might be concealed in our analysis by removing land plot heterogeneity. Better-informed tenants will submit higher (lower) bids for plots that are undervalued (overvalued) by non-informed bidders. Our analysis cannot identify these effects since the “true” land value is unobserved.

Finally, we analyze whether bidders groups with foreign participation have a different valuation of land compared with domestic bidders. Figure 2c reveals that the often alleged dominance of foreign (financial) investors is not supported by our results. It even appears that domestic bidders assign higher values to land than foreign bidders below the 70% quantile. However, this deviation is not significant (p-value of K-S test: 0.362), a finding which can be attributed in part to the low number of auctions where foreigners are involved (99 cases). The result that domestic and foreign bidders' private values are drawn from the same distribution does not necessarily imply that both groups face identical decision problems. It could also mean that potential advantages and disadvantages associated with a particular bidder type offset each other. On the one hand, foreign investors may have a lower cost of capital, and benefit from risk diversification by including land into their financial portfolios. On the other hand, since foreign investors typically rent out acquired land to local farmers, returns from farming must pay off the investor as well as the operating farmer. In contrast, land rents need not to be shared if operating farmers acquire land, which may lead to a higher valuation by this bidder group. In any case, it is difficult to attribute specific (dis)advantages in costs and returns of using land clearly to the considered bidder groups because their composition is diverse. For example, domestic bidders do not represent solely farmer-owners, but can also involve financial investors.

7 Concluding Remarks

This study was motivated by the question of whether auctions facilitate policy goals such as a "sound" distribution of land property rights, a prevention of dominant market positions, and a diversity of legal forms, ownership, and production systems. The current debate across Europe and beyond questions that land markets, and in particular auctions, can cope with these issues in a satisfactory way and proposes tightening market regulations. Most prominently discussed is restricted market access for agents treating land as an investment asset without farming interests, so-called non-agricultural or financial investors. Likewise, privileged access to land markets has been proposed for small family farms, particularly younger farmers. Using a unique and representative data set, we empirically analyze the outcomes of agricultural land auctions in eastern Germany and investigate the behavior and the performance of specific bidder groups, which we differentiate regarding their legal status, their tenancy status, and their nationality. We apply a structural econometric auction model to estimate the distribution of latent land values for these bidder groups, and to test for differences in their land valuations between bidder groups. Value distributions are derived from the Bayes-Nash equilibrium rationale and can be estimated using nonparametric techniques.

Though earlier studies report that higher transaction prices for agricultural land are realized in auctions compared with search markets, we cannot find empirical evidence for the claim that this market type discriminates against certain buyer groups in the sense that they are forced out of the market or dominated by other bidder types. The 9,781 BVVG land auctions that we analyze are won by a diversity of legal forms, by former tenants, as well as non-tenants. Only a small fraction of tendered land plots has been sold to foreign bidders. The successful acquisition of land by bidders who are not former tenants documents that this group is able to compete with former tenants in the market, and that the prevalent property situation is not locked in. Legal entities win about 30% of the tendered plots, which may appear large in relation to the total number of farms in Eastern Germany. This share, however, is rather low in relation to farm size. The distributions of winning bids, after controlling for heterogeneity in land amenities, are quite similar for all pairs of

bidder types. Also, the underlying distributions of land valuations, from which bids are derived, do not show pronounced differences. This is particularly true when distinguishing between former tenants and non-tenants, as well as between foreign and domestic bidders. We conclude that foreign investors do not have a different valuation of land than other participants in the agricultural land market, despite a different utilization of this asset. In other words, their expectations about potential returns from investing in land are similar to other bidders. Thus, in our empirical context, foreign investors can hardly be blamed for driving up land prices. Increasing land prices are rather the result of fierce competition among all bidder groups, including operating farmers and domestic investors. Statistically significant differences in the valuation of land can only be identified if bidders are classified into natural persons and legal entities. Higher private values of land for legal entities most likely reflect the economic strength of large-scale farms compared to small-scale farms, which has already been pointed out by other studies (e.g., Bojnec and Fertő 2013; Woodhouse 2010; Hansson 2008; Lissitsa and Odening 2005). In this regard the advantage of non-fragmented land-use was found to be particularly relevant (e.g., Latruffe and Piet 2014; Curtiss et al. 2013). Nonetheless, ascertained differences in the valuation of land between natural persons and legal entities remain modest. From this, we conclude that these differences will not entail allocative land market inefficiencies.

Our results are relevant for the current policy debate on land market regulations. First at all, the concerns among policy makers in many EU Member States about whether the acquisition of land by non-locals and non-farmer crowds farmers out of land markets fosters ownership concentration and reduces variety of the farming structure is not supported by our findings. An apparent implication is that a tightening of existing market regulations can hardly be justified, at least for the considered land market. While many concerns about the land acquisition by large holdings or foreign investors are based on case studies or anecdotal evidence, our empirical study refers to a comprehensive data set that covers a major segment of the agricultural land market in eastern Germany. Our analysis does not reveal economic reasons for not using auctions as an instrument for selling or privatizing land. Thus, proposed policy interventions into land markets can only be justified by political arguments that go beyond economic efficiency, such as social preferences for certain farm types.

From a methodological perspective, this study contributes to the understanding of price formation in land auctions. The micro-structural approach offers the advantage of analyzing the distribution of latent valuations behind observed bidding behavior and investigating potential asymmetries among bidder groups. Identification of the model, however, relies on the independent private value paradigm. While we provide arguments for the plausibility of this assumption, a more formal testing of this assumption against the alternative of common values would be desirable. Regarding the validity of the implications of our empirical results, we have to acknowledge that we consider only one segment of the German land market. For example, land is also auctioned by other state-owned land trusts than BVVG. These land trusts offer preferential conditions for local farmers and former tenants and it cannot be ruled out that certain bidder types select themselves into particular auction formats. Moreover, land acquisition not only takes place on land markets but also through shared deals of agricultural cooperatives. This kind of transaction, which we disregard in our analysis, is typically linked with financial investors. Finally, the extent to which our empirical findings apply to agricultural land markets in other regions with different institutional settings and regulatory frameworks is an empirical question that we propose for further research.

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8 Appendix

8.1 Details on the Land Auction Data

Table A1: Number of Observations per Year

Year	Number of auctions
2007	754
2008	903
2009	1,292
2010	1,188
2011	1,269
2012	1,136
2013	1,354
2014	1,314
2015	571
Total	9,781

Source: BVVG 2007-2015.

Table A2: Transaction Shares by Group

Group	**Purged data**		**Raw data**	
	Share on total by auction	**Share on total by transacted hectares**	**Share on total by auction**	**Share on total by transacted hectares**
Legal entities	31.22%	36.30%	30.08%	34.28%
Naturals	68.78%	63.70%	66.28%	60.16%
Non-tenants	72.52%	69.97%	72.52%	69.97%
Tenants	27.48%	30.03%	27.48%	30.03%
German buyers	98.98%	98.15%	98.98%	98.15%
Foreign buyers	1.02%	1.85%	1.02%	1.85%

Source: BVVG 2007-2015.
Note: Fractions of raw data may not necessarily sum up to one, as “total” in this instance includes cases of missing values, cases with only one bidder, and so on.

8.2 Additional Results

Table A3: Hedonic Regression of Winning Bids, cf. Equation (6)

	Estimated coefficient (Std. Error)
Number of bids	0.021***
	(0.001)
Lot characteristics	
Lot size [hectare]	0.000***
	(0.000)
Average soil quality index	0.006***
	(0.000)
Number of parcels	-0.002***
	(0.000)
Share arable land [0,1]	0.328***
	(0.006)
Dummy variables for year	
2007	-0.056***
	(0.011)
2008	0.020
	(0.010)
2009	0.074***
	(0.009)
2010	0.123***
	(0.010)
2011	0.192***
	(0.009)
2012	0.231***
	(0.010)
2013	0.279***
	(0.010)
2014	0.329***
	(0.009)
2015	0.448***
	(0.012)

Note: Dependent variable: log winning bids; $R^2 = 0.919$.
Asterisks *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table A4: Bandwidth Parameter by Group

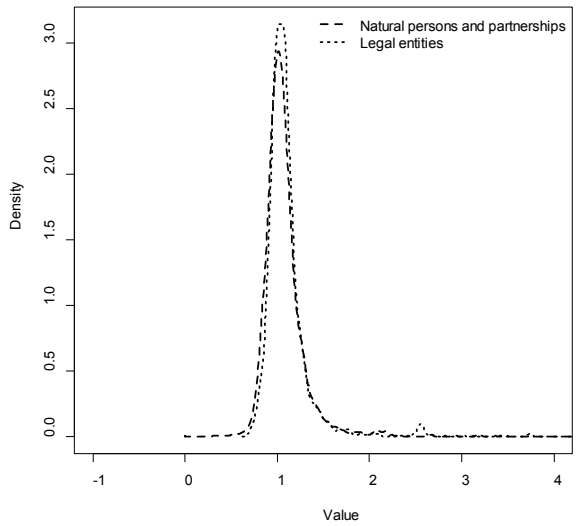
Group	Bandwidth
Legal entities	0.156
Naturals	0.180
Non-tenants	0.141
Tenants	0.175
German buyers	0.187
Foreign buyers	0.402

Table A5: Summary Statistics of Homogenized Bids and Estimated Values by Group

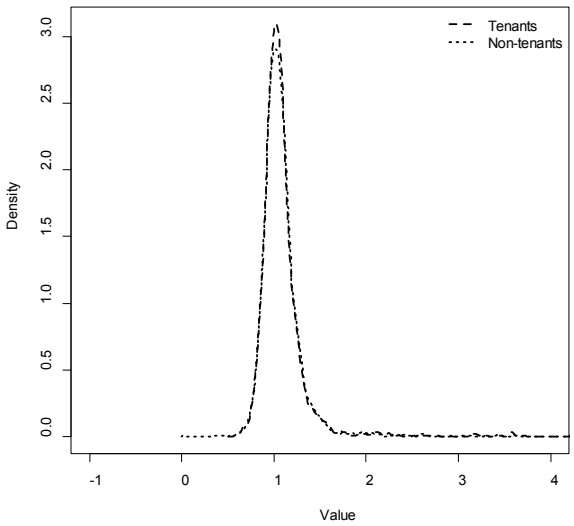
Group	Value	Mean	Median	Mode	Std. dev.
Legal entities	Homgeneous Winning Bid	1.098	1.042	0.864	0.428
	Estimated *v*	1.108	1.055	1.051	0.305
Natural persons and partnerships	Homgeneous Winning Bid	1.065	0.971	0.848	0.605
	Estimated *v*	1.079	1.037	1.013	0.263
Non-tenants	Homgeneous Winning Bid	1.094	1.001	0.995	0.607
	Estimated *v*	1.086	1.043	1.018	0.277
Tenants	Homgeneous Winning Bid	1.037	0.974	0.868	0.450
	Estimated *v*	1.091	1.040	1.024	0.311
German buyers	Homgeneous Winning Bid	1.080	1.055	0.792	0.305
	Estimated *v*	1.100	1.082	1.079	0.188
Foreign buyers	Homgeneous Winning Bid	1.004	0.998	1.129	0.478
	Estimated *v*	1.062	1.061	1.092	0.202

Source: BVVG 2007-2015.

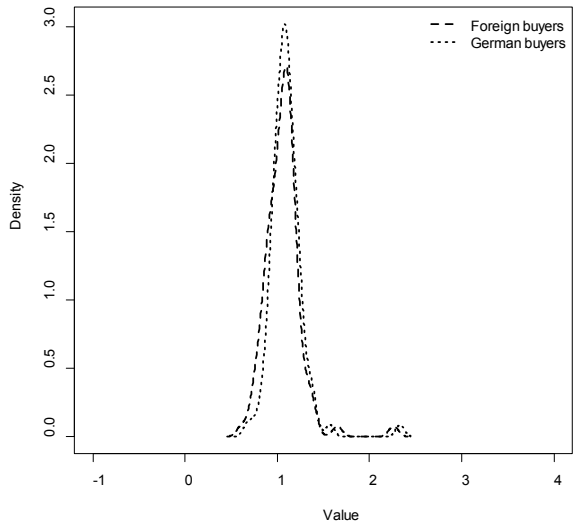
Figure A1: Densities of estimated pseudo-values by a) legal form, b) tenancy status and c) foreigner participation



a) Legal form

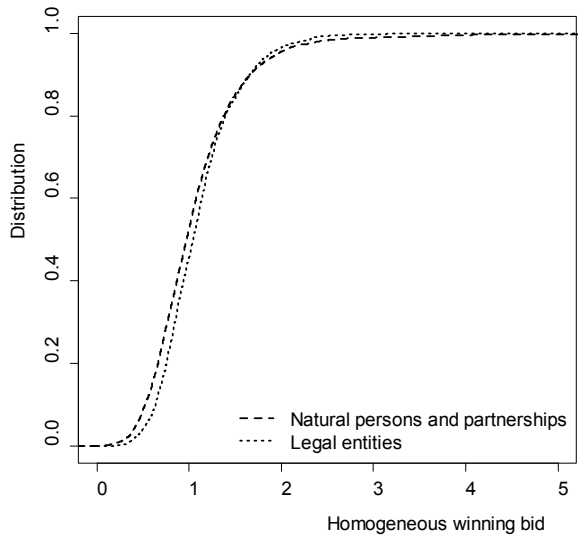


b) Tenancy status

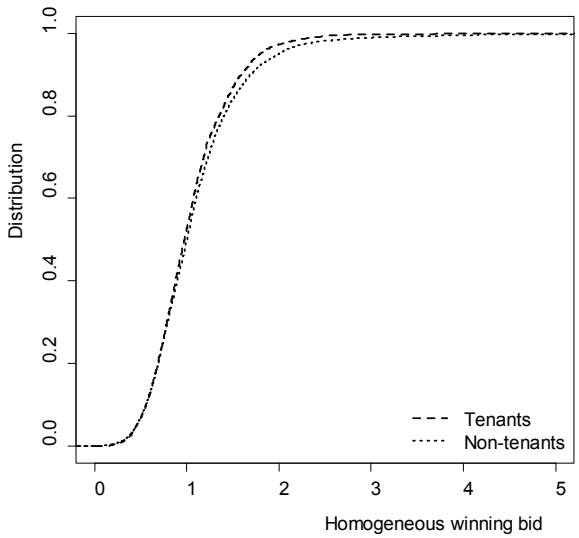


c) Foreigners involved

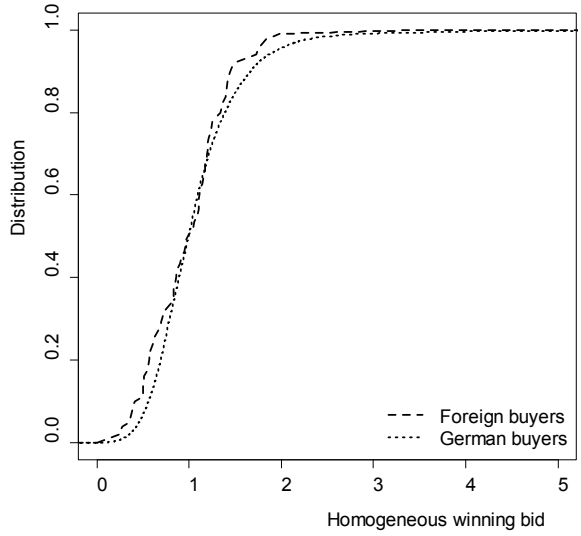
Figure A2: Cumulative distribution functions of the homogeneous winning bids in €/m² by a) legal form, b) tenancy status, and c) foreigner participation



a) By legal form



b) By tenancy status



c) By foreigner participation