Price Formation on Land Market Auctions in East Germany – An Empirical Analysis

Auktionspreise auf dem ostdeutschen Bodenmarkt – eine empirische Analyse

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Abstract

Although determinants of agricultural land prices have received considerable attention in the literature, little is known about price formation on structured markets such as land auctions. This paper aims to empirically test theoretical predictions regarding price formation in land market auctions. The analysis is conducted for the case of Saxony-Anhalt, Germany, where state-owned land constitutes a significant share of the agricultural land market. The utilised data consists of public auction data provided by the Landgesellschaft Sachsen-Anhalt (i.e. the rural development agency in Saxony-Anhalt), and covers approximately 700 calls for bids from 2003 to 2010, supplemented with regional and structural data. Spatial correlation of land prices is considered by applying a spatial econometrics approach. Our analysis shows that apart from land characteristics, the number of bidders and the share of non-agricultural investors have an impact on the land price.

Key Words

agricultural land prices; land auctions; spatial econometrics

Zusammenfassung

Der landwirtschaftliche Bodenmarkt ist Gegenstand zahlreicher empirischer Analysen, und es ist weitgehend unstrittig, welches die hauptsächlichen Preisdeterminanten sind. Allerdings ist wenig über die Preisbildung in strukturierten Märkten bekannt, beispielsweise Auktionen mit öffentlichen Ausschreibungen. Ziel dieser Studie ist es, auf Basis der Auktionspreistheorie Hypothesen über die Wirkung auktionsspezifischer Preisdeterminanten herzuleiten und empirisch zu prüfen. Die Analyse wird exemplarisch für Sachsen-Anhalt durchgeführt, da in diesem Bundesland die Landgesellschaft Sachsen-Anhalt im Rahmen des Privatisierungsprozesses der ehemals volkseigenen Flächen als institutioneller Anbieter auf dem Bodenmarkt agiert und öffentlich ausschreibt. Der verwendete Datensatz umfasst circa 700 Ausschreibungen im Zeitraum von 2003 bis 2010, die mit strukturellen Daten aus der Regionalstatistik angereichert werden. Unter Berücksichtigung von räumlicher Korrelation der Preise mittels räumlich-ökonometrischer Methoden kann gezeigt werden, dass zum einen die Eigenschaften des Flächenloses, wie zum Beispiel die Bodenqualität, und zum anderen auktionsspezifische Variablen, wie die Anzahl der Gebote sowie der Anteil nicht-landwirtschaftlicher Bieter, den Preis signifikant beeinflussen.

Schlüsselwörter

Bodenpreise; Auktionen; räumliche Ökonometrie

1 Introduction

Land is indisputably the most important production factor in agriculture. Indeed, farmland in Germany accounted for about two-thirds of agricultural assets in 2010/11 (BMELV, 2012), and hence any change in farmland values is likely to impact the solvency of farms and their access to capital. Thus, it is not surprising that a vast body of literature is dedicated to the analysis of farmland values. At least two strands of literature can be distinguished. The first research direction focuses on the dynamic analysis of land prices. The primary objective here is to test whether the development of land prices corresponds with specific asset pricing models. In the simplest case, it is hypothesised that land prices are equal to the present value of land rental prices (e.g. FALK, 1991; FALK and LEE, 1998). A second strand of literature aims to iden-

99

tify factors that determine the level of land prices at a given point in time. Knowledge of these factors is helpful for understanding price differentials in cross-sectional data. This kind of analysis is usually conducted in a hedonic pricing framework (cf. PALMQUIST, 1989). Observed price differentials are assumed to reflect the valuation of land characteristics by market participants. Based on an extensive literature review, HUANG et al. (2006) classify factors that are commonly used in hedonic studies on land prices into four groups, namely productivity characteristics, neighbourhood characteristics, location and environmental characteristics. Almost all empirical studies on farmland values include a measure of soil quality and parcel size in order to capture productive capacity (e.g. XU et al., 1993). MENDELSOHN et al. (1994) focus on the effect of climatic variables on farmland values. Population density and per capita income are frequently used to represent non-farm factors and competing potential land uses. An example of a location characteristic is distance to a large city, and environmental variables may refer to swine farm density or the number of biogas plants in a region (BREUSTEDT and HABERMAN, 2011). Moreover, almost all recent hedonic studies on land prices emphasise the necessity of properly dealing with spatial effects (cf. PATTON and MCERLEAN, 2003).

Despite the vast body of literature on agricultural land prices, there are few studies that analyse the price formation process itself. Usually it is implicitly assumed that land prices are formed on a competitive market. This is a rather abstract view of land market transactions, because regulations on market access, market power of participants or informational aspects are not taken into account. Moreover, it is frequently ignored that at least two different mechanisms for determining land prices are available: first, observed prices can be the outcome of a (bilateral) negotiation process between sellers and buyers, which is a common method of price formation in Germany. Second, land prices can be formed on structured markets, particularly land auctions, in which a set of rules governs bidding and acceptance by a finite number of buyers and a seller; this market form is widely used in some countries, e.g. Australia, but its application in Germany is mainly limited to forced land sales (but with increasing attention for other sales). One important exception, however, are the sales of formerly state-owned land in the new German federal states. Here, the Bodenverwertungs- und –verwaltungs GmbH, i.e. the Land Utilisation and Administration Company

(BVVG), as well as public land agencies, for example the Landgesellschaft Sachsen-Anhalt mbH (LGSA), i.e. the association for rural development in Saxony-Anhalt, sell land publicly via first-price sealed-bid auctions. The fact that land prices realised by public land agencies are, on average, higher compared to those from private sales (cf. BÖHME, 2009) led to the conclusion that the market mechanism itself has an impact on prices.

Against this background, the objective of this paper is to empirically explore the formation of prices on land auctions. We conduct this analysis for the case of Saxony-Anhalt, where state-owned land constitutes a significant portion of the traded agricultural land. Auction theory provides a rich set of hypotheses for the impact of observable variables on realised auction prices, e.g. the number of bids in an auction, bidder characteristics and characteristics of the good (e.g. MCAFEE and MCMILLAN, 1987; MILGROM, 1989; QUAN, 1994). Some of these hypotheses have already been empirically tested in the real estate literature (e.g. OOI et al., 2006; AMIDU et al., 2008). Applications to agricultural land auctions, however, are lacking. Our paper aims to close this gap.

The remainder of this article is organised as follows. Section 2 briefly describes the land market in Saxony-Anhalt. Section 3 explains the modelling framework and formulates hypotheses on the determinants of land prices. The econometric approach is developed in section 4, followed by a discussion of the results (section 5) and conclusions (section 6).

2 The Land Market in Saxony-Anhalt, Eastern Germany

Agricultural land generally becomes available on the market when farmers quit production and the land of the vacated farms is sold or rented out. This means that opportunities for farms to increase their land rentals or land endowment typically only arise when other farms leave the market. In regions and countries with a history of land collectivisation where land is being privatised, private farms may have the possibility to buy or rent previously state-owned land. Being one of the new federal states in Germany, Saxony-Anhalt's land market is influenced by the Eastern German history of expropriation and land collectivisation between 1945 and 1989. After German reunification, an agency called Treuhand (or Treuhandanstalt) was founded with the objective of privatising state-owned agricul-

ture and forestry property in the new federal states. Initially, the Treuhand administered about 25% of the arable land of GDR, corresponding to approximately 1.5 million hectares (KOESTER and BROOKS, 1997). Today, the successor of the Treuhand, the BVVG, is the main organisation responsible for privatising previously state-owned land in Eastern Germany. The land market in Eastern Germany is, similar to other European land markets, characterised by a high share of rental contracts. In Saxony-Anhalt, the share of rental contracts of total land was 78 per cent in 2010.[1] The high share of rental contracts in Saxony-Anhalt can, similar to the whole of Eastern Germany, be explained by the historical preference of Treuhand and BVVG to rent out land rather than sell it (partly due to unclear property and ownership rights[2]), in combination with a typically long duration of rental contracts, as well as a relatively low equity per hectare of East German farms.

In the Federal State of Saxony-Anhalt, land privatisation activities are – in addition to those administrated by BVVG – performed by the LGSA, which is the main association for rural development in Saxony-Anhalt, and was formed in 1992 from the preceding corresponding associations in Magdeburg and Halle (LGSA, 2012). LGSA is a non-profit company whose tasks include, among other things, the administration of land transactions of state-owned land in Saxony-Anhalt. As indicated above, the empirical part of our analysis is concerned with the land auction sales conducted by the LGSA in Saxony-Anhalt from 2003-2010. At present, the LGSA has approximately 28,000 hectares of its own farmland and manages about 8,000 hectares of farmland on behalf of the state government (LGSA, 2012). This land is gradually being privatised. As in the case of BVVG, LGSA is active in all counties of Saxony-Anhalt, although the main part of their remaining stock of land is concentrated in south-central Saxony-Anhalt, with the highest shares in the following counties: "Bördekreis", "Harz", "Salzlandkreis", "Anhalt-Bitterfeld" and "Saalekreis" (see also Figure 2b, which shows the amount of sold land in 2009-10). The BVVG has a higher share of the total

agricultural land to be privatised in Saxony-Anhalt, around 65,000 hectares at the end of 2011 (BVVG, 2011). Similar to BVVG, LGSA uses a form of public first-price sealed-bid auction in their current tendering procedure. This means that anyone interested in buying the land can anonymously submit a bid and, when the end-date of the auction is reached, the land is sold to the bidder with the highest bid (or to the current tenant if he has a pre-emption right and wants to buy the land) for a price equal to the highest bid. There are, however, some differences between the land auction procedures applied by BVVG and LGSA. For example, unlike the auctions performed by BVVG, the procedure employed by LGSA always provides the current land tenant a pre-emption right, i.e. the right to buy the land at the winning bid without actively participating in the auction. As will be shown in section 4, this option is exercised in approximately 50 per cent of the cases. Another difference is that since 2007, BVVG has published the realised prices on their homepage, whereas LGSA does not have a similar publication policy. A further point worth mentioning is the political aim of LGSA, which is to simplify farms' financing of land. LGSA notifies their tenants well in advance when the land will be sold and tries, as far as possible, to make smaller pieces out of larger slots. The purpose is to avoid situations where a large share of a farm's rented land is sold within a short period of time. Therefore, only a few plots sold by LGSA are larger than 10 hectares.

To summarise, as we can infer from oral correspondence with representatives of BVVG and LGSA, the selling strategies of both suppliers are independent of each other. Both have a predetermined set of rules for auctioning land which do not vary with respect to the competitor's land stock, and are independent of the local degree of competition. The overall supply of land within a region, in turn, may affect the bidders' strategies since there is, at least to some extent, substitutability between plots. This will be discussed later in the text.

The development of average annual prices per hectare for land sold in Saxony-Anhalt from 2003-2010, as well as the average prices for land sold by BVVG and LGSA, is illustrated in Figure 1a.[3] A sub-

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[1] According to Statistisches Landesamt Sachsen-Anhalt, Halle (Saale), a total of 1,129,747 hectares of land was used for agricultural production in Saxony-Anhalt in 2010, of which 880,694 hectares were rented.

[2] According to KOESTER and BROOKS (1997), some estimates suggest that a large share of the land administrated by Treuhand did not in fact have any pending claims, and Treuhand and BVVG preferred to rent out the land for other reasons, such as fear of depressed land prices.

[3] The average annual prices for sales of LGSA consider all land types (arable, pasture and "other uses") since a price differentiation was not possible. It should be noted, however, that after removing plots that only contain the land type "other uses", land for "other uses" corresponds to 3 per cent of the total area of the remaining land sales by the LGSA.

stantial increase in land values during this period can be observed, particularly for the last years; average land prices in Saxony-Anhalt increased by 63 per cent between 2007 and 2010. The figure further reveals that the land sales by BVVG and LGSA are characterised by remarkably higher average prices than the general average in Saxony-Anhalt. These observations suggest that land prices seem to be strongly affected by the specific market form. It can also be noted that after 2006, the price for land sold by the BVVG in Saxony-Anhalt is either higher than or similar to that of LGSA. Figure 1a thus underlines the relevance of an adequate understanding of land price formation, including the impact of specific market forms such as auctions. In Figure 2a the average prices are illustrated by county ("Landkreis") for the years 2009 and 2010 (please see the Appendix for an explanation of the abbreviations used for counties in Figures 2a and 2b); the highest prices are obtained in the counties with more favourable natural conditions like "Harz (HZ)" with a high average soil quality. It can further be noted that the BVVG prices are not higher in all regions. For example, in the "Bördekreis (BK)" the LGSA obtained a higher average price in 2009-10.

The total number of hectares annually sold in Saxony-Anhalt, as well as the number of hectares sold through BVVG and LGSA, is illustrated in Figure 1b. Over the observed time period, the sales of BVVG correspond to 23.5 per cent of total land sales in Saxony-Anhalt, whereas the sales of LGSA amount to 5.7 per cent on average. In 2010, 11,440 hectares of agricultural land were sold in Saxony-Anhalt, of which 2,450 hectares were administered by BVVG and 580 hectares by LGSA. Figure 2b illustrates the total amount of land sold in Saxony-Anhalt by county, and it can be noted that both BVVG and LGSA performed sales in most counties from 2009-10.

3 Land Price Determinants and Hypotheses

This section discusses the way in which various plot and regional characteristics are expected to influence the valuation of land, and thus its final price. We further discuss how factors related to the tendering procedure, such as the number of bidders, are expected to influence the final land price. Auction theory provides an appropriate theoretical framework for this purpose.

The literature on auctions is separated into two types of auction environments: first, *Common Value* auctions (CV), in which the value of the item is the same for all bidders, but not known by the bidder, and *Independent Private Value* auctions (IPV), where the item creates different values for the bidders. In the latter, uncertainty arises from the fact that the value for competing bidders is unknown. This distinction is relevant, because the optimal bidding strategy, as well as the impact of conditioning variables, differ under these two auction environments. Land market auctions probably do not belong to any of these two extreme environment types (QUAN, 1994). Instead, they are more likely characterised by "uncertain private values". In the remainder of the paper, we assume that there is a pool of potential risk-averse bidders who compete for a plot of land in a first-price sealed-bid auction.[4] Each bidder has an individual expectation of the value of the land, v, which can be interpreted as the present value of future returns from utilising the land. Since land utilisation differs across bidders, their valuation will likewise differ, following a distribution $G(v)$. From this distribution, N bidders, who actually participate in the land auction, are drawn. An important assumption about the nature of uncertainty is that bidders do not know the valuation of their competitors. The number of participants (N) and the distribution of values $G(v)$, however, are known to all potential bidders.

The ex post return of the land plot for a bidder i is random and given by $v_i + \varepsilon$, with $E(\varepsilon) = 0$ and $Var(\varepsilon)$ being bounded. Assuming that bidders have an uncertain basic wealth, c, from other investments, the expected utility of the auction for bidder i can be expressed as in OOI et al. (2006):

$$(1) \quad EV_i = P(b_i, N) Eu(c + v_i - b_i + \varepsilon) \\ + (1 - P(b_i, N)) Eu(c)$$

where b_i denotes the bid of bidder i and P is the probability of winning the auction, i.e. making the highest bid. The first term on the right-hand side of (1) is

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[4] A first-price sealed-bid auction is an auction form where the bidders simultaneously submit their bids in a concealed manner, and the bidder with the highest bid is granted the possibility to buy the object for a price equal to his bid (MILGROM and WEBER, 1982). This auction form thus differs from the most common auction form, the English auction, where participants sequentially submit bids in an open manner and every new bid has to exceed the previous bid.
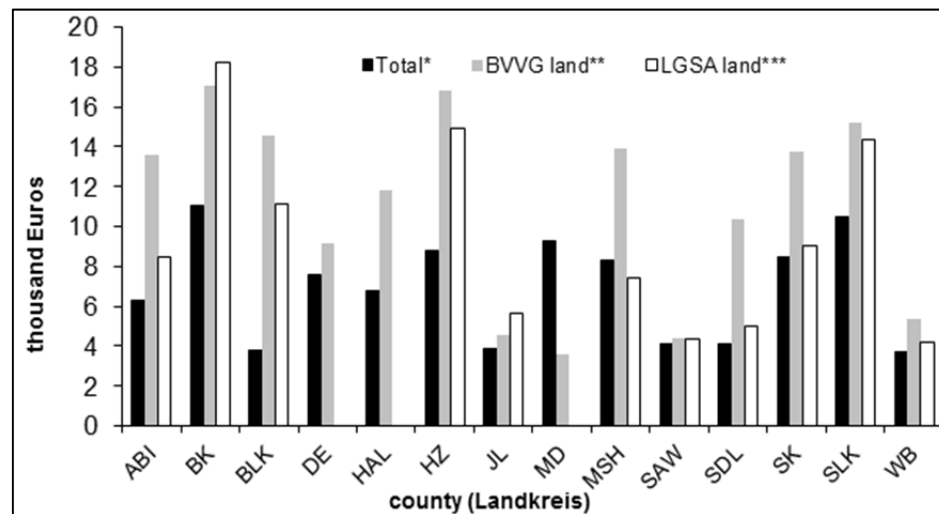
Figure 1a. Average agricultural land sale prices in Saxony-Anhalt 2003-2010
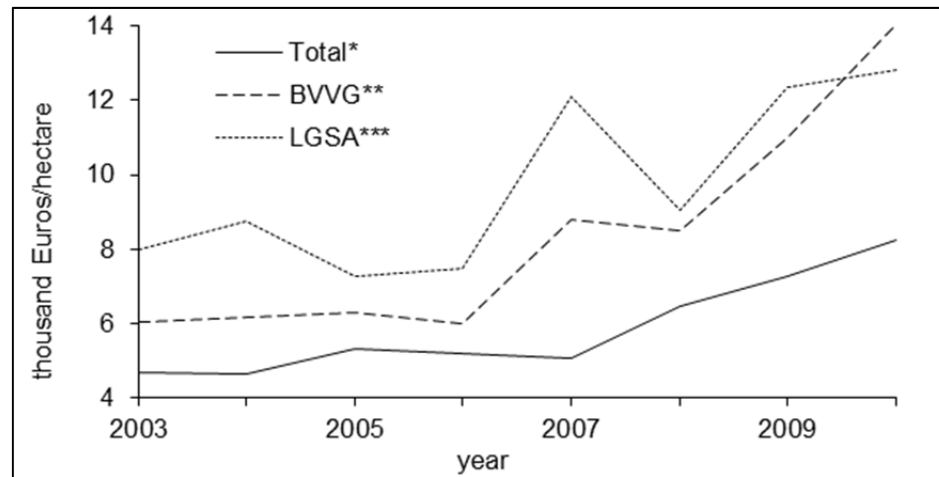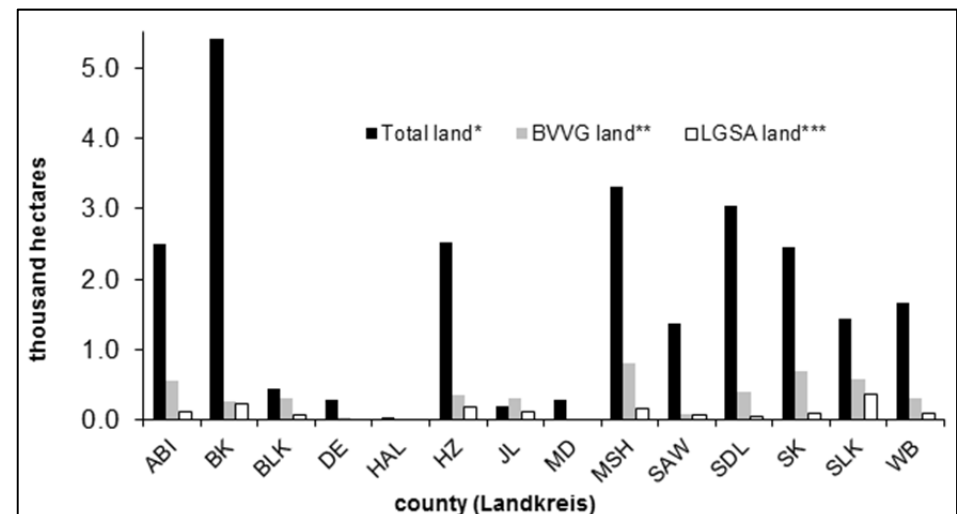

Figure 1b. Sold agricultural land in Saxony-Anhalt 2003-2010
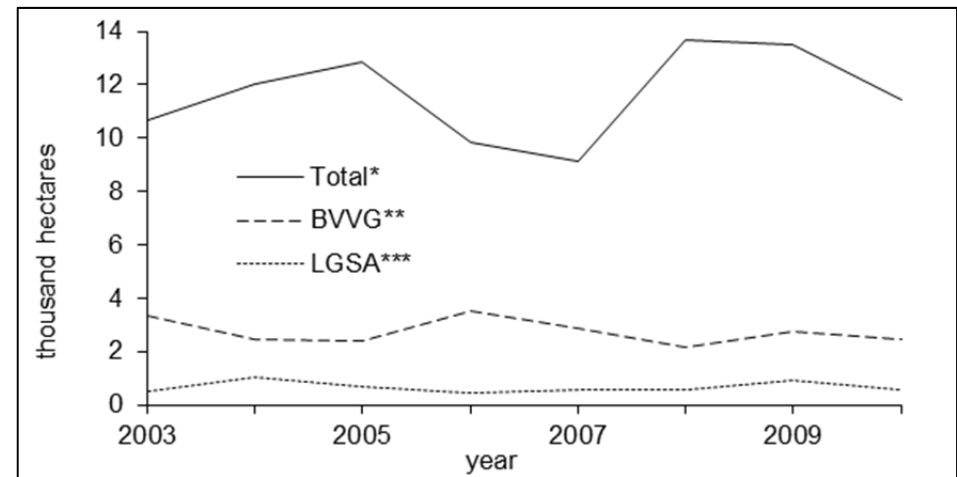
Figure 2a. Average sale price 2009-2010 in Saxony-Anhalt by county (Landkreis)

Figure 2b. Sold agricultural land 2009-2010 in Saxony-Anhalt by county (Landkreis)

Note: Total sales published by the statistical offices include beneficiary sales to previous owners.

Sources: *STATISTISCHES LANDESAMT SACHSEN-ANHALT (2010); **Meldesystem der BVVG, ab 2003 Controlling-Bericht der BVVG/Values obtained from data provided by BVVG; ***Values obtained from data provided by LGSA. Own compilation.

the expected utility in the case of winning the auction, and the second term represents the expected utility if a competitor wins the tender. Note that this probability is a function of the bid and the number of participants. Under the assumptions that: a) bidders are symmetric in a sense that they do not differ apart from their valuation; and b) their values are statistically independent from each other, the outcome of the auction can be derived as a Nash equilibrium (MCAFEE and MCMILLAN, 1987). The optimal bid b_i maximises eq. (1), and thus has to satisfy the first order condition:

$$(2) \quad \frac{\partial EV_i}{\partial b_i} = \frac{\partial P}{\partial b_i} \left(Eu\left(c + v_i - b_i + \varepsilon\right) - Eu\left(c\right)\right)$$

$$-P\left(b_i, N\right) \frac{Eu\left(c + v_i - b_i + \varepsilon\right)}{\partial b_i} = 0 \qquad .$$

Moreover, one can show that the probability of b_i being the winning bid is

$$(3) \quad P\left(b_i, N\right) = \left(\int^{v_i} dG\left(v\right)\right)^{N-1}$$

which equals the probability that all competing bidders have a lower valuation than bidder i. From (2) and (3), it is possible to derive optimal bidding strategies, b_i. However, here we are more interested in the comparative statics of the bidding strategies than in their explicit form. By inserting the probability (3) into the optimal bid condition in eq. (2) and implicit differentiation, OOI et al. (2006) prove that $\partial b / \partial N > 0$. This means that the optimal bid, and hence the expected equilibrium price of a private value auction, both increase with the number of bidders. This finding, which constitutes a testable hypothesis for our empirical model, can be intuitively explained as the demand effect and the effect of increased competition among the bidders[5]. An issue related to this variable is whether it should be treated as endogenous or exogenous. Usually the number of bidders is regarded as an exogenous determinant of the final auction price. An exception is LUCKING-REILEY et al. (2000), who argued that the number of bids is endogenously determined by the bidders' choices and therefore decided to not include it as a determinant.

The auction pricing framework also allows us to derive hypotheses on the price effect of land plot characteristics. To see this, we investigate the effect of a shift in the distribution of land values $G(v)$, which could be modelled by a shifting parameter θ, such that the expected land value becomes $v + \theta$. Substituting v in eq. (1), OOI et al. (2006) prove that the optimal bid is an increasing function of θ, i.e., $\partial b_i / \partial \theta > 0$. This result is not surprising; it simply tells us that the expected auction price will be higher if the land becomes more valuable for all bidders. In our empirical model we substitute the shift parameter θ by a function of observable land characteristics such as, for example, soil quality or plot size. In so doing, we capture all variables that are usually included in hedonic land price models.

A further comparative static result refers to the stochastic return from other investment projects, c. Similar to the land value, one can decompose these earnings into a mean value $\bar{c}$ plus a random term and analyse the effect of a rightward shift in this distribution. Carrying out similar steps as before, it can be shown that $\partial b_i / \partial \bar{c} > 0$. That means the higher the average return from other projects is, the higher is the optimal bid for the uncertain land return. An empirical test of this hypothesis is difficult, since information about the bidders' alternative earnings is rarely available. An indirect approach is to surmise that different groups of bidders have different returns from other projects, and to test for the significance of auction price differences between these groups. For example, it is often claimed that the participation of non-agricultural investors drives up prices in land auctions (cf. FORSTNER et al., 2011). We will take up this hypothesis in our empirical model.

An interesting feature of the land price auctions conducted by the LGSA is the pre-emption right of the current tenant, i.e. the option to buy the auctioned land at the winning bid. This option is valuable, because it causes an informational asymmetry and a last-mover-advantage for the tenant. The tenant needs not to participate in the auction, but can rather wait and compare the realised auction price with his private value. On the one hand, this entering option may reduce the auction price, because the number of bidders N will be smaller than without an entering option. On the other hand, one may argue that the winner of the auction will not receive the land if the bid is below the reservation price of the current tenant. Unfortunately, we cannot verify these conjectures, since in our data

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[5] Note that the number of bidders has a negative impact on the final auction price in a common value auction environment. The argument is that bidders in common value auctions are afraid of overbidding (winner´s curse) and as the number of bidders increases they become more cautious to avoid being the "cursed winner" (cf. HANSEN and LOTT, 1991; KAGEL and LEVIN, 1986).

set the entering option is always prevalent. Another variable that is relevant from the perspective of auction theory is the existence of a reserve price, i.e. a minimum acceptable bid which is announced prior to the auction's opening. According to MCAFEE and MCMILLAN (1987) an optimally chosen reserve price, i.e. one that is strictly larger than the seller's valuation of the good, will increase the expected price of an auction. The reason is that a reserve price allows the seller to skim off part of the winning buyer's rent.

4 Data and Empirical Model

4.1 Data and Descriptive Evidence

This study applies a hedonic pricing approach for cross-sectional data to explain land prices through the characteristics of the land plot, the surrounding (regional) conditions and the auction-specific variables. The econometric analysis uses data on purchase prices for land in Saxony-Anhalt that was provided by the LGSA. Our analysis focuses on purchase prices, since rental prices are to some extent derived administratively. The data covers the period from 2003 to 2010 and contains realised prices for all sold plots of land by the LGSA, which corresponds to 762 observations. Some observations have been removed from the original data set, including observations with missing values, pure horticultural and forestry plots, as well as plots containing only non-agricultural land (e.g. potential building land or minor land). The final data set consists of 722 observations that in total represent 5,231 hectares of agricultural land (arable land and grassland) sold during the observed period. The available data set contains, for each parcel of land sold, information about plot size and composition (arable-, grassland), soil quality, location (municipality and local sub-district[6]), period of call for bids, ending date of the call for bids, the number of bids, the number of

bids from non-agricultural bidders, the highest bid, the lowest bid, the final decision (winning bid), whether the winning bidder was the former tenant, whether the winning bidder is local, and the legal status of the new owner. This unique data set allows us to test the theoretical predictions discussed in section 3 concerning the impact of the public auction-specific variables, such as the number of bids, on the final price.

Table 1 provides descriptive statistics of the LGSA data for sale prices, characteristics of the sold plot (total size, share of arable land and soil quality), the number of bidders[7] and share of non-agricultural bidders. The average price is about 0.82 Euros per square metre over the entire time period, but this figure increased to 1.06 Euros per square metre in the last two years (2009-2010). The average soil quality equals 64 points[8], which is slightly above the average soil quality in Saxony-Anhalt (60 points). This indicates a relatively high quality of the plots sold by the LGSA. The share of arable land is rather high, with an average of 85 per cent. This high share is not surprising, since the plots of the LGSA are, as mentioned in section 2, mainly located in central and southern Saxony-Anhalt, whereas the main grassland regions are located further north (close to the Elbe River). The average number of bids per auction is 4, but shows some variation; the standard deviation is 3 and the maximum number of bidders was 17. Around 90 per cent of the offers were made by people related to the farm business, on average, per auction. In 48 per cent of the cases, the acceptance bid was made by the

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6 According to the NUTS (Nomenclature of territorial units for statistics) the classification used by Eurostat, Federal states ("Laender"), correspond to NUTS 1, and counties ("Landkreise") correspond to NUTS 3 (NUTS 2 does not exist in Saxony-Anhalt). However, local sub-districts ("Gemarkungen") do not have a notation in the classification systems used by Eurostat. In Germany, municipalities ("Gemeinden") consists of several local sub-districts ("Gemarkungen") and the German municipalities correspond to LAU 2 (previously NUTS 5) in the LAU (Local Administrative Units) classification system.

7 The decision to bid is made based on observable factors like soil quality, but also on unobservable factors like accessibility to the plot from the farmer's perspective. The latter are only captured by the error term of the empirical model and thus there might be a strong correlation between the number of bids and the errors. As noted by HAYASHI (2000), in such cases an endogeneity problem may occur which calls for an instrumental variables approach. Good instruments, however, are not available and the instrumental variables regression using weak instruments showed poor results.

8 The soil quality points can be interpreted as an index which is constructed such as to unify within one measure pedologic, scientific and (agro-)economic measures of potential yields from using the land. It is specified for each officially stated land parcel (several land parcels may constitute a plot of land). The higher the soil quality index, the higher is the potential yield and quality. Originally, the highest quality was declared as 100. In the meanwhile, the highest value that has been measured is 102 (note the LGSA dataset contains such plots) and the lowest value was 7 (theoretically, however, the lowest value it can take is 0).

Table 1.   Descriptive Statistics LGSA data 2003-2010 (722 observations)

Variable	Mean	Standard Deviation	Min.	Max.
Soil quality (points [0,102])	64	22	23	101
Plot size (ha)	7.25	3.47	0.06	26.48
Arable land (ha)	6.39	3.54	0	25.86
Share of arable land per plot (per cent)	85	28	0	100
Grassland (ha)	0.67	1.79	0	15.85
Number of bids	4	3	1	17
Share of bids from farmers per auction (per cent)	89	17	30	100
Dummy = 1 if the winning bidder is local	0.94	0.24	0	1
Price (Euros per square metre)	0.82	0.47	0.1	2.61

Data source: LGSA (2003-2010)

tenant, and in 94 per cent of the cases the winning bidder had a local background.

In the empirical model we consider three plot-specific *land characteristics* to capture natural price determinants: soil quality, share of arable land and plot size. The soil quality points reflect the potential yields and it is expected that the higher the soil quality points are, the higher the land price is. Similarly, the share of arable land is expected to influence the price positively since a higher share of arable land usually reflects higher possible returns. Plot size is considered separately for arable and grassland and is introduced in linear and quadratic forms in the model. For arable land we expect a positive impact of the linear term, since larger plots may have a cost-reducing effect that implies a higher willingness to pay per hectare compared to smaller plots. For example, a farm consisting of non-contiguous land plots will face costs of transporting machinery and labour between the plots. An additional issue is that the sold plots are in some cases only a fraction of the respective fields. That is, farmers have to combine different plots, partly by exchanging plots among neighbours, where larger plots may reduce related transaction costs. The quadratic term is included in order to allow for a non-linear relationship. Here we expect a negative sign of the coefficient, reflecting a reduction in the expected positive effect with increasing plot size. For grassland the expected sign is less obvious. It may be argued that, similar to arable land, larger plots may reduce machinery and transportation costs. However, grassland may also be treated as a necessary part of the whole tendered slot and the quality range of grassland is

rather broad, varying from high quality forage area to minor land being idle. This may reduce the willingness to pay for higher grassland shares. It should further be noted that it is not possible to control for the policy of the LGSA, which prohibits selling plots larger than roughly 10 hectares (with only some exceptions). Even though this may refer to a censored regressor issue from an econometric view-point, it is not possible to identify the plots as cut plots since no information about their initial size is available.[9]

Of particular interest are the *auction-related variables* such as the number of bids, the share of bids per auction coming from farmers and whether the winning bidder is local. The latter is considered as a dummy variable. As elaborated on in the previous section, the land price is expected to increase with the number of bids. Since different groups of bidders may also have different returns from other investment projects, it may be argued that non-agricultural bidders have a higher willingness to pay; this is taken into account by the share of bids coming from agricultural entrepreneurs, where a higher share is expected to be negatively related to the price. Moreover, residents (farmers and non-farmers) may have more detailed information, for instance about the local infrastructure, and this may be an advantage used for the optimal bidding strategy. This is captured by the dummy variable indicating whether the winning bidder is a resident. Even though it may be hypothesised that the presence of the guaranteed pre-emption right of the tenant may have an impact on the land price, it is not possible for us to measure the impact of this option since the information on whether the former tenant buys the land does not capture the impact of this right on the bidding strategy.

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[9]   Possibly, a censored regressor may induce a bias and the estimates may even be inefficient; however, accounting for the censoring within the estimation requires the identification of the censored observations. Further details can be found, for instance, in RIGOBON and STOKER (2007).

Since the data cover a time period of eight years, year dummy variables are included in the empirical model to account for yearly shifts in the price function (using 2003 as the reference year) and to capture possible effects of inflation (note that the average inflation rate from 2003-2010 was about 1.5 per cent).

The analysis is enhanced by *regional variables* describing the respective regional setting including the regional competition in the land market in which the land parcel was sold. It is well-known that, in addition to soil quality, the amount of precipitation and its distribution are important determinants for land productivity.

Table 2. Descriptive Statistics of the regional structural variables (county, "Landkreis", level including the cities of Halle (Saale) and Magdeburg unless otherwise indicated)

Variable	Mean	Standard Deviation	Min.	Max.
Regional exit rate (per cent, bi-annual)[a]	-0.019	0.019	-0.061	0.020
Tendered land by LGSA (hectares per local sub-district level)[b]	8.777	5.921	0.066	58.419
Installed kW from biomass per hectare of agricultural land (annual stock)[c]	0.011	0.015	0	0.077
Livestock unit per hectare of agricultural land (bi-annual)[a]	0.349	0.109	0.130	0.540
Value added excluding agriculture per inhabitant (annual)[d]	17.860	3.211	11.8	25.8
Precipitation (yearly average; local sub-district) (mm)[e]	518	44	432	669

Data sources: [A]STATISTISCHES LANDESAMT SACHSEN-ANHALT (2012); [b]LGSA; [c]KONARO (2012) and BNA (2012); [d]variable calculated using annual data for the period 2003-2009 obtained from Regionaldatenbank Deutschland (published by Official Statistics Federal Republic of Germany) available at http://www.regionalststatistik.de; predicted values were used for 2010; [e]Deutscher Wetterdienst

Therefore, we include the regional average of the annual precipitation sums from 1961-1990, resulting in a time-invariant variable that varies over the regional sub-districts (Gemarkung).[10] Regional characteristics, which may affect the price for land, include the amount of tendered land of the LGSA by local sub-district ("Gemarkung"), regional exit rates of farms, concentration measures of biomass plants and livestock, as well as the regional value added excluding agriculture per inhabitant to account for possible outside options or additional off-farm income. These variables are available at either the county ("Landkreis") level or local sub-district ("Gemarkung") level, and are summarised in Table 2. Besides these variables, there exist many unobservable factors that may have an impact on the land prices, such as regional infrastructure or land development plans. In order to capture such factors we include county dummy variables. It should be noted here that we use the old county specification (NUTS 3), used before the reform in 2007, because the number of counties is higher.

The variables "livestock density", "regional exit rate", "tendered land by sub-district", "regional value added" and "bioenergy cropping density" (discussed below) are included as explanatory variables, as they all reflect the regional competition in the land market.

"Livestock density" is the average livestock units per hectare at the county level (NUTS 3). This variable is used in lagged terms. For instance, the livestock density for 2003 is considered for price observations from 2004-2005 (for price observations in 2003, the livestock density in 2001 is considered). It should be noted that we face some data limitations since the available data on livestock units per hectare is only available bi-annually, and for 2005 only the overall average for Saxony-Anhalt has been published (here we use the values from 2003). The livestock density may account for regional land demand by livestock holders, and it is expected that the higher the livestock density is, the higher the regional demand for land is. Thus, a positive impact on the land prices is expected (cf. among others BREUSTEDT and HABERMANN, 2011, or FUCHS, 2002). It can be noted that the overall level of livestock units per hectare is rather low compared to other regions in Germany, and the measured impact is expected to be low.

The regional exit rate, together with the amount of land tendered by the LGSA, is used as a proxy for regional land supply. The availability of land may affect the bidders' strategy since land plots are substitutable, at least locally. Unfortunately, we do not have detailed information about the distribution of the agri-

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[10] Unfortunately, we cannot account for other parameters of the rainfall distribution.

cultural land in stock of the BVVG, i.e. the direct competitor of the LGSA. The latter may be partially captured by the county dummies. The regional exit rate is defined as the difference in the number of farms between two years. This variable was provided by the Statisches Landesamt Sachsen-Anhalt and is available on a county (NUTS 3) level on a bi-annual basis, implying that we are restricted to bi-annual exit rates. Therefore, the difference in number of farms between 2003 and 2001, for example, is used as a measure for exit rate in the years 2003 and 2004.[11] A positive sign of this variable means that the number of farms increased between the two years (a positive value must thus be interpreted as an entry rate), whereas a negative sign means that the number of farms decreased.

Off-farm income possibilities are accounted for by considering the regional value added per inhabitant, excluding agriculture on a county level (NUTS 3) as an explanatory variable. High value added per inhabitant reflects better off-farm income possibilities compared to regions with a lower productivity. It is expected that the higher the off-farm income possibilities are, the higher the exit rate is, and the more land will be supplied in the market. This in turn may be negatively related to the prices of the LGSA tenders. A positive impact may also be possible if the off-farm income possibilities create additional incentives for part-time farming and thereby increase the capacity to pay for land.

We further account for bioenergy cropping, as it is highly subsidised in Germany through the guaranteed price for the produced energy and may thus drive demand for land. Potential demanders are in this case farms having invested in bioenergy cropping, which is often based on long-term use of land. The variable "bioenergy cropping density" is defined as the annual stock of installed kilo Watts from biomass (including biogas but also short rotation coppice and others) related to the agricultural land by county. A high demand for land reflected by a high density of biomass within a region is expected to positively influence the price for land.

4.2 Specification of the Empirical Model

In order to find an appropriate model specification, two major steps are carried out. First, a Box-Cox test procedure is conducted to determine the appropriate functional form of the price function (DAVIDSON and MACKINNON, 2004). Second, based on the resulting model specification, possible spatial correlation in the residuals is tested for, as is, if present, the respective spatial model specification.

Applying the Box-Cox procedure we essentially test a linear model against a log-linear or log-log model. Linear here means that the left-hand side and right-hand side variables are linearly related; log-linear means that the left-hand side variable is, in logarithmic form, linearly related to the right-hand side variables; log-log implies that both sides are in logarithmic terms. The test is based on transformation parameters – one for each equation side – where a parameter of one means no transformation and a parameter of zero implies a logarithmic transformation. In the literature it is recommended to keep the transformations as simple as possible (cf. OSBORNE, 2010). This strategy is further supported by the fact that the Box-Cox testing procedure involves some disadvantages under a possible spatial correlation, which may even lead to imprecise results (BALTAGI and LI, 2004). Note that we try to reduce the possible spatial correlation within the Box-Cox model as much as possible through the inclusion of regional variables and the county ("Landkreise") dummy variables. Accordingly, since the transformation parameter for the explanatory variables (excluding all dummy variables), at 0.864 is close to one (i.e. in the range from 0.75-1.25), we do not transform the right-hand side variables in the final model specification. The transformation parameter for the land prices (left-hand side variable) is, at 0.166, close to zero (i.e. in the range of -0.25-0.25). Accordingly, we take the natural logarithm of the land prices, resulting in a log-linear model. Thus,

$$(4) \quad \ln(p_i) = \sum_k x_{ik}\beta_k + \sum_l d_{il}\delta_l^{county} + \sum_t d_{it}\delta_t^{year} + e_i$$

where $\ln(p_i)$ denotes the natural logarithm of the price in Euros per square metre of the ith observation, with i now indexing the plots (note that they are sold in different periods and belong to different sub-districts, which is not indexed here) with $i=1,…,722$. In the ith row of the matrix of k explanatory variables denoted by $\sum_k x_{ik}$, i.e. land characteristics of the ith observation, are summarised, and vary with each parcel. This

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[11] In one case there is a three year gap (between 2007 and 2010). The number of farms exiting between 2007 and 2005 has been used to derive the respective exit rate for price observations in 2007, 2008 and 2009.

108

matrix also contains the structural variables and regional characteristics varying at the local sub-district and county level, respectively (these are directly related to the observed prices). Further, d_{il} denotes the regional county dummy-variables of the ith observation and d_{it} the respective time-dummy variables, while l indicates the respective region (county) and t indexes the respective year of purchase, excluding the year 2003 since it serves as the reference year. Lastly, β_k, δ_l^{county} and δ_t^{year} denote the respective vector of parameters to be estimated and e_i denotes a disturbance term.

Many previous studies find that land prices are spatially correlated, i.e. prices show a dependency on neighbouring prices (e.g. PATTON and MCERLEAN, 2003). As can be seen from Figure 3, prices differ regionally. Also, regions with high prices show a high soil quality, and one may argue that controlling for these variables will remove spatial price correlation in the regression analysis. Nevertheless, other factors for which we cannot account may embody possible sources of spatial correlation. Examples of such factors are regional land market settings, regional infrastructure, or rainfall distribution. In the price regression (eq. (1)) we only account for regional variation by means of structural variables and county dummies. Nevertheless, due to the unobserved factors, we expect the error terms of the regression model in (4) to be spatially correlated.

Technically this means that after having specified the functional form, it is necessary to test for possible spatial correlation. For this step it is necessary to define the spatial relationship or contiguities within the price data. This is achieved by the spatial weight or contiguity matrix (see LESAGE and PACE (2009) for further details).

Since our data set does not provide any information about spatial coordinates of the land plots, we refer to the local sub-district levels (Gemarkung) to indicate contiguities. This lack of information prevents us from referring to the distance between plots as an indicator for neighbouring plots. We, therefore, opt for a binary weight matrix based on the Queen Contiguity scheme. The latter implies that for each plot of land, the surrounding plots with a common border are indexed as being neighbours. For our data, we assign, for each observation within a local sub-district, the observations in the neighbouring (i.e. common border) local sub-district as neighbours. The binary weighting scheme implies that neighbouring plots are indexed by a "1" in the matrix, the main diagonal, and all remain-

Figure 3. **Average prices in Euros per square metre of each "Gemarkung" 2009-2010**
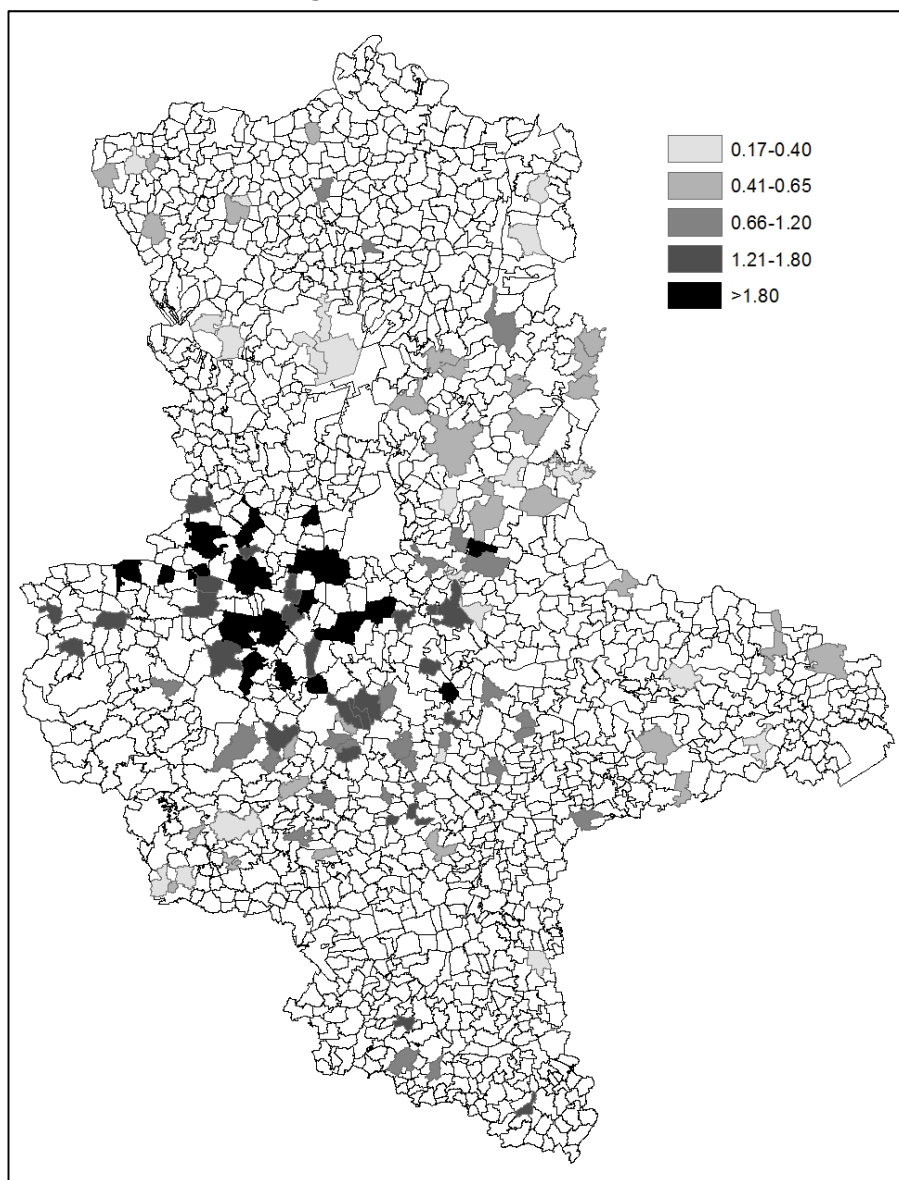
Data source: LGSA (2009-2010)

ing elements are indexed by "0". We further assume that all plots located within a local sub-district are neighbours and are weighted with a "1". It is common to use a row-standardised weight matrix (LESAGE and PACE, 2009); that is, each element is divided by its respective row sum such that each row of the matrix sums up to one. This has the advantage that the spatially-lagged variables (e.g. the prices multiplied by the weight matrix) may be interpreted as the locally-weighted average of the neighbouring variables' values. Note that the weighting scheme is time-independent.

The test for spatial correlation within the residuals from the regression model in equation (4) is carried out using the Moran statistic (ANSELIN, 1988). The respective Moran statistic reveals a value of about 0.065, with a p-value of 0.011. The positive and significant spatial correlation implies that we likely observe high prices in regions where the average neighbouring prices are also high; this is also indicated by Figure 3 (a negative value would imply a chessboard structure, where high and low prices co-exist within a region).

Since we cannot reject the presence of any spatial correlation and we cannot capture the main sources of it, e.g. regional land market settings and others, it is necessary to consider it in the price regression. Spatial correlation may either be taken into account by adding the spatially weighted average of the prices (spatially lagged dependent variable) as an additional explanatory variable (spatial lag model), or by means of a spatial error model wherein a spatially autoregressive process of the disturbances is modelled (see ANSELIN (1988) for further details). To decide whether a spatial lag or a spatial error model is appropriate, we conduct a further specification test based on the Lagrangean Multiplier. Since the spatial lag model inherits the spatial error structure we must refer to the robust test version (cf. ANSELIN, 1988, and YANG, 2010). The results show that the spatial error model is rejected at the 5 per cent level but not at the 10 per cent level, whereas the spatial lag model is not rejected at all. We opted for the spatial lag alternative.

The model finally used is thus given by:

$$(5) \quad \ln(p_i) = \rho \sum_j w_{ij} \ln(p_j) + \sum_k x_{ik}\beta_k$$
$$+ \sum_l d_{il}\delta_l^{county} + \sum_t d_{it}\delta_t^{year} + e_i$$

where w_{ij} denotes the elements of the spatial weighting matrix such that $\sum_j w_{ij} \ln(p_j)$ denotes the spatially-lagged natural logarithm of the prices with $i \neq j$. The

latter may be interpreted as the regional average prices of the neighbouring plots (prices of the other plots in the local sub-district and prices achieved in the surrounding local sub-districts are taken into consideration here). The respective parameter ρ measures the impact of the spatially-weighted average of all neighbours' land prices on the respective price observation i. This model is estimated using the method of maximum likelihood due to the spatial structure (see ANSELIN (1988) for further details).

5 Results and Discussion

The results of the log linear spatial lag model are presented in Table 3. Since the model is estimated by spatial maximum likelihood and the residuals are, by definition, not uncorrelated, we cannot refer to the commonly-known R-squared to assess the overall performance of the model. Thus, we refer to the squared correlation coefficient that indicates the degree of linearity in the relationship between natural logarithm of the price and its explanatory variables. The value of this coefficient, 0.853, is within an acceptable range. The recent price increase, depicted in Figure 1a, is reflected by the significant positive estimates of time dummies beginning in 2008. In what follows we group the interpretation of the coefficients as introduced above.

Land Characteristics

The theoretical model described in section 3 considered a parameter, θ, functioning as a shifter in the bidders' valuation of land. In our empirical model, θ is represented by a vector of observable variables expected to influence the potential buyers' valuation of land, which are commonly considered in hedonic pricing models. These include the regional and structural variables described in section 4.1. As these variables function as shifters in the bidders' valuation, and since a higher valuation implies a higher winning bid in the auction, they are expected to influence land price in the same way as in any empirical land price model. Not surprisingly, soil quality has a significant positive impact on land price. The coefficient of this variable is 0.01, i.e. an increase of 1 soil point causes the land price to increase by 1 per cent. Referring to the overall sample mean, this coefficient translates into an absolute price increase of about 80 Euros per hectare. Also, a higher share of arable land increases the land price significantly.

The expected impact of the lot size, however, is less obvious. There are reasons to expect a positive impact of both plot and field size on land price since larger plots reduce, for instance, machinery costs, resulting in a higher willingness to pay per ha. In contrast to this kind of reasoning, several empirical studies, such as XU et al. (1993), found a negative effect of parcel size on land values. Our results are inconclusive in this respect: none of the four coefficients related to plot size, i.e. linear and quadratic terms of the size of arable land and grassland, are significantly different from zero. This may be partly due to the fact that only a few plots are larger than approximately 10 hectares, which arises from the aforementioned policy of the LGSA not to sell larger plots. Experts doubt that it is possible to observe a size effect within this range of plot size. Moreover, the sold lots do not necessarily consist of one plot, i.e. the lots themselves may be fragmented, which is not documented within the dataset. In addition, auxiliary regressions revealed that the number of bids is significantly influenced by soil quality, the absolute size of the arable land of the plot and the installed electric power from biomass plants per hectare agricultural land. This may imply that the size effect is weak and already captured in the number of bids.

Table 3. Results of the spatial lag model

Land price determinant	Estimated Coefficient	P-value
Land characteristics		
Arable land (absolute, ha)	0.013	0.149
Arable land squared	-0.000	0.606
Grassland (absolute, ha)	-0.026	0.171
Grassland squared	0.001	0.368
Per cent of arable land	0.414	0.000***
Soil quality	0.011	0.000***
Auction related variables		
Number of bids	0.033	0.000***
Share of bids from agriculture (per cent)	-0.217	0.001***
Local buyer (dummy; yes = 1)	0.061	0.090*
Tendered land of LGSA per local sub-district	0.000	0.901
Regional and spatial variables		
Installed kW from biomass per hectare agricultural land per county	1.360	0.038**
Regional share of exiting farms (per cent)	-0.301	0.511
Precipitation (log-scaled; mm; local sub-district)	-0.022	0.833
Regional value added excluding agriculture per inhabitant	-0.009	0.363
Livestock density (LU per hectare by county)	0.243	0.361
Weighted average of neighbour prices (ρ, spatially lagged dependent)	0.181	0.000***
Location dummies		
Salzwedel	-0.199	0.336
Stendal	-0.292	0.152
Jerichower Land	-0.402	0.047**
Wittenberg	-0.234	0.236
Sangerhausen	0.043	0.821
Bördekreis	0.069	0.716
Halberstadt	0.145	0.439
Wernigerode	0.239	0.215
Quedlinburg	-0.022	0.908
Saalkreis	-0.182	0.327
Ohrekreis	-0.267	0.196
Mansfelder Land	-0.172	0.395
Bitterfeld	-0.113	0.575
Aschersleben	-0.108	0.567
Bernburg	-0.168	0.380
Schönebeck (Elbe)	-0.059	0.753
Anhalt-Zerbst	-0.310	0.101
Köthen	-0.062	0.737
Merseburg-Querfurt	-0.051	0.782
Weißenfels	-0.181	0.389
Burgenlandkreis	0.001	0.995
Dessau-Roßlau	-0.121	0.493
Year dummies		
2004	-0.012	0.689
2005	-0.048	0.173
2006	-0.045	0.272
2007	0.043	0.383
2008	0.203	0.000***
2009	0.286	0.000***
2010	0.370	0.000***
Constant	-1.542	0.039**

Note: ***, ** and * denote significance at the 1, 5 and 10 per cent levels, respectively.
Source: own calculations based on LGSA data (2003-2010)

Regional and Spatial Variables

The impact of the considered regional variables is mixed. A significant positive effect of the regional density of biomass plants measured in terms of installed kilo Watts per hectare in the counties confirms the results as reported by BREUSTEDT and HABERMANN (2011) for rental prices. Likewise, a positive but insignificant impact of the regional income level (value added per inhabitant) is in line with previous studies, e.g., BREUSTEDT and HABERMANN (2009) and HUANG et al. (2006). The coefficient of the livestock density has the expected sign, but is not significantly different from zero. The same holds for the regional exit rate, which may be explained by the fact that the farm size distribution in the study region is highly

111

skewed, i.e. it is conjectured that exiting small farms do not release much land. The variable accounting for the amount of tendered land by local sub-district of the LGSA is also not significant. Thus, both variables directly accounting for general land market activity turn out not to influence the price. The spatially-lagged dependent variable is the weighted average of the neighbouring prices (due to the row-standardised weight matrix), and shows, however, a significant impact on the land prices; taking a value of 0.181, the coefficient is in the acceptable range between zero and one. The rainfall variable is non-significant; a possible explanation is that the employed spatial modelling approach and the county dummy variables may already capture regional differences in rainfall. Interestingly, only the dummy variable for Jerichower Land (known for good natural conditions such as preferable rainfall distribution) shows a significant positive impact on the observed prices.

Auction Related Variables

Perhaps most interesting in view of the objective of this study is the discussion of variables related to the auction process and its bidders. The number of bids is highly significant and has a positive sign, which is in line with the hypothesis derived in section 3 assuming an independent value auction framework. One should note, however, that this finding could also be explained by the winner's curse in a common value auction if one assumes that bidders are not fully rational in the sense that they do not act strategically optimal, but may be subject to overoptimistic expectations.

Another remarkable result is that realised land prices are higher the lower the share is of agricultural bidders in an auction. FORSTNER et al. (2011) report that farmers in the "Bördekreis" county are concerned about activities of non-agricultural and/or non-residential investors in the land market because this engagement will drive up price levels. Our study provides empirical evidence that supports this expectation. Unfortunately, we do not have further information about the objectives, expectations and financial power of non-agricultural investors. This means it is not possible to trace the willingness to pay higher prices back to special buyer characteristics, such as, e.g. diversification of assets or optimistic assumptions about future returns from agriculture. However, it is likely that non-agricultural investors interested in buying land face less financial constraints compared to farmers. Differences in financial power and liquidity between agricultural and non-agricultural investors may also explain the fact that land is bought by inves-

tors and then rented out to local farmers.[12] Another explanation of the price-increasing effect of the share of non-agricultural investors is offered by the theoretical model in section 3, which relates optimal bids to the expected return from alternative investments. It may be assumed that non-agricultural investors can realise benefits from more diversified portfolios than farmers do, and therefore offer higher bids. However, one should be careful in concluding that non-agricultural investors in general are in a superior position when bidding for agricultural land. Actually, we find that the realised auction price is higher if the winning bidder is a resident. Indeed, local bidders may have informational advantages such as knowledge about land development plans and local infrastructure that is necessary to assess whether the agricultural land may later be converted to building land. Such information may allow them to better reflect the returns from their investment into land. In cases where local buyers are farmers, this finding can be explained by lower marginal costs of utilising the land, particularly due to lower transportation cost, or to lower transaction costs that residential farmers face compared with other bidders.

6 Conclusions

Empirical evidence indicates that specific land market mechanisms, such as public auctions, have a significant impact on land prices. This paper analyses how land prices are formed under public auctions for the case of Saxony-Anhalt, Germany. Our study is based on a unique data set covering public auction data of approximately 700 calls for bids from 2003-2010 by the Landgesellschaft Sachsen-Anhalt. A spatial econometrics approach was employed to account for spatial correlation among land prices. The results showed that auction-specific variables have a statistically significant impact on the realised land price and the direction of the effects was consistent with predictions from auction theory. In particular, the number of bids turned out to have a positive impact on the final price. Moreover, we find that the higher the land prices are, the higher is the share of non-agricultural bidders in the auction. The realised auction price is also higher if the winning bidder is a resident. The effect of plot size on land prices remains ambiguous; its impact is found to be insignificant, but this may possibly be due to the

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[12] Some experts reported sale-and-lease-back activities by farmers.

capping of plot sizes by the LGSA to a level lower than what field sizes are. Moreover, auxiliary regressions using the number of bids as dependent variable revealed that the plot size for arable land positively and significantly affects the number of bids, which in turn increases the price. This suggests that there is an indirect positive effect of plot size on land prices; the more attractive a certain lot is regarding size and characteristics, the higher is the competition for it and thus also the relative price.

Despite these empirical insights, this study is only a first step towards understanding the formation of prices in public land market auctions. Several features of land market auctions and their impact of realised prices remain to be explored. For example, the effect of making the winning bid publicly available by the BVVG could not be assessed with the data used in this study. It would also be interesting to analyse whether learning effects exist among the bidders. Another effect that needs to be explored in future work relates to the pre-emption right of the tenant to take over the highest bid and buy the land for that price, which the LGSA guarantees all their tenants. A quantification of this effect was not possible with the sample used in this study since the pre-emption right is present in all observations, thus preventing a comparison of prices with and without this option. Similarly, isolating the effect of the plot-capping by the LGSA, which is to avoid selling plots large than 10 hectares, requires the identification of the cut plots in order to relate cut to non-cut plots. Land auctions administered by the BVVG, for example, would offer the possibility to compare plots and their respective prices in order to evaluate the permanent tenant option and the capping. Since the prices achieved by both suppliers are based on first-price sealed-bid auctions with public tenders, it may be presumed that their rules basically differ in these two points. We conjecture that the permanent entry option, as well as the capping of plots, reduces the price in LGSA auctions compared to BVVG auctions. Assessing the impact of these two issues on the land prices would allow the quantification of the forgone revenues from land sales that the LGSA encounters in order to promote their objectives regarding agricultural structure in Saxony-Anhalt.

A comprehensive analysis of land markets also requires the consideration of other, non-structured market segments. Land sales on traditional search markets, which have the highest share in land market transactions in Saxony-Anhalt, constitute an alternative to land auctions. As mentioned above, average prices realised on auctions are considerably higher compared to the traditional market. This price difference led to complaints that public auctions of former state-owned land increased land prices in the new federal states and thereby jeopardised existing farms. A direct comparison of these market segments is certainly not possible without controlling for further price-relevant factors such as the social relationship between buyer and seller. Nevertheless, the real estate literature provides theoretical and empirical evidence that land can be sold with a mark-up on auctions (e.g. LUSHT, 1996; QUAN, 2002). With regard to the ongoing land privatisation processes in former centrally-planned economies, we suggest the study of price formation in different land market segments as a promising area of further research.

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Appendix

Abbreviations used for counties (“Landkreise”)
in Figures 2a and 2b

ABI   – Anhalt-Bitterfeld
BK   – Börde
BLK   – Burgenlandkreis
DE   – Dessau-Roßlau, Stadt
HAL   – Halle (Saale), Stadt
HZ   – Harz
JL   – Jerichower Land
MD   – Magdeburg, Stadt
MSH   – Mansfeld-Südharz
SAW   – Altmarkkreis Salzwedel
SDL   – Stendal
SK   – Saalekreis
SLK   – Salzlandkreis
WB   – Wittenberg