On the price effect of a right-of-first-refusal in farmland auctions

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Abstract

Current European Union legislation offers public authorities to grant a right of first refusal (RFR) in farmland auctions with public tenders in favour of the current tenant. That is, tenants can purchase the auctioned lot by matching the highest bid. Granting this right secures tenants to buy the land they use; however, it may deter other potential buyers' auction participation and incentivise bidders to adjust their strategies. A RFR for tenants is thus hypothesised to decrease the number of bidders and lower sales prices. Empirical evidence seems lacking thus far; in this paper, we target at closing this gap by analysing a tenants' RFR effect on the number of bidders and winning bids in first-price privatization auctions in eastern Germany. Using around 4,000 land auction results in one German Federal State over 2007-2018 by two agencies that differ in granting the RFR to tenants, we combine non-parametric nearest neighbour matching based on the Mahalanobis distance with parametric post-matching regressions. Our results indicate that the RFR reduces competition by an average 8.3% bidders per auction and lowers the prices paid in land auctions by 16.7 %.

Keywords: *right-of-first-refusal; land auctions; farmland pricing; privatisation*

JEL classifications: *Q15, D44, C21.*

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1 Introduction

In the European Union, farmland market regulation must not conflict with free movement of capital, and current legislation offers support of local farmers. Among others, public agencies privatising farmland can grant a right of first refusal (RFR) for current tenants (Ciaian *et al.*, 2017). Granting the RFR to tenants gives them as right holders the possibility to purchase the land under tenancy at the highest bid the seller is able to get from another buyer without actively participating in the price discovery process. This right thus offers tenants as local farmers to buy land, and not to lose their operating base by the privatisation process. Granting such a right is positively perceived among the group of farmers (Galletto, 2018), especially for tenants. In contrast, the right limits the chances to win the auctions by other farmers or buyers, for instance, start-up farming businesses or young farmers, and could hamper expansion possibilities. All potential non-right holders' auction participation could even be deterred (Kahan *et al.*, 2012). Thus, granting a RFR to tenants is hypothesised to decrease the competition in land auctions, resulting in lower sales prices. The RFR can also incentivise all auction participants to adjust their bidding strategies: Since the right holder has no incentive to submit a competitive bid, non-right holders must bid against the anticipated valuation of the right holder (Brisset *et al.*, 2020). In either case, the seller might suffer from losses compared to non-granting the right because of the missing competitive bid of the right holder in the price discovery process.

This begs the questions how effective is granting RFRs for tenants in land privatization auctions with public tenders to support local farmers, and at which public cost local farmers as tenants are supported. To our knowledge, thus far no study exists that empirically investigates this question based on auction data. Experimental studies suggest for instance, that non-right holding bidders bid slightly more aggressive under RFR (Brisset *et al.*, 2015); empirical evidence, however, seems scarce. In this paper we take a partial perspective and target at quantifying effects of granting the RFR to tenants in land privatization auctions on the number of participating bidders and the achieved sales prices as reflected by the winning bid. Main challenges for empirically studying RFR effects in auctions comprise the need of detailed auction data with sufficient variation across auctions regarding the RFR to identify respective RFR effects. Using detailed land auction data from two agencies privatizing farmland in the eastern German Federal State of Saxony-Anhalt that differ by granting the RFR to tenants, we use auction results of the one to estimate counterfactual auction results of the other.

The regional rural settlement agency in Saxony Anhalt (LGSA) privatises land of former state farms on behalf of the Federal State, and the federal privatisation agency (BVVG) privatises

land on behalf of the Federal Ministry of Finance that was collectivized and expropriated during the socialist phase. To support local farming structures, LGSA grants their tenants a right of first refusal, supports tenants in acquiring financing sources for land purchases and tendered land shall not exceed about 15 hectares lot size. BVVG, active in all Federal States of eastern Germany, does not grant a RFR to their tenants, and reduced tendered lot size from 50 to 15 hectares in 2015 due to public pressure (BVVG, 2020).

Our data set covers auction results, including land characteristics, of both agencies covering the period 2007–2018. This offers us contrasting auctions results of these two agencies in the same region, that is, under the same regulatory framework of farmland markets and implementation of EU's Common Agricultural Policy, both organized at the Federal State level in Germany.

We apply non-parametric nearest neighbour matching to estimate a set of counterfactual auctions. We rely on the Mahalanobis distance as measure for similarity between auctioned land lots with variables describing land heterogeneity such as soil quality and lot size, official standardised land value zones, and auction date. By using Poisson and hedonic price post-matching regressions, we quantify effects of granting the RFR along with support of tenants on the number of bids and land transaction prices. Our results suggest empirical evidence for lower number of bidders and prices paid on average in auctions with a RFR, but the price discrepancy between the auctions to decrease in the number of bidders. The remainder of this paper is organised as follows. We start presenting theory of first-price auctions to illustrate how introducing a RFR impacts bidding behaviour and thus auction results, which frames our hypotheses. In section 3, we describe the organization of land privatisation in eastern Germany, and introduce the data set. This is followed by presenting the empirical strategy, results and the discussion. The paper closes with concluding remarks.

2 RFR in first-price land auctions

2.1 Bidding behaviour in first-price auctions

According to EU regulation (*Official Journal of the European Union* No. 1997/C209/05), in most post-communist transition economies, first-price sealed-bid auctions with public tenders have become the predominant mechanism for privatisation of farmland (Hartvigsen, 2014). Bidders submit simultaneously their sealed bids; the person with the highest bids wins the auction and pays her own bid. Following Krishna (2010, pp. 13–17), when forming the bid, bidders try to overbid their competitors with the lowest bid possible to maximize their expected payoff. Thus, a bidder starts from her maximum willingness to pay equal to her valuation of the auctioned object. A bidder would never place a bid equal to her valuation, as in that case the

bidder's profit would always be zero. Therefore, bidders conduct "bid shading" that is bidding below their valuation. By maximizing the profit, a bidder faces a trade-off between the probability of winning, i.e. being the highest bidder, and the possible amount of payoff. The expected profit of participating at a first-price auction for a bidder is:

$$\pi(v, b) = p(b) \times (v - b), \tag{1}$$

Where $p(b)$ denotes the probability of winning with bid b, and v is the valuation for the good. The perfect bidding strategy $b(.)$ depends, however, on the nature of the valuation, asymmetries between bidders and bidders' characteristics such as risk aversion (Krishna, 2010).

2.2 Effects of the RFR in first-price auctions

By granting the RFR to one bidder, its right holder has the possibility to purchase an object at the highest price the seller is able to get from another buyer. Favouring a bidder with a RFR in first-price auctions, bidders do not determine their bidding strategy simultaneously anymore and thus splits the auction process into two steps. Due to the right, the right holder must not actively participate at the price discovery process. Instead of conducting bid shading, the favoured bidder can form her bid b_{RH} after the bid submission in a buy-refuse decision, described as:

$$b_{RH} = \begin{cases} \overline{b}, & if\ v \geq \overline{b} \\ 0, & if\ v < \overline{b} \end{cases} \tag{2}$$

Therein $\bar{b}$ denotes the highest bid of any other bidder. Due to a positive profit, the right is exercised and the right holder pays $\overline{b}$; otherwise, the right is not exercised and the bidder submitting $\overline{b}$ wins the auction. Thus, a competing bidder can only acquire the object, if her bid exceeds the valuation of the right holder. As the competitors compete against the right holder's valuation instead of the shaded bid, the right reduces the competitors' chances of winning. Thus, non-right holders are always worse off under the RFR as the right decreases their expected profit (e.g. Brisset *et al.*, 2020).

In presence of the RFR, other bidder may thus adapt their bidding strategies. For first-price auctions with independent private values and symmetric bidders, Arozamena and Weinschelbaum (2009) show that bidders may react on the presence of the right by bidding less or more aggressively. The direction depends, however, on functional form assumptions of the bidders' valuation distribution. Lee (2008) model the RFR in a asymmetric first-price procurement auction with a weak and a strong bidder. Favouring the weaker bidder may thereby level the playing field in the auction and thus induce the stronger bidder to bid more aggressive.

The seller, however, only benefits from the aggressiveness premium, if the asymmetry between the two bidder is sufficiently large. In a first-price auctions with asymmetric bidders' risk aversion, Brisset *et al.* (2020) show that a risk-averse bidder may bid more aggressive under the RFR, while the bidding strategy of risk neutral bidders remains unchanged. When the bidding strategy of non-right holders remain unchanged under the RFR, granting an RFR never benefits the seller in terms of sales prices, as the sellers suffers from the absence of the right holder's bid in the price discovery process (Arozamena and Weinschelbaum, 2009).

Due to the negative externality for other bidders, the right may constitute an entry barrier for bidders. If the RFR reduces the expected profit of non-right holders sufficiently, the costs of bid preparation and information gathering may outweigh the expected profit. A bidder might thus decide not to enter the auction (Kahan *et al.*, 2012). Further, Walker (2000) argued that entrants fear to bid against an insider owning a RFR as the right holder may have idiosyncratic values increasing her willingness to pay. In practice, a tenant might value the land much higher as a tenant faces reallocation if she loses her operating basis in the tendering process. Bidding against a strong right holder reduces the competitors' changes of winning even more as the right holder is very likely to exercise the right. Thus, encumbering an asset with a RFR deters bidder to enter the auction and reduce its marketability (Kahan *et al.*, 2012).

The deterring effect of the RFR on bidders' participating, however, is contrary to a seller's potential aim of achieving high prices. To make auctions more profitable, sellers should encourage as many serious bidders as possible to take part in the price discovery process (Bulow and Klemperer, 1996). In first-price auctions, winning bids increases with the number of competitors for two reasons: First, more bidders increase the probability that a bidder with a high willingness to pay participate. Second, bidders assuming more competition in the auction might reduce their bid shading to increase their probability of winning and thus submit larger bids (Krishna, 2010).

Based on the theoretical models reviewed, first, we expect that granting the RFR to tenants in privatisation land auction to impact the number of bidders negatively. We expect that other potential bidders anticipate a strong interest of the tenants as right-holder to buy the land, and thus a high willingness to pay, and we expect them thus to reject participation in the auction. We will refer to this effect as the deterrence effect of the RFR and frame it under hypothesis 1 (H_1):

> *H_1 Auctions granting a RFR for tenants show a lower number of bidders compared to auctions without RFR for tenants.*

Second, we expect the right to incentivise all participants to adjust their bidding strategy. Owning the RFR, the tenant itself has no incentive to place an own competitive offer in the price discovery process. That is, auctions with and without RFR differ by at least one competitive bid, and participants in auctions where a RFR is granted, other bidders must bid against the valuation of the right holder instead of anticipated competitive bid, and may thus bid more aggressively. Due the expected deterrence effect and the missing incentive of the right-holder to submit a competitive bid, less potential bidders may enter the auction process. This lower competition in the price discovery process may lead to lower winning bids, but has to be evaluated against potentially more aggressive bids by non-right holders since these must bid against the valuation of the right-holder. Tenants could have further advantages, for instance, their costs in forming a bid could be lower compared to non-local farmers, but also their knowledge about future substitute offers (Seifert *et al.*, 2020); however, none of these advantages seems systematic and price-influence by potential asymmetries between tenants and non-tenants in farmland privatization auctions could thus far not been supported (Croonenbroeck *et al.*, 2020).

We thus expect valuation for land of the right-holders to be high and since non-right-holders have to bid against the valuation of the right-holder, but not to compensate for other disadvantages, more aggressive bidding may be present, but we expect the competition effect to counteract this price effect. We thus expect a net price effect of the RFR in land auctions and frame it under hypothesis 2 (H_2).

> *H_2 Auctions granting a RFR for tenants show lower winning bids on average compared to auctions without RFR for tenants.*

3 Empirical Setting and Data

3.1 Land privatisation in Saxony-Anhalt, eastern Germany

The land market and the agricultural sector of Saxony-Anhalt have been shaped by the expropriation and collectivization during communist era in East Germany from 1945-1989 (see Wolz, 2013). Today, the land market of Saxony-Anhalt involves private and public market participants including the two agencies used in our empirical analysis, BVVG and LGSA (Hüttel *et al.*, 2016).

On behalf of the German Ministry of Finance, BVVG manage and privatise formerly state-owned agricultural and forest land in east Germany since 1992 (BVVG, 2020). In line with the German privatisation principles and EU legislation, BVVG uses since 2007 public tenders with first-price sealed-bid auctions mechanism with the objective to privatise land at market prices.

The BVVG provides detailed information on the auctioned land lot online and in farmers' magazines. Thereby, to ensure that agricultural firms can provide the capital for a competitive offer, the auctioned land lots of the BVVG should not exceed 15 ha. Bidder are invited to submit a sealed bid including a proof of financing until a deadline. Subsequently, the bidder with the highest offer is awarded the contract for a price equal to her own offer.

Beside the BVVG, the land administration company Saxony-Anhalt (LGSA) also privatise formerly state-owned land in Saxony-Anhalt since 2000 (LGSA, 2020). Declared objective of this settlement agency is to strengthen the economic and social structure in rural regions of Saxony-Anhalt. Like BVVG, LGSA uses first-price sealed-bid public tenders and detailed information on the tendered lots are likewise provided online; the offered lots are however primarily less than 10 ha in size. In contrast to the BVVG privatisation schedule fixed till 2030, LGSA can adapt its sales activities to the current economic situation of its tenants. In particular, if a tenant signals liquidity constraint, LGSA may extend the lease and postpone the tender. Further, to support locally operating agricultural firms, LGSA grants their tenants a RFR in the tendering process and supports financial and liquidity management. That is, while BVVG and LGSA use the auction mechanism, in the same market, and at the same time, LGSA tenders have favoured bidder with the right of first refusal. Contrasting the auctions of these two agencies offers us a unique chance to observe the impact of the RFR on first-price auctions within a real market setting. Although the sellers differ in their sales strategies, once a land lot has been advertised for sales, the RFR seems the only difference in the tendering procedure.

On the demand side, the LGSA and BVVG face both farmers and non-farmers. In 2016, nearly 4,400 farms cultivate on average 270 ha agricultural land in Saxony-Anhalt (MULE, 2019). The farms, however, differ in their farming structure according to their legal status: While single farms with an average size of 180 ha account for approximately 65% of the farms. In contrast, cooperatives and legal entities operate on average 373 ha and 787 ha, respectively, and cultivate around 70% of agricultural land in Saxony-Anhalt. While both farm types may acquire land with the intention to operate it, the intention of non-farmers to enter the land market is, however, heterogenous and cannot clearly be defined (Tietz *et al.*, 2013).

3.2 Data

To analyse the impact of the RFR on auction outcomes, we use data on in total $n = 3{,}884$ auctions carried out between 2007 and 2018. The sample contains $n_t = 909$ LGSA auctions in Saxony-Anhalt. For BVVG, we rely on a sample of $n_c = 2{,}975$ auctions. Thereby, we consider 1,338 BVVG auctions in Saxony-Anhalt, but also consider 1,637 auctions in the neighbouring

counties. For each auction lot, we observe main lot characteristics including lot size, soil quality, the respective shares of arable, pasture and other land, and the respective jurisdiction including the Gemarkung.[2] Further, we observe the exact date of the auction, the winning bid, the number of submitted bids, and for LGSA auctions, information on the use of the RFR by the tenant. In line with auction theory (Brisset *et al.*, 2020), we consider only auctions with competition. Therefore, for BVVG we removed auctions with one bidder as there was virtually no competition. In contrast, for LGSA auctions, we considered auctions in which at least one bid was submitted by a bidder that is not the right holder, i.e., the tenant. In total our sample represents a transaction volume of 21,350 ha agricultural land (LGSA: 6,740 ha, BVVG: 14,617 ha) generating revenues of about 370 million EUR (LGSA: 131 million EUR, BVVG: 241 million EUR).

Table 1. Descriptive statistics of BVVG and LGSA land auctions, 2007–2018

n=3,884		*Seller*: LGSA (n_t=909)					*Seller*: BVVG (n_c=2,975)				
		Mean	Median	SD	Q1	Q99	Mean	Median	SD	Q1	Q99
Lot Characteristics											
Lot Size (ha)	x_s	7.41	8.37	3.19	0.18	13.33	4.91	3.41	4.83	0.07	20.80
Soil quality index	x_q	67.23	71	21.45	22.92	99	50.20	46	20.52	18	97
Share of arable land (%)	x_a	86.90	98.12	24.42	0	100	68.92	91.56	39.32	0	100
Share of pasture land (%)	x_p	9.98	0	23.05	0	100	25	0	37.46	0	100
Share of other land (%)	x_o	3.12	0	6.76	0	34.72	6.08	0.52	10.80	0	47.75
Auction Characteristics											
Number of bids	b	4.52	4	2.38	1	13	4.22	4	2.41	2	13
Price (EUR/m²)	p	1.88	1.71	1.20	0.27	4.71	1.45	1.17	0.98	0.26	4.41
Right holder											
submitted bid (%)		72.83	100	44.51	0	100					
used RFR (%)		58.86	100	49.24	0	100					
won with own bid (%)		11.44	0	31.85	0	100					
rejected RFR (%)		29.70	0	45.72	0	100					

Note: Due to strong data privacy regulations, the table does not include information about the minima or maxima of the data, but list instead the 1 per cent and the 99 percent quantiles (Q1 and Q99).

While BVVG is the larger supplier of land, LGSA auctioned on average larger land lots with higher soil quality (cf. Table 1.).[3] Further, auctions by LGSA offer on average a higher share of arable land, while the auction lots of both sellers contain small shares of unspecified land, including, for instance agricultural roads or woodland areas. For both auctioneers, we observe up to 13 submitted bids. In LGSA auctions, on average 4.52 bidders placed a bid in the tendering process, while 4.22 bids were submitted on average in auctions of the BVVG. The observed

[2] A Gemarkung is the smallest administrative unit used in Germany and Saxony-Anhalt consists of in total 1677 Gemarkungen of 12km² on average.

[3] The soil quality index (points) is an official index in Germany for the valuation of field productivity and unifies pedologic, scientific and economic factors within one unitless measure. Low (high) numbers indicate low (high) productivity (Ritter *et al.*, 2020).

winning bid range for both sellers between 0.25 and 6 EUR/m². On average 1.88 EUR/m² for LGSA and 1.45 EUR/m² for BVVG auctions. In the observation period, winning bids increased for both sellers (Figure 1.), which is in line with the observed price surge in Saxony-Anhalt during this period (Seifert *et al.*, 2020). The average prices obtained by both sellers increased from 0.58 EUR/m² in 2007 to 2.20 EUR/m² in 2018, which corresponds to a price increase of 280% during the observation period. In each observation year, however, we observe on average higher winning bids in LGSA auctions.

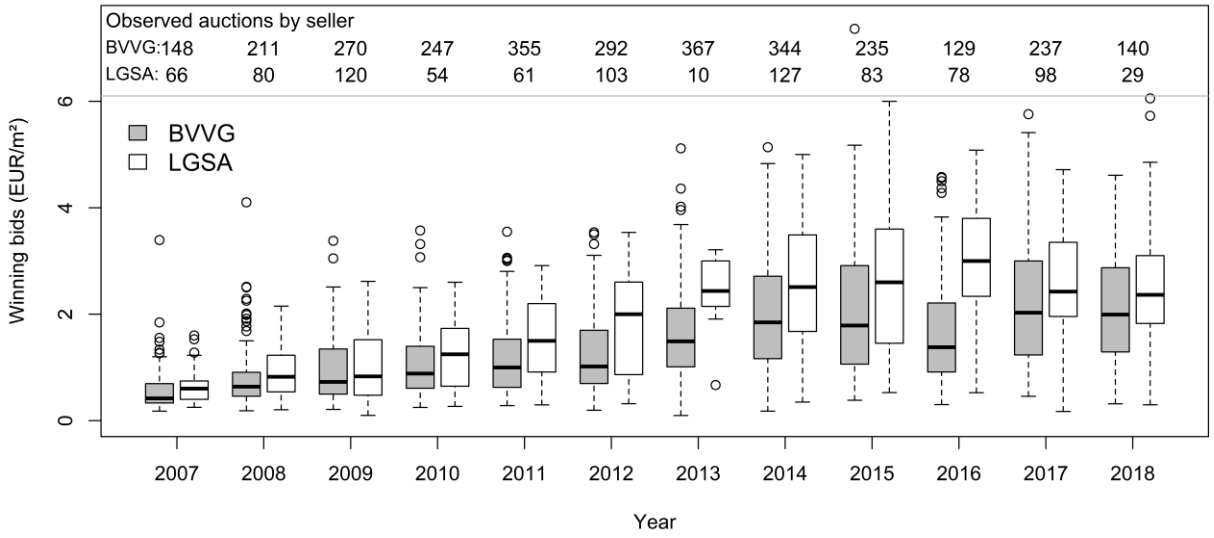

Figure 1. Winning bids of BVVG and LGSA land auctions, 2007–2018

While the bidder with the highest bid automatically acquires the land lot in BVVG auctions, in LGSA auctions the tenant exercise the RFR and we observe the tenant as the winner of the auction in 70% of the cases. This includes, however, two different cases (cf. Table 1.): In 59% of LGSA auctions, the tenant acquired the land lot by exercising the right. We, however, also observe a regular bid by the right holder in around 75% of LGSA auctions. In 11% of the auctions, the tenant won the auction with such bid, although he could have matched the highest bid using the RFR. We assume that tenants still submit an intentionally low offer to avoid auction failure and potentially higher prices in a repeated auction. In around 30%, the tenant declined using the RFR and thus a non-tenant won the tendering process.

4 Empirical Strategy

To estimate the impact of the RFR on number of bidders (H_1) and winning bids (H_2), we combine non-parametric matching with parametric regression as proposed by Ho *et al.* (2007). Thereby, we aim at comparing auctions with and without a tenants' RFR and define a treatment variable T_i that equals one if the seller granted the RFR to the tenant in auction i ($i = 1, \ldots, n$), and zero otherwise. In line with potential outcomes framework (Rubin, 1974), we specify an

outcome under treatment and a outcome without treatment by Y_i^1 and Y_i^0, respectively. The difference between the treated and non-treated outcome, $[Y_i^1|T_i = 1] - [Y_i^0|T_i = 1]$ represents the causal effect of the RFR (Rubin, 1974). Because the counterfactual outcome Y^0 is unobservable to us within LGSA auctions, it has to be estimated. To overcome this problem, we aim at constructing a valid counterfactual based on auctions results of the BVVG. A valid counterfactual requires conditional independence and common support (Imbens, 2004). That is in our context after conditioning for price determinants X, the differences in outcomes between auctions should be on average only due the difference in the sales mechanism. Satisfying both assumptions asserts that the mean outcome conditional on covariates X is identical for treated and control units, $E[Y_i^0|X, T_i = 1] = E[Y_i^0|X, T_i = 0]$.

To implement the conditioning on X, we use matching as a pre-processing step that aims at ensuring that the considered auctions are as similar as possible with respect to the characteristics of the auctioned land lots. Using the matched sample, we estimate the causal effect of the RFR in a post-matching regression using a count data model (H_1) and a hedonic pricing model (H_2). This procedure provides the advantage that the treatment effect becomes less sensitive to model mis-specification (Ho *et al.*, 2007). Moreover, the parametric analysis adjusts for remaining imbalances on covariate distribution after matching. This offers us a doubly robust approach as the treatment effect estimation becomes consistent, if at least one of the two steps is correctly specified (Ho *et al.*, 2007).

4.1 Matching

Aim of the matching approach is to find a set of control auctions without a RFR that is identical to the treated auctions with a RFR. We assume that identical land lots sold in the same region at the same time create the same value for a bidder, independent from the sales mechanism. Therefore, we match the control (BVVG) and treated (LGSA) auctions on hedonic characteristics, on the temporal, and on the spatial dimension.

Based on an assessment of the covariate balance of several matching approaches, we selected non-parametric one-nearest neighbour matching based on the Mahalanobis distance as the measure of similarity. The Mahalanobis distance takes the correlation between the land characteristics into account and combines the information within one unitless measure (Rubin, 1980). To implement the matching approach, the Mahalanobis distance is calculated using six variables: Four hedonic variables lot size (x_s), soil quality (x_q), the respective shares of arable (x_a) and unspecified land (x_o) describe land productivity and are main price determinants for farmland (Nickerson and Zhang, 2014). Additionally, we match on geo-coordinates in terms of

latitude and longitude.[4] Matching on coordinates thereby shall increase the similarity of the matches also in terms of factors unobserved by us, such as the underlying market micro-structure, and water availability. Given the price surge in the observation period (cf. Figure 1.), we match auctions on a time corridor to ensure that matched auctions are only up to one year apart. That is, for LGSA auction in year t, we consider BVVG auctions in $[t-1; t+1]$ as potential matches. Because a BVVG auction can serve as a match in up to three time corridors, the matching procedure ultimately corresponds to matching with up to three replacements. We therefore weight the control observations proportional to the number of matches it contributes to, where the control weights are scaled to the sum of uniquely matched control units (Ho *et al.*, 2011).

4.2 Post matching regression

We set up two post-matching regression approaches: First, to identify the causal effect of the RFR on bidders' participation (H_1), we implement a count data model, based on a negative binomial regression. Thereby, the number of observed can be interpreted as the result of a count process generated by the occurrence of bids during the tendering period. The observed number of bids is as strictly non-negative integer, with rare occurrence of high numbers in our application. Therefore, count data modelling is a suitable approach to explain the variation in bids across auctions (Cameron and Trivedi, 2013). Second, we apply a weighted least squares regression to estimate the causal effect of the RFR on the winning bids (H_2) within a hedonic pricing framework, where the price of farmland can be decomposed into shadow prices for its inherent attributes (Rosen, 1974).

In the negative binomial regression, we use the number of competitive bids the winning bidder has faced in the auction ($b^{comp} = b - 1$) as our response variable, a common step in auction count data modelling (e.g. Piet *et al.*, 2020). To control for core price determinants of farmland (Nickerson and Zhang, 2014), we use lot size ($x_{i,s}$), soil quality ($x_{i,q}$), share of pasture ($x_{i,p}$) and other land ($x_{i,o}$) as explanatory variables. To capture spatial and temporal effects within Saxony-Anhalt's land market, the regression includes dummy variables for the respective county d_l and sales year d_t of the auctioned land lot. For the hedonic pricing framework, our dependent variable is the log price in EUR per m². We consider the same land characteristics explanatory variables ($x_{i,s}$, $x_{i,q}$, $x_{i,p}$,$x_{i,o}$). In this regression, we omit, however, the intercept and add dummy variables $d_{i,p}$ representing the number of participants in an auction. The

[4] The coordinate of a land lot is based on the centroid of a Gemarkung in which the respective land lot is located.

number of participants is specified as the sum of potential buyers which corresponds to all number of bidders in BVVG auctions. In LGSA auctions, however, this also includes the right holder in cases the tenant does not have submitted a bid. The dummy variables represent 2,3,4,5,6-8 and 9+ participants, which ensures at least 65 observations for each seller for each dummy variable. This allows us to adjust for a potential price-increasing competition effect in first-price auction, which assumed to increase with the number of bidders (Hüttel *et al.*, 2013). Within the count data model, we identify the causal effect of the RFR on the number of bidders by including a LGSA treatment variable $d_{i,LGSA}$. Within the hedonic pricing framework, we specify two regression models, M2a and M2b: In M2a, we estimate the average causal effect of the RFR on price by including a LGSA dummy variable $d_{i,LGSA}$. In M2b, we interact the treatment variable with the dummy variables for participant classes to identify potential variations of the RFR-effect over the number of bidders within an auction. To avoid mis-specification of the functional form, we rely on the Box-Cox procedure (Davidson and MacKinnon, 2004) and enter lot size x_s in squared form, and all other variables linearly. The three models are given by:

$$h(.) = \beta_s x_{i,s}^2 + \beta_q x_{i,q} + \beta_a x_{i,a} + \beta_o x_{i,o} + \sum_l \gamma_l^{county} d_{i,l} + \sum_t \gamma_t^{year} d_{i,t}$$

$$\text{Model M1} : \ln\left(b_i^{comp}\right) = \alpha + h(.) + \delta^{LGSA} d_{i,LGSA} + \varepsilon_i$$

$$\text{Model M2a} : \log(p_i) = \sum_p \alpha_p^{part} d_{i,p} + h(.) + \delta^{LGSA} d_{i,LGSA} + \varepsilon_i$$

$$\text{Model M2b} : \log(p_i) = \sum_p \alpha_p d_{i,p} + h(.) + \sum_p \delta_p{}^{LGSA} (d_{i,LGSA} \times d_{i,p}) + \varepsilon_i$$

Where β's, γ's,and α's are parameters to be estimated related to lot characteristics, spatial and temporal controls, and the number of participants, respectively. δ's identifies the effects of the RFR on the respective outcome of interest, and ε is the error term. The negative binomial regression M1 is estimated using maximum likelihood estimation. The estimation of M2a and M2b uses linear regression. To account for the possibility of having a control unit matched to multiple treated units, all regressions include weights on the control units proportional to their matching frequency (Ho *et al.*, 2011). To account for potential heteroscedasticity, inference is based on robust standard errors (White, 1980).

5 Results and Discussion

One-nearest neighbour matching based on Mahalanobis distance with up to three replacements matched the 909 LGSA auctions with 575 control auctions of the BVVG. More than half (316 auctions) of the control units were matched once, the remaining controls were used two (184

auctions) or three times (75 auctions) as a match. Figure 2. illustrates the covariate balance before and after matching based on common key figures (Stuart, 2010). Panel A shows the absolute standardised difference in means pre and post matching, which compares the difference in means between two samples (LGSA and BVVG, and LGSA and matched BVVG) taking the variance into account; thereby, values greater than 0.2 indicate meaningful imbalances of a covariate on the treatment effect (Rosenbaum and Rubin, 1985). After matching, the standardised difference is below 0.1 for all core land characteristics indicating a satisfying balance improvement. Panel B to E show quantile-quantile (QQ) plots for the hedonic variables lot size, soil quality, and share of arable and pasture land pre and post matching. The QQ-plot reveals identical covariate distribution to the LGSA sample if the distribution coincides with the 45-degree line. For the matched BVVG auctions, the dotted line is in all four QQ-plots close to the 45-degree line and thus indicates common support on the covariate distribution between the treated sample and the matched control sample. Due to the matching also on the geo-coordinates, the matched pairs are on average only 26km apart, which provides a good match also on other unobserved price determinants.

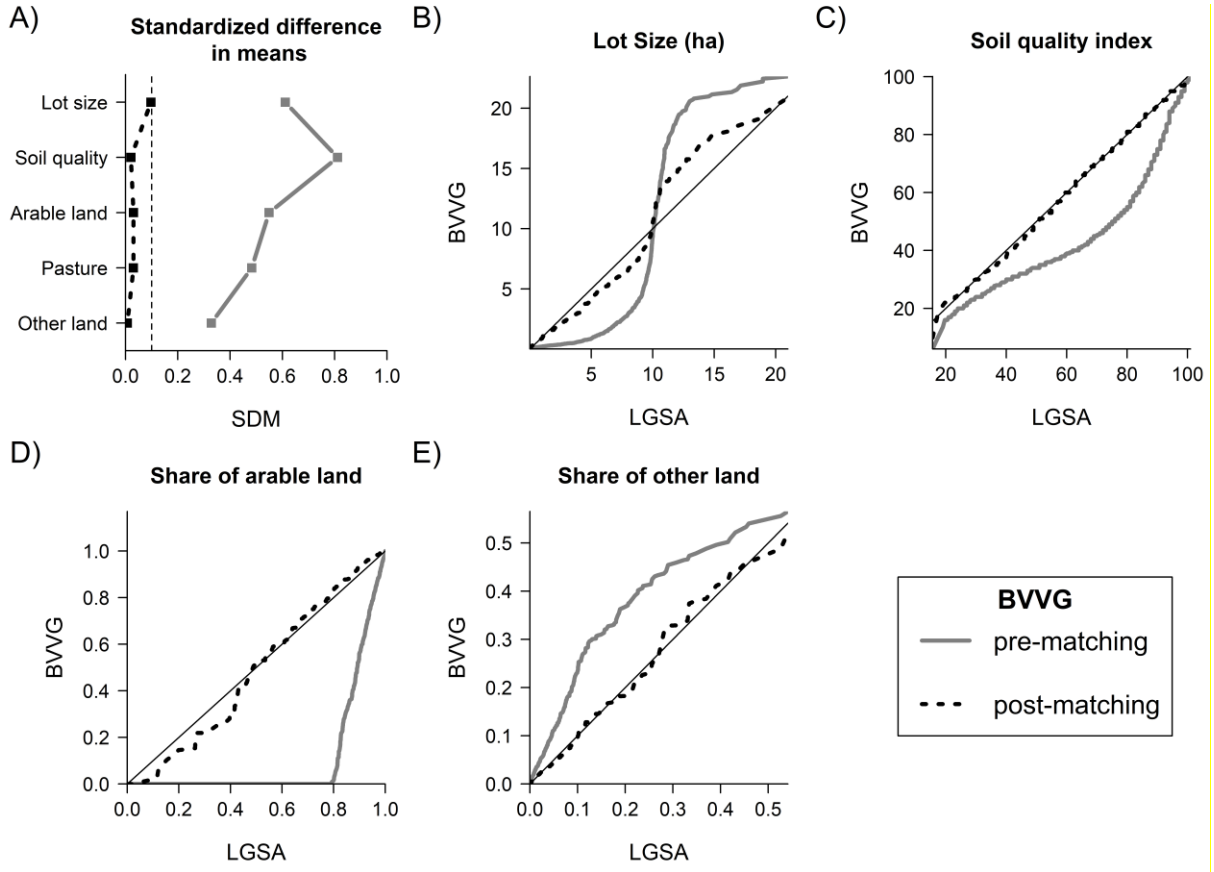

Figure 1. Matching quality measures

Table 2. presents the results of our three post-matching regression. The first column shows the results of model M1 that estimates the impact of the RFR on the number of bids (H_1). To ease the interpretation of the negative binomial regression, the parameter estimates are transformed using $\exp(.) - 1$ and can be interpreted as the proportional change in the expected mean of the number of competitive bids by a one-unit increase in the regressor, holding all other variables constant (Cameron and Trivedi, 2013). All parameter estimates for the hedonic land characteristics show statistically significant effects at the 1%-level. For soil quality, a unit increase corresponds to 0.9% more bids on average. In line with Piet *et al.* (2020), we find for larger land lots higher competition in land auctions. The results also indicate that higher shares of pasture and unspecified land attract less bidders. While arable land is useable for all types of farmers, pasture may be of particular interest only for livestock farmers and might therefore lower competition.

Table 2. Post-matching regression results

	M1	M2a	M2b
Intercept	0.352** (0.137)		
Competition			
Participants: 2		−1.434*** (0.056)	−1.414*** (0.061)
Participants: 3		−1.368*** (0.057)	−1.311*** (0.060)
Participants: 4		−1.350*** (0.057)	−1.290*** (0.061)
Participants: 5		−1.277*** (0.059)	−1.262*** (0.065)
Participants: 6-8		−1.222*** (0.059)	−1.250*** (0.059)
Participants: 9+		−1.191*** (0.062)	−1.243*** (0.063)
Lot characteristics			
Sol quality	0.009*** (0.001)	0.013*** (0.001)	0.013*** (0.001)
Lot size²	0.002*** (0.000)	0.001*** (0.000)	0.001*** (0.000)
Share Pasture land	−0.370*** (0.087)	−0.663*** (0.058)	−0.666*** (0.058)
Share other land	−1.578*** (0.286)	−1.054*** (0.160)	−1.056*** (0.160)
Treatment effect			
LGSA	−0.083** (0.041)	−0.167*** (0.017)	
LGSA:Participants 2			−0.175*** (0.046)
LGSA:Participants 3			−0.233*** (0.031)
LGSA:Participants 4			−0.231*** (0.037)
LGSA:Participants 5			−0.165*** (0.039)
LGSA:Participants 6-8			−0.095*** (0.028)
LGSA:Participants 9+			−0.034 (0.033)
Weights	Yes	Yes	Yes
Treated n_t	909	909	909
Control n_c	575	575	575
R^2	0.310	0.873	0.875

Note: Heteroscedasticity-consistent standard errors in parentheses. Asterisks indicate*=p<0.1; ** =p<0.05; *** =p<0.01. For M1, R^2 is specified as the squared correlation coefficient between observed and fitted values. Parameter estimates for county and year dummy variables are omitted for brevity.

Model M1 reveals a negative impact of the RFR (and other support of LGSA) on competition in LGSA's land auctions. Compared to the BVVG auctions without the RFR, bidders can expect on average around 8% less competitors in LGSA auctions. The estimated effect of the RFR on bidders' participation is statistically significant at the 5%-level and provides evidence for a deterrence effect of the RFR in land auctions (H_1).

Columns two and three of Table 1. present the regression results of M2a and M2b, respectively. R^2's of around 0.87 are in a satisfying range. Estimated coefficients for land characteristics show expected signs and are statistically significant at the 1%-level. In line with other studies on farmland price formation in Saxony-Anhalt (e.g. Seifert *et al.*, 2020), positive parameter estimates for soil quality and lot size suggest a positive impact of farmland productivity potential on the price. Both models also indicate a negative price effect for land lots with higher shares of pasture, and even lower prices for higher shares of unspecified land (Nickerson and Zhang, 2014). Parameter estimates for participant classes increase with the number of participants. That is, the expected winning bid in land auctions increases with the number of bidders, which is in line with previous empirical reduced form auction studies (e.g. Hüttel *et al.*, 2013).

Both models show statistically significant negative parameter estimates for the RFR-effect on the winning bid in line with H_2. In M2a, we find an average price-decreasing effect related to the RFR of about 16.7%. That is, LGSA auctions with a tenants' RFR received on average 16.7% lower winning bids than the matched BVVG auctions without such right. Based on robust standard errors, we reject the null-hypothesis of no RFR price-effect at the 1% level. Model M2b indicates, however, that the effect related to the RFR on the price varies across auctions and decreases with number of participants. For instance, in LGSA auctions with two to four participants, the parameter estimates suggest a price-decreasing effect related to the RFR ranging from 17.5% to 23.3% (cf. Table 2.). This effect decreases, where we find for six to eight bidders 9.5% lower prices related to the RFR, while for auctions with more than eight participants, we find no significant price-effects.

The decreasing price effect of the RFR over the number of participants might indicate that the main effect price effect attached to the RFR is the absence of the right holders competitive bid and non-right holding bidders must bid against the anticipated valuation of the right holder. Further, as the tenant might face reallocation costs when losing the tendered land in the privatisation process and potential economic losses, we argue that tenants have a high valuation and act risk averse in their bidding strategy by bidding close to their valuation. It seems very

likely that the group of tenants are the price-determining bidders in auctions attracting only few bidders, where this group shows likely highest valuations; this may be no longer the case in auctions with many bidders: First, the tenant may compete with other types of bidders, e.g. non-agricultural investors, which may have a similar valuation for the land lot (Croonenbroeck *et al.*, 2020). Second, bidders anticipating increased competition within auction may reduce their bid shading, resulting in a bid strategy similar to that of the tenant (Brisset *et al.*, 2020). Thus, the absence of a tenants' competitive bid due to the RFR is less noticeable in the amount of the winning bid in auctions attracting more bidders compared to those auctions attracting more.

6 Concluding remarks

This paper aims at investigating the impact of a tenants' RFR in first-price land privatisation auctions empirically and quantifying the effects on prices and number of bidders. We could rely on auctions results of two land privatisation agencies, LGSA and BVVG, in the German Federal State Saxony-Anhalt, where LGSA grants tenants a RFR, along with qualitative support for tenants. We combined non-parametric matching with parametric post-matching regression to estimate these effects. Our results suggest that auctions with granted tenants' RFR receive on average lower number of bids. By awarding the RFR, the tenant itself has no incentive anymore to submit an own competitive bid. We further find lower winning bids on average in auction with RFR. We conclude that LGSA's strategy to favour tenants with a RFR results in lower prices compared to auctions of the federal privatisation agency BVVG without the right. The price effect, however, varies across number of bidders within the auction and we find on average larger (lower) price effects related to the RFR for land lots attracting less (more) bidders.

This paper provides first empirical evidence for a deterrence effect of the RFR on bidders' participation and quantifies price effects in a land auction setting. Answering our initial question regarding the effectiveness of the RFR in supporting tenants, we conclude that granting a RFR may lower competition in these auctions and enable tenants to purchase land on average at lower prices. Granting the RFR along with qualitative support for farms' financing and liquidity management may therefore contribute to securing stability of locally operating agricultural firms thus support these firms in the privatisation process. However, this comes at the cost of lower public revenues from the privatisation.

Regarding the validity and interpretation of our results, we acknowledge some limitations: First, while the RFR seems to determine the only differences between BVVG and LGSA, unobserved heterogeneity between sellers may confound the estimated causal effect of the RFR. If bidders'

bid preparation and information gathering costs, for instance, vary by seller type for reasons unrelated to the RFR, bidders' selection into auction may depend on the auctioneer. Likewise, differently set secret reservation prices by the agencies may result in sample selection due to repeated auctions, which remain unobservable to us. Second, we identify average prices effects related to the RFR in first-price land auctions, the result of an incentivised bidding strategy of all potential bidders induced by the RFR. While theory assumes that non-right holders may adapt their bidding strategy to the presence of the RFR, we cannot rely on structural estimation to identify such effects as we observe only the winning bid in LGSA auctions. Identifying this effect requires a structural estimation of the valuations of all bidders and a subsequent comparison of the average difference between valuations and bids of both agencies.

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