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# PRICE FORMATION IN AGRICULTURAL LAND MARKETS - HOW DO DIFFERENT ACQUIRING PARTIES AND SELLERS MATTER?

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## Abstract

This paper sets out to empirically analyse land price formation in Saxony-Anhalt with the aim to quantify the impact of sellers' and acquiring parties' structural identity on land prices. We use a hedonic price regression with a detailed data set covering the years 2009–2010. Besides productivity, neighbourhood and location attributes, we control for the major privatization agency as a seller, farmers as sellers or buyers and if tenants purchase the land. The model is estimated using spatial-econometric techniques where weight matrices are not only based on pure air distances, but also on travel time. We further take into account that price levels of adjacent parcels have an impact but only if they are observed prior to the respective price formation process. We find that prices realised by the major privatization agency are on average higher, and if the former tenant purchases the land, a lower price is realized.



## Keywords

farmland prices, hedonic model, spatial correlation, spatio-temporal model

**JEL-codes:** Q 11, Q 15, D 44, C 21

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## 1 Introduction

Farmland prices in the European Union and many other regions have increased considerably in recent decades. This is also true for Germany, where land prices increased by nearly 50 % from 2003-2012 according to the official statistics (DESTATIS, 2012). In view of these price increases, debate continues about whether land is still affordable for active farmers; this is particularly relevant for East Germany, where tenants often need to buy their land to avoid losing it to the privatisation process. Considering these issues, is it unsurprising that calls for policy intervention like price boundaries or regulations have arisen? But what are the reasons for the recent price developments?

A main driver for the growing attractiveness of investments in agricultural land is the recent boom in food prices, which may further be enforced by highly subsidised bioenergy cropping (cf. BREUSTEDT and HABERMANN, 2009; VON WITZKE et al., 2009). Moreover, the 2008 financial crisis has reduced the profitability of other financial assets, leading to a (re)discovery of the agricultural sector, also by non-agricultural investors. It has been shown when confidence in money investments based on derivatives is low land is used to store wealth, or is used as a hedge against inflation (e.g., DEININGER and FEDER, 2001). In view of these developments, the question has been raised regarding whether and to what extent non-agricultural

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investors have caused the price developments (cf. CIAIAN et al., 2012). Though the role of financial investors is heatedly discussed among stakeholders, there is little empirical evidence on this issue. For example, FORSTNER et al. (2011; 2013) emphasise that the group of non-agricultural investors in German land markets is heterogeneous and has to be differentiated with regard to the scale of investment, regional involvement and origin of capital. A statistical analysis of the effect on land sale prices, however, has thus so far not been undertaken.

Besides the increased demand, the fact that the overall supply of land is limited adds to this development. In Western countries the overall availability continuously declines because land is taken out of production for recreation or ecological compensation areas as well as land needed for buildings or street/ motorway construction. Given that all land is utilized, land supply in the local market emerges if farms cease production (private suppliers) or former owners wish to sell the land instead of renting out. In East Germany a considerably large portion of agricultural land is still state-owned; thus, the assigned state agencies act as major land suppliers in addition to private sellers. Sales of formerly state-owned land in the new German federal states are carried out by the Bodenverwertungs- und -verwaltungs GmbH, i.e. the Land Utilisation and Administration Company (BVVG), as well as public land agencies serving as non-profit settlement companies for each federal state[2] with the aim to preserve and strengthen rural regions, for example the Landgesellschaft Sachsen-Anhalt mbH (LGSA). It is frequently hypothesized that land prices realised by public land agencies are, on average, higher compared to those from private sales. One argument for this is that non-agricultural investors are attracted because public agencies use first price sealed bid auctions with public tenders and publish the realized prices, which in turn may ease finding a reference price for the bid (cf. BÖHME, 2009).

The specific role that different buyers and sellers may have in the price formation process, however, remains relatively unexplored in the quantitative literature. Numerous hedonic pricing studies (cf. PALMQUIST, 1989; PALMQUIST and DANIELSON, 1989; PATTON and MCERLEAN, 2003; BREUSTEDT and HABERMANN, 2011) explain the land prices by productivity characteristics, neighbourhood characteristics, location, and environmental characteristics. HUETTEL et al. (2013) further argue that the market mechanism itself has an impact on prices.

At this point we aim to shed light on the role of different acquiring parties and sellers within the price formation process. The potential effect of the sellers' structural identity, i.e. institutions versus private persons, corresponds with the impact of the market mechanism: state-owned agencies usually sell land using first price sealed bid auctions, whereas private sellers use either first price auctions that are locally published or direct negotiations with potential sellers, where prices achieved within a first price sealed bid auction with public tenders are found to be higher compared to other market mechanisms. With regards to the acquiring parties, it is often hypothesised that non-agricultural buyers bid more 'aggressively' in the sense that they may benefit from more diversified portfolios than farmers do, and therefore are able to offer higher bids. Furthermore, non-agricultural investors that are interested in buying land very likely 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 investors and then rented out to local farmers (cf. FORSTNER et al., 2013). On the other, local buyers or local farmers may have better information with regards to local infrastructure, soil quality and constitution, and land development plans.

Against this background we aim to empirically analyse land prices for Saxony-Anhalt, one of the federal states in East Germany. Using the official data from Saxony-Anhalt covering all land transactions in the years 2009 and 2010 (LVERMGEO, 2013), we pursue to quantify effects of different sellers, such as private sellers or the state-agencies like the BVVG. We fur-

[2] 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.

ther explore whether a price effect exists if a farmer or the former tenant buys the land or if a person unrelated to the (local) farming business wins the final acceptance bid. We use a hedonic price regression model and explain the land prices using lot-specific productivity characteristics, neighbourhood and location variables, and variables accounting for sellers' and acquiring parties' identity: the BVVG, farmers or tenants, respectively. We estimate the hedonic price regression using spatial-econometric techniques and compare a standard general spatial model with a spatio-temporal modelling approach to appropriately consider time effects as suggested by PACE et al. (1998) and MADDISON (2004). In contrast to other studies, our approach uses weight matrices not only based on pure air-distances, in addition a travel time-based distance weight matrix is used.

The remainder of the paper is organized as follows. We first describe the land market in Saxony-Anhalt, as well as the data employed in our study. This is followed by a description of the empirical model and an introduction to the spatial and spatio-temporal estimation approach. We then present the results and close with some concluding remarks.

## 2 The market under study: background information and data

### 2.1 The farmland market in Saxony-Anhalt, East Germany

As all the federal states in East Germany, Saxony-Anhalt's agricultural structure and land market is influenced by the Eastern German history of expropriation, land collectivization and socialistic policy between 1945 and 1989. After the German reunification in 1990, a privatization agency (Treuhandanstalt) administrated and started the privatization of the formerly state-owned properties including agricultural and forest assets (DELLS, 2008). In 1992, the Bodenverwertungs- und -verwaltungs GmbH (BVVG) has been established and took over the tasks of the Treuhandanstalt privatization agency with regards to the management, privatization and restitution of the agricultural / forest land on behalf of the ministry of finance. Since 2007 the formerly state-owned land is sold at market prices. Tenants have the general option to buy directly at the market value which considers the auction-based prices from comparable lots (Müller, 2011). These sales have a share of about one third on average over all East German Federal States (FORSTNER et al., 2011).

In addition to the BVVG, the Landgesellschaft Sachsen-Anhalt mbH (LGSA) is another institution that supplies formerly and currently state-owned land. BVVG and LGSA sell the land using first-price sealed-bid auctions with public tenders. The selling strategies of both suppliers are independent of each other (cf. HUETTEL et al., 2013). The main difference of the LGSA compared to the BVVG is that 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. According to the LGSA, approximately 80 % of the tenants make use of this right (cf. FORSTNER et al., 2011). Another difference is that according to the current law of privatization the lot size should not exceed 50 ha (exceptions possible); the LGSA uses a more restrictive policy and avoids lot sizes with more than 10 ha.

In Figure 1a the average prices are illustrated; prices obtained by LGSA and BVVG are higher compared to the average price published in Saxony-Anhalt (including all observations); the regional levels differ considerably. In the majority of the counties ("Landkreise") in Saxony-Anhalt the BVVG achieved higher prices in 2009 and 2010 compared to the LGSA, as well as to the officially published sales containing also private land sales. Both institutions are active in all counties as shown in Figure 1b. The LGSA always has a lower share compared to the BVVG, which has on average a market share of roughly 20 per cent over the past 15 years (BVVG, 2010).

**Figure 1a: Average sale price 2009-10 in Saxony-Anhalt by county (Landkreis)**

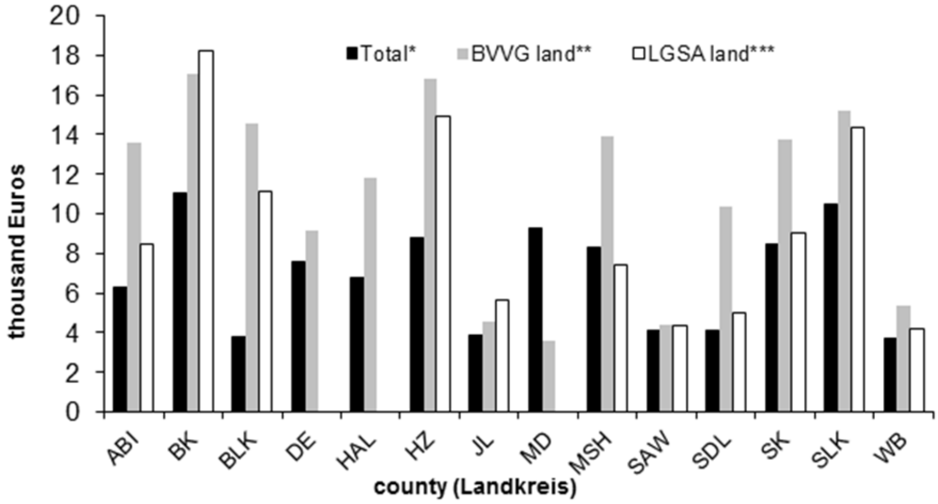
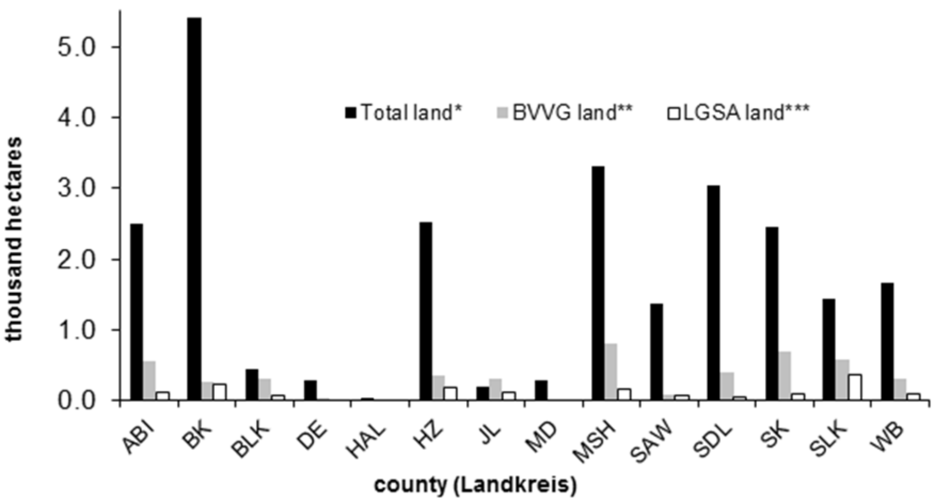



**Figure 1b: Sold agricultural land 2009-10 in Saxony-Anhalt by county (Landkreis)**



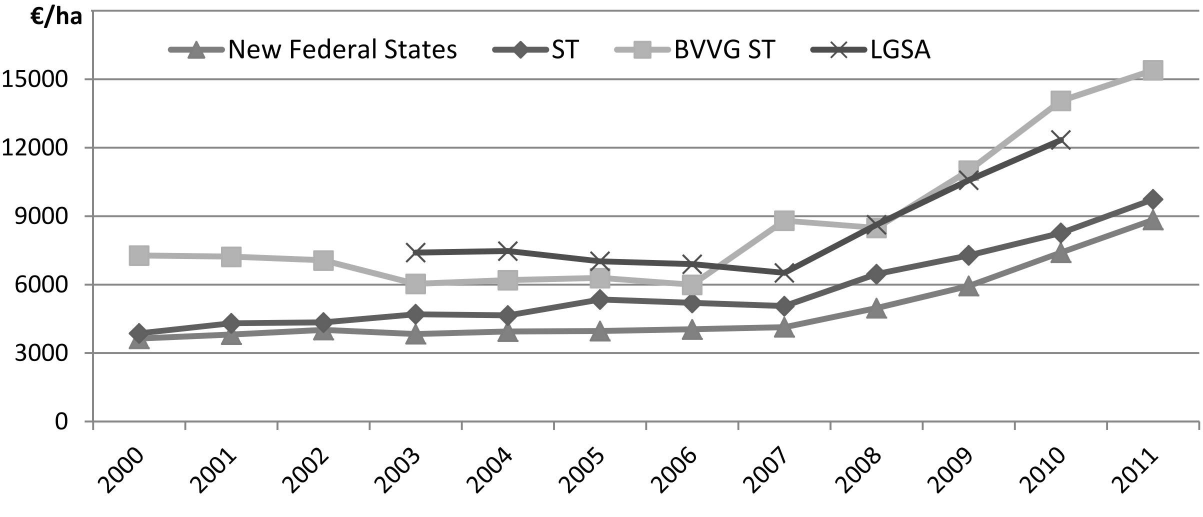

Abbreviations used for county ("Landkreis"): ABI – Anhalt-Bitterfeld; BK – Börde; BLK – Burgenlandkreis; DE – Dessau-Roßlau, Stadt; HAL – Halle (Saale), Stadt; HZ – Harz; JL – Jerichower Land; MD – Magdeburg, Stadt; MSH – Mansfeld-Südharz; SAW – Altmarkkreis Salzwedel; SDL – Stendal; SK – Saalekreis; SLK – Salzlandkreis; WB – Wittenberg
Data Sources: *STALA (2010b); **Meldesystem der BVVG, from 2003 onwards Controlling-Bericht der BVVG/Values obtained from data provided by BVVG; ***Values obtained from data provided by LGSA.

On the demand side, it is mainly the growing farms that buy the land, but also the tenants buy land not to losing the farm area/ size. Other reasons for farmers might be to increase the equity ratio and to improve the financial stability of the respective farm/ holding. Farmers may have advantages in terms of costs and may better evaluate their returns from buying the land. Further, they may only participate if they have advantages and are thus able to bid higher or gain from cost advantages compared to other bidders. The average farm size in Saxony-Anhalt is about 280 ha of which 79 % of the area is rented. Single farms or family farms have an average size of about 116 ha and make up a share of 28 % of total utilized agricultural area (UAA) (STALA, 2010a).

Formerly state-owned farms or typical GDR-type production cooperatives now being cooperatives or corporates have an average size of about 391 ha and 911 ha, respectively. Corporates are on average larger than the cooperatives and this often goes along with a better liquidity situation as well as financial stability. This in turn may provide an advantage in their bidding strategies such these farms are able to bid higher for land (cf. FORSTNER et al., 2013). Cooperatives often face financial restrictions due to compensation claims of former members/owners. This may have two implications: cooperatives face disadvantages in their bidding strategies, that is, they cannot bid as high as comparable corporative firms without compensation claims, and furthermore, they are more open to equity investments. According to FORSTNER et al. (2013) such investors often come from West German regions but are related to the agricultural business. Through their direct participation, such equity investments are not identifiable for outsiders but provide cooperatives advantages in their bidding strategy. Observable, however, is whether the land is sold to firms / persons not being directly related to the agricultural business. There is an on-going discussion whether non-agricultural investors have substantial price-increasing power. Since the identification of such investors is difficult, it remains a challenge.

In Figure 2 the average prices for farmland for East Germany, Saxony-Anhalt (ST), the BVVG and the LGSA over time are shown. From 2007/08 on the prices considerably increased. Based on this graph, however, it is not possible to evaluate whether the prices differences are because of the different sellers or other reasons, e.g., such as different qualities.

**Figure 2: Average per hectare prices for farmland in Saxony-Anhalt and East Germany**




Data Sources: www.bodenmarkt.info, www.destatis.de, StaLa (2010b), data directly provided by LGSA (2003-2010).

## 2.2 Data and hypotheses

We use data from the official institution being responsible for collecting the data from all land transactions according to German law, the "Landesamt für Vermessung und Geoinformation (LVermGeo)". The data set contains all land sales in the years 2009 and 2010, but sales between relatives or unusual conditions were excluded before we received the data (LVermGeo, 2013). For each price observation further information about the lot size, the main usage of the land, soil quality indices[3] for arable and grassland, the respective community (Gemeinde) where the lot is mainly located and the exact date of sale. A further notable collection rule is that for cases with lots being composed of several usage plots (e.g. arable and forest land)

3 The soil quality points are an official index in Germany which has been constructed such as to unify pedologic, scientific and (agro-)economic measures within one measure. 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 quality of the land in terms of achieving a high potential yield from using the land. The highest value that has been measured is 104 and the lowest value was 7.

only those prices are considered if for each usage a price is documented. We fully rely on the selection procedure of the LVermGeo and remove only incomplete observations, e.g. if information about lot characteristics is missing. The finally used sample contains 5,082 observations. In total, 5,063 observations are related to arable land and grassland, 10 to forest land and 7 to horticultural usage. 3 sales contain buildings as well. In the first part of Table 1 the descriptive statistics are given.

Since our aim is to quantify the effect of the identity of the buyers and sellers we refer to the dummy variables if the buyer is the former tenant set equal to one, and zero if not. Further, we define a dummy being equal to one if the buyer is related to the agricultural business, and zero if the buyer is formally not related to the farm business. The zero-category indicated some money investment from non-agricultural investors. Here we rely on the definition of the groups as given by in the original data set. This information comes from a survey induced by the federal ministry of agriculture in Saxony-Anhalt. To identify whether the BVVG sells the land, we refer to the published BVVG prices. These data contain besides prices the exact size, the county and constitution of the lot, which allows us to identify 73 BVVG-sales in the data set by the LVermGeo. The identified lots show the same distribution in the prices and in the core lot characteristics like size and soil quality as the in the original data set.

Besides these main variables of interest we consider further price determinants that are commonly used in hedonic studies on land prices. Neglecting crucial price determinants would result in biased estimated effects regarding the variables accounting for the buyer and seller structure (omitted variables bias). According to HUANG et al. (2006) we classify three groups of characteristics: *productivity*, *neighbourhood*, and *environmental*.

Regarding the *productivity characteristics* we consider the soil quality index for arable and grassland unified in a joint measure since almost all empirical studies on farmland values include a measure of soil quality and parcel size to capture productive capacity (e.g. XU et al. 1993). We expect higher prices with higher soil quality. In the appendix we further provide a graph (Figure A1) showing that in all regions in Saxony-Anhalt higher prices are observed if the soil quality is higher. The usage, i.e., arable land, grassland or other land, are further expected to strongly influence the possible revenues from the land. The share of arable land is expected to have a price increasing effect whereas the share of grassland is expected to have a negative price effect like forest area, and horticultural usage or building area may again have an increasing price effect. The summary statistics can be found in Table 1.

The need to take *neighbourhood characteristics* into account when analysing price formation on land markets is emphasised by several authors, including VRANKEN and SWINNEN (2006), who consider imperfect competition on land rental markets in transition economies. The immobility and shortage of land as a production factor may cause a strong interdependence of farms within a region (CHAVAS, 2001). While high land prices constitute an incentive to quit farming, they also form a barrier for potentially expanding farms. Even though the local supply is considerably determined by the privatization agencies, the ‘private’ land market supply may also be considered since it is the total supply within a region that influences the price. The local supply in the sales and rental market will be captured by the number of exiting and shrinking farms. In addition, population density and per capita income measured in terms of the regional value added excluding agriculture on a county level (NUTS 3) are used to represent non-farm factors and competing potential land uses. High value added per inhabitant reflects better off-farm income possibilities compared to regions with a lower productivity[4]. We expect 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. A positive impact may also be possible if the off-farm income possibilities create additional

[4] Since the value added defined per inhabitant and by county also reflects county size we relate it to the total utilized agricultural land in the country.

incentives for part-time farming and a negative effect on exits (cf. Table 1 for the summary statistics).[5]

**Table 1: Descriptive statistics**

| ***Lot characteristics*** | **mean** | **standard deviation** | **min.** | **max.** |
|---|---|---|---|---|
| Price [€ per square metre] | 0.8176 | 0.4758 | 0.0400 | 3.73 |
| Soil quality index [6;102] | 65.8467 | 22.582 | 12 | 104 |
| Lot size [ha] | 3.1889 | 10.821 | 0.004 | 469.51 |
| Grassland share on total lot size [0;1] | 0.1253 | 0.3311 | 0 | 1 |
| Share horticultural area [0;1] | 0.0013 | 0.0371 | 0 | 1 |
| Share forest land [0;1] | 0.0020 | 0.0443 | 0 | 1 |
| Share building area [0;1] | 0.0004 | 0.0198 | 0 | 1 |
| ***Dummy variables*** | | | | |
| Seller = farmer | 0.0242 | 0.1537 | 0 | 1 |
| Buyer = farmer | 0.7588 | 0.4279 | 0 | 1 |
| Buyer = tenant | 0.2639 | 0.4408 | 0 | 1 |
| Seller = BVVG | 0.0153 | 0.1230 | 0 | 1 |
| ***Structural and environmental variables*** | | | | |
| Precipitation [average mm by year][a] | 529 | 63 | 453 | 1057 |
| Value added excluding agriculture [€ per inhabitant][b] | 16,589 | 2,747 | 11,966 | 24,443 |
| Value added excluding agriculture related to agricultural land [€ per inhabitant*ha UAA][b] | 0.1628 | 0.0362 | 0.1062 | 0.2463 |
| Lifestock density [ LU per ha UAA][c] | 0.3100 | 0.0868 | 0.21 | 0.54 |
| Bioenergy density [kW per ha UAA][d] | 0.3225 | 1.4484 | 0 | 45.6269 |
| Farm exit share on total number of farms [0;1][c] | -0.0218 | 0.0234 | -0.0611 | 0.0201 |

Data sources: LVermGeo (2013a) and BVVG (2011) for lot characteristics. Structural variables: [a] Deutscher Wetterdienst; [b] Regionaldatendatenbank Deutschland (www.regionalstatistik.de), 2010: predicted values; [c] StaLa (2010a); [d] KoNaRo (2012), BNA (2012) and StaLa (2011).

The respective *environmental characteristics* refer to livestock density and biogas production density in a region. The definition follows Huettel et al. (2013), i.e. the annual stock of installed kilo Watts from biomass 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. Since bioenergy cropping is highly subsidized in Germany, which in turn may allow farmers to achieve higher gains from the land, a higher density may result in higher bids and higher prices (cf. von Witzke et al., 2009). Mendelson et al. (1994) and Lippert et al. (2009) further emphasize on the effect of climatic variables on farmland values. We consider precipitation at a regional community level and expect higher prices in regions with a better water availability.

5 We use logarithmic changes to express the change in the number of farms in percentage. The base is the difference in the number of farms between 2007 and 2010 (StaLa 2010b) at the county level (NUTS 3). A negative number implies a reduced number of farms whereas a positive number implies an increase in the number of farms.

## 3 The farmland pricing model

### 3.1 The hedonic pricing model

We use a hedonic pricing model and explain the per-square-metre prices for land $p_i$ by a linear function of lot-specific, structural as well as environmental variables (cf. section 2.2). Besides all relevant price-determining variables we consider the dummy variables accounting for the structure of the buyers and sellers to capture these identity-effects. The explanatory variables are summarized by $x_{ik}$ where *k* indexes the number of variables and *i* indexes the number of sales in the sample.

Since a functional form misspecification may also lead to biased estimates similar to the omitted variables bias, we rely on the Box-Cox testing procedure.[6] We use a power 0.25 transformation of the price, a power 0.5 one for the variable accounting for the lot size, denoted by $x_{i,ha}$ and a power 1 as well as a power 2 transformation for soil quality denoted by $x_{i,bz}$. The remaining variables are considered in linear form. The idea is to keep the transformations as simple as possible, also because the Box-Cox testing procedure involves some disadvantages, such as impreciseness under a possible spatial correlation (BALTAGI and LI, 2004). Since farmland prices are likely spatially correlated we further considered county dummy variables denoted by $d_{i,l}$, where *l* indexes the number of counties, within the testing procedure to minimize the possible spatial correlation within the error terms; however, they have been excluded from the test for power transformation thus they remain additive linear with the respective coefficients $\delta_l$. We further account for the two years by means of two time dummy variables representing the years 2009 and 2010, respectively. They are denoted by $d_{i,t}$ and the respective coefficients by $\delta_t$.

The hedonic pricing model shows the following structure:

$$\sqrt[4]{p_i} = \sum_k x_{i,k}\beta_k + \sqrt[2]{x_{i,ha}}\beta_{sqrt\_ha} + \left(x_{i,bz}\right)^2 \beta_{sq\_bz} + \sum_l d_{i,l}\delta_l + \sum_t d_{i,t}\delta_t + \varepsilon_i \quad (1)$$

wherein $\varepsilon_i$ denotes an error term which is symmetrically distributed given the Box-Cox transformation.

Bidders often refer to observed prices of comparable lots to finalize the respective bids, i.e. reference prices. Comparable lots are likely found in the same region. Such a dependency is not captured by county dummy variables. Other reasons for spatial autocorrelation are unobserved facts such as local infrastructure, which may cause spatially correlated error terms. Thus we use the residuals of equation (1) to test for spatial correlation using the standard Moran's I test; we need to define a spatial weight matrix, which we describe next.

### 3.2 The spatial weight matrix

The challenge in defining the weight matrix is that only the local municipality[7] level ("Gemeinde") is given to us for data security reasons. Thus, we cannot use the exact distance between the lots as a measure for neighbouring. Instead, we refer to the distance between the

[6] This test is based on transformation parameters - one for each equation side - ranging from one (no transformation) to zero (logarithmic transformation). Essentially, a linear price model is tested against a logarithmic-linear, logarithmic-logarithmic or other power transformation model specification. According to Osborne (2010), the estimated parameter should be used pragmatically, i.e. the exact estimates should not be used. Rather one should decide whether the parameter is close to 1 (no transformation), to 0.25 / 0.5 (root transformations) or to 0 (logarithmic).

[7] The German municipalities correspond to LAU 2 (previously NUTS 5) in the LAU (Local Administrative Units) classification system.

municipalities. According to ANSELIN (2005), spatial regions should be of homogenous size, which could be approved using the official administrative units. We weight all observations within a municipality as close as possible and assign a zero-distance weight.

The idea of the spatial weight matrix is to assign a neighbourhood relationship between the observations, which loses importance with distance. Possible measures for distance are travel time or kilometres based on the airway, respectively. The advantage of using travel time is that topographical issues and natural barriers like forest areas or lakes are taken into account (cf. Figure A.2), whereas air-distance is a commonly accepted measure. Since the majority of the buyers are farmers and in their view travel time matters through transportation cost as well as labour time organisation. This in turn is taken into account within price bid (cf. FORSTNER et al., 2011). Accordingly, we define two weight matrices based on the inverse distances between the municipalities, either measured in travel time[8] or in kilometres[9].

Based on the weight matrix it is possible to evaluate how up to the cut-off distance level the neighbouring prices influence the price. Referring to BREUSTEDT and HABERMANN (2010) we cut at 10 kilometres and at 15 minutes, respectively. Both matrices are considered in row-standardized form (cf. ANSELIN, 1998). Both Moran's *I* statistics are highly significant, where the kilometre distance-based weight matrix shows a higher correlation (cf. Table 2). Both measures indicate a positive spatial autocorrelation in the residuals, that is, after controlling for soil quality and county regions through dummy variables, still uncaptured neighbouring effects exist. High residuals are associated with residuals (unexplained) in the neighbourhood.

**Table 2: Moran's I Test for global autocorrelation**

| | ***I*** | |
|---|---|---|
| | $W_l$<br>spatial weight matrix<br>based on kilometre measure | $W_r$<br>spatial weight matrix<br>based on travel time |
| **Moran's *I*** | 0.106*** | 0.112*** |

*** denotes significant at the 1% level based on the standard z-score.

### 3.3 The spatial regression models

Given the spatial correlation in the regression residuals it is necessary to account for the spatial correlation either by using the average neighbouring prices as an additional explanatory variable (spatial lag model), by means of a spatially autoregressive error term process (spatial error model) or both (general spatial model). The decision for the appropriate model specification is based on the Lagrange Multiplier test. That is we test the spatial lag and spatial error against no spatial correlation, respectively. Since the spatial lag model inherits the spatial error structure and since it is not robust against local misspecification of the spatial structure, it is recommended to use the robust version of the test (cf. ANSELIN and BERA, 1992). The robust testing results for both weight matrices are given in Table 3.

[8] Travel time is based on ©GoolgeMaps with the fastest route (OZIMEK und MILES, 2011).

[9] The distance between municipality *i* and *j* is given by (DRUKKER et al., 2011):

$6378.137 \cdot \operatorname{acos}\left(\sin\left(lat_i\right)\cdot\sin\left(lat_j\right) + \cos\left(lat_i\right)\cdot\cos\left(lat_j\right)\cdot\cos\left(lon_j - lon_i\right)\right)$. Herein denote $lat_i$ and $lat_j$ the latitude of the municipality centres, respectively. $lon_j$ and $lon_i$ denote the respective longitudes in decimals.

**Table 3: Lagrange Multiplier (LM) test for spatial lag versus spatial error**

| | LM-statistic | |
|---|---|---|
| | $W_l$ spatial weight matrix based on kilometre measure | $W_r$ spatial weight matrix based on travel time |
| ***Spatial error*** | | |
| **Robust Lagrange Multiplier** | 520.861*** | 330.96*** |
| ***Spatial lag*** | | |
| **Robust Lagrange Multiplier** | 305.862*** | 316.60*** |

*** denotes significant at the 1% level.

The test results show no clear decision since both alternatives are significant under both weight matrices. It is recommended to refer to the most significant one to decide about the proper spatial alternative model (e.g., ANSELIN, 2005); however, there are reasons that both effects should be taken into account. Farms usually base their price bids on documented or published prices for comparable lots, which is a clear argument in favour of the spatial lag model. Furthermore, travel time as an indicator for spatial dependencies seems to be more relevant because locally observed prices being relevant as a reference are within the action radius of the local farmers (majority of the buyers), also because the probability that the farmers/ other bidders have already bought within the travel-time radius. In addition to that, this weight matrix offers more neighbouring observations. On the other, further arguments exist to also use a spatial error structure. The lack of information about regional settings, local infrastructure, local market conditions and other neighbourhood relationships may cause unobserved spatial heterogeneity effects, which are not fully captured by means of the model specification including the spatial lag. Here, the air-distance based spatial weight matrix shows higher LM-values.

Following DRUKKER et al. (2011) we use in the final estimation a ***general spatial model*** with the travel time distance spatial weight matrix in the spatial lag and the kilometre distance spatial weight matrix in the spatial error.[10] Different to the model in (1) we consider a constant term but leave out one time dummy variable instead.

$$\sqrt[4]{p_i} = \alpha_0 + \sum_j w_{ij,r} \sqrt[4]{p_i}\,\rho + \sum_k x_{i,k}\beta_k + \sqrt[2]{x_{i,ha}}\,\beta_{sqrt\_ha} + \left(x_{i,bz}\right)^2 \beta_{sq\_bz} + d_{i,2010}\delta_{2010} + u_i \qquad (2)$$

with $u_i = \lambda \sum_j w_{ij,l} u_i + \varepsilon_i$ .

This model constitutes by construction a simultaneous system of equations, where coefficients $\lambda$ and $\rho$ capture spatial heterogeneity and simultaneous impact of neighbouring prices on the observed prices, respectively. The simultaneity implies that the observed prices $p_i$ are influenced by the prices of adjacent parcels but also in turn, that the observed price influences the prices of nearby plots. Moreover, since the time dimension is only implicitly modelled by means of dummy variables and no distinction between time and space dependency is made within the weight matrix, it is further possible that future prices of neighbouring parcels would affect past prices. MADDISON (2004, 2009) points to further identification problems of the parameter estimates if both types of spatial correlation (lag and error dependence) are modelled and the specification fully relies on the Lagrangean Multiplier tests because it may not fully reflect the price formation process.

[10] We use STATA command "spreg" (DRUKKER et al., 2013).

Farms' price bids are mainly based on the productivity value for given in- and output prices but also on reference prices. In particular investors put considerable weight on the prices of comparable and nearby parcels. This means that the information on price formation in the local market is relevant, but this information must be observable before the respective price formation starts (cf. MADDISON, 2009). Against this background we redefine the weight matrix for generating the spatial lag variable (travel time as a distance measure) such that that the price of a parcel of land is determined by the price adjacent plots which are observed before the respective parcel was sold (PACE et al., 1998). Given this definition of the weight matrix, we treat the spatially lagged prices as exogenous regressors. Since we cannot neglect the presence of spatial error dependence because there might still be unobserved price determinants like development plans, accessibility or neighbourhood relations, we estimate the model as a spatial error model with spatio-temporally lagged price as exogenous variable. The ***spatio-temporal model*** is given by: [11]

$$\sqrt[4]{p_i} = \alpha_0 + \sum_j v_{ij,r} \sqrt[4]{p_i} \rho_{lag} + \sum_k x_{i,k} \beta_k + \sqrt[2]{x_{i,ha}} \beta_{sqrt\_ha} + \left(x_{i,bz}\right)^2 \beta_{sq\_bz} + d_{i,2010} \delta_{2010} + u_i \quad (3)$$

with $u_i = \lambda \sum_j w_{ij,l} u_i + \varepsilon_i$.

The spatio-temporal dependencies are captured by the weights in $\sum_j v_{ij,r}$, the respective coefficient for the exogenously treated spatial lag is denoted by $\rho_{lag}$. Note that we keep the spatial error structure of the general spatial model in (2).

## 4 Results and discussion

The estimated coefficients are given in Table 4 and the marginal effects in the Appendix, Table A1. For the latter we use the average total direct impact (ATDI) since the general spatial model forms a system of equations, in which a change in an explanatory variable induces a change in all endogenous variables. The average total direct impact captures how a change in the average price is attributable to sequential changes in the respective explanatory variables (cf. DRUKKER et al., 2013). In the spatio-temporal model, where the neighbouring price levels are treated as fully exogenous, we refer to marginal effects evaluated at the respective means.

The usual measure for goodness of fit in spatial models estimated by maximum likelihood is the squared correlation coefficient between the predicted and the observed values. 0.69 and 0.70 for the general spatial model and the spatio-temporal model, respectively, the coefficients are in an acceptable range. Interestingly, the dummy variable accounting for unexplained price changes between the years 2009 and 2010 is significant in both models, though the effect is larger in the spatio-temporal approach (cf. Table 4). That is, there are still unconsidered issues that drive up the price by 0.059 Euros per square metre in the general spatial model and by 0.12 Euros in the spatio-temporal approach. The lower effect in the general spatial model may point to an inappropriate representation of the time dependency in the general spatial model.

The core question was to analyse whether the structure of buyers and sellers has a price-influencing effect and if so, to what extent. We refer to the dummy variables if the seller is the either a farmer or the BVVG, if the buyer is the former tenant and if the buyer is related to the agricultural business. Both models show significant impacts if the seller is the BVVG and if the former tenant purchases the land. On average, prices achieved by the BVVG are more expensive compared to other sellers. The ATDI is 0.1217 Euros for the general spatial model and 0.18 Euros per square metre for the spatio-temporal approach. One of the major differ-

[11] We use the STATA command "spatreg" (PISATI, 2001).

ences of the BVVG to other suppliers is the first price sealed bid auctions with public tenders. In addition to the public call for tenders, the reference prices are also published online and thus easily accessible. HUETTEL et al. (2013) have already shown that the prices increase with the number of bids; that is, if access to information and the call for tenders is uncomplicated, very likely more bidders will be attracted. Moreover, there might be an institutional effect since BVVG is perceived as trustable such that if the highest bid wins the respective purchase contract will be concluded. We further find that if the former tenant buys the land, this goes along with lower prices. On average the prices are 0.029 Euros lower per square metre in the general spatial model and 0.032 Euros in the spatio-temporal model. This begs the question of causality: does this effect capture that tenants with pre-emption right might take the land if the price is low, or does this effect reflect lower prices if the tenants directly purchase the land. We cannot find any significant price difference if the acquiring parties are directly related to the farming business. Since we fully rely on the official distinction (LVERMGEO, 2013), one should further note, however, that in particular the distinction between a farmer and an external investor is rather difficult (FORSTNER et al. 2013). By means of the given categories we cannot disentangle farmers' purchases and such purchases officially carried out by farmers but financially supported through investors e.g. through a direct participation in the cooperative or corporate.

The reference prices for the bids are captured by the spatially and time-lagged prices in the spatio-temporal approach. If the prices in the neighbouring regions increase by 1 Euro, as a consequence the price today would have been higher by 0.34 Euros per square metre (ceteris paribus) in the spatio-temporal model, whereas this effect is considerably lower in the general spatial model (0.03). This finding seems to be a clear argument in favour of the spatio-temporal modelling since the simultaneous idea of the general spatial model does not reflect the price formation process.

The *productivity characteristics* are all significant and show the expected signs. Soil quality positively influences the prices. With regards to the lot size, we find that larger lots are more expensive compared to smaller ones, which has so far to our knowledge not been empirically shown yet. Furthermore, the grassland share has as expected a negative price impact. Horticultural area offers higher productivity gains and thus the price increases with the share of horticultural land and buildings but decreases with the share of forest land.

Regarding the *neighbourhood* and *environmental characteristics*, the results of the general spatial model reveal a significant impact of precipitation with a positive price effect of about 0.01 Euros per 100 mm (cf. Table A1). The spatio-temporal model shows no price influencing effect of rainfall. The value added has a negative effect in both models, but it is only significant in the general spatial model. The higher the value added is, the lower is the farmland price in that region. Possible reasons might be that farmers have an incentive to cease production and supply the land in the local market since there might be better outside options reflected by the higher value added. BREUSTEDT and HABERMANN (2009) and HUANG et al. (2006), however, point to positive effects but in regions that are not comparable to Saxony-Anhalt.

The regional density of biomass plants measured in terms of installed kilo Watts per hectare in the counties turns out not to influence the sales prices in 2009 and 2010. This contradicts the reported findings by BREUSTEDT and HABERMANN (2011) for rental prices in West Germany; however, it might be conjectured that the high policy support affects the price formation land rentals and, furthermore, Saxony-Anhalt is known for its low livestock and bioenergy production density compared to other federal states in Germany. The farm exit share shows with 0.9396 and 1.0752 (cf. Table A1) a strong and significant impact on the price. This variable has a negative mean, that is, a reduced farm exit share increases the price. This means that more farms compete for the land in a region and this in turn may increase the respective price in a region (for a further discussion see MARGARIAN, 2010).

**Table 4: Coefficient estimates, N=5,082**

| Variable | Spatial general model | | Spatio-temporal model | |
|---|---|---|---|---|
| | *coefficient* | *p-value* | *coefficient* | *p-value* |
| spatial-lag ($\rho$) | 0.0090 | 0.000*** | 0.3956 | 0.000*** |
| spatial-error ($\lambda$) | 0.4431 | 0.000*** | 0.6961 | 0.000*** |
| ***Lot characteristics*** | | | | |
| $\sqrt[2]{\text{Lot size}}$ | 0.0179 | 0.000*** | 0.0107 | 0.000*** |
| Soil quality index [6;104] | 0.0029 | 0.000*** | 0.0018 | 0.000*** |
| $(\text{Soil quality index})^2$ | -0.0000 | 0.019** | -0.0000 | 0.233 |
| Grassland share on total lot size | -0.0628 | 0.000*** | -0.0403 | 0.000*** |
| Share horticultural area [0;1] | 0.0491 | 0.145 | 0.0277 | 0.562 |
| Share forest land [0;1] | -0.2537 | 0.000*** | -0.1586 | 0.000*** |
| Share building area [0;1] | 0.0893 | 0.000*** | 0.0537 | 0.301 |
| ***Dummy variables*** | | | | |
| Seller = farmer | -0.0106 | 0.196 | -0.0053 | 0.456 |
| Buyer = farmer | -0.0007 | 0.825 | -0.0003 | 0.897 |
| Buyer = tenant | -0.0211 | 0.000*** | -0.0086 | 0.002*** |
| Seller = BVVG | 0.0903 | 0.000*** | 0.0485 | 0.000*** |
| ***Structural and environmental variables*** | | | | |
| Precipitation [average mm by year] | 0.0001 | 0.053* | -0.0000 | 0.920 |
| Value added excluding agriculture related to agricultural land [€ per inhabitant*ha UAA] | -0.1583 | 0.007*** | -0.1260 | 0.125 |
| Livestock density [LU per ha UAA] | *Omitted due to collinearity problems* | | | |
| Bioenergy density [kW per ha UAA] | 0.0002 | 0.850 | 0.0009 | 0.679 |
| Farm exit share on total number of farms [0;1] | 0.4570 | 0.001*** | 0.2916 | 0.022** |
| ***Time and intercept*** | | | | |
| Dummy 2010 | 0.0296 | 0.000*** | 0.0312 | 0.000*** |
| Constant | 0.3329 | 0.000*** | 0.4678 | 0.000*** |
| Squared correlation coefficient | 0.695 | | 0.703 | |
| Log likelihood | 5082.12 | | 6238.29 | |

***, ** and * denote significance at the 1 %, 5 % and 10 % level, respectively. For standard errors the Huber/White/sandwich estimator of variance is used instead of the traditional calculation.

## 5 Concluding remarks

The purpose of our paper is to answer the question whether the acquiring parties' and sellers matter in the price formation process for farmland in East Germany. To answer this question we consider a classical hedonic price model which captures classical farmland price influencing productivity characteristics, but also regional and environmental characteristics. We enhance this model by dummy variables that represent whether the seller is the either a farmer or the BVVG, if the buyer is the former tenant and if the buyer is related to the agricultural business.

It is undisputed that analysing farmland prices requires an appropriate modelling since very likely farmland prices are spatially correlated for two major reasons. First, likely not all price influencing issues are appropriately taken into account. As a result, spatial effects appear in the disturbance term. Second, famers, tenants and in particular investors use reference prices of comparable lots. Likely those lots could be found in the neighbouring regions; thus, the regional average prices seem to be a relevant price determinant as well. According to that we use a general spatial model with autoregressive error terms; however, since prices being appropriate reference prices must be observed prior to the time the respective parcel is sold, we use a modification of the general spatial model that takes the time lag into account. By means of a comparison of both models, the advantages of the spatio-temporal approach become apparent.

The results give first empirical evidence that it matters who sells and who purchases the land. We find that prices realised by the BVVG are, on average, higher compared to those from private sales or the Landgesellschaft Saxony-Anhalt. However, we cannot find significantly lower prices if farmers buy the land, which could have been interpreted as indirect support for the hypothesis that non-agricultural investors drive up prices. As pointed by FORSTNER et al. (2013), investors might influence the price formation indirectly because public agencies use first price sealed bid auctions with public tenders and publish the realized prices, which may ease finding a reference price for the bid and thus attract potentially interested parties. Likely the prices increase with the number of bids within a first-price auction. Moreover, financial participation in corporates or cooperatives is not measurable at all and increases farms' financial power to offer higher bids. Furthermore, different sellers may have different strategies. Maximising revenues from land sales is a reasonable objective for land suppliers; but state-controlled agencies may pursue different, partially conflicting objectives, for instance, they may have an interest in controlling the regional structure of the agricultural sector. From a policy perspective it could be desirable to prevent a high concentration of land, or to support smaller farms. The Landgesellschaft Sachsen-Anhalt, for instance, offers a pre-emption right and local support in planning for farmers, which may act as an indirect subsidy and might induce some reluctance to bid for non-farmers. This fact may likely be the reason why our results reveal a lower price if the former tenant purchases the parcel. It is left for future research to disentangle the different effects corresponding to different market mechanisms and different strategies of the sellers.

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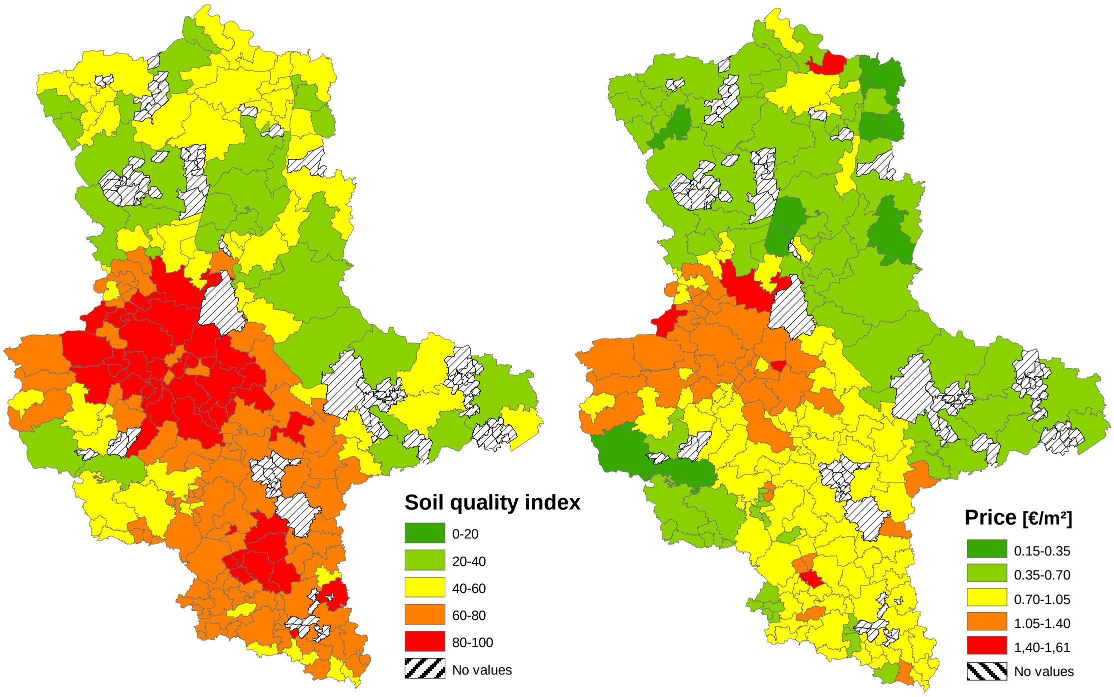
## Appendix

### Figure A1: Soil quality and average prices (2009/10) in Saxony-Anhalt




Data source: LVermGeo, 2013 and DESTATIS (2012)

### Figure A2: Illustration: airway distance and travel time distance

**Table A1: Marginal effects: average total direct impact, N=5,082**

| Variable | Spatial general model | | | Spatio-temporal model | |
|---|---|---|---|---|---|
| | *ATDI* | *marginal effect* | *p-value* | *marginal effect* | *p-value* |
| spatial-lag | 0.0059 | 0.0034 | 0.000*** | 0.3329 | 0.000*** |
| ***Lot characteristics*** | | | | | |
| Lot size | 0.0117 | 0.0060 | 0.000*** | 0.0139 | 0.000*** |
| Soil quality index [6;102] | 0.0019 | 0.0007 | 0.000*** | 0.0042 | 0.000*** |
| Grassland share on total lot size | -0.0411 | -0.0846 | 0.000*** | -0.1488 | 0.000*** |
| Share horticultural area [0;1] | 0.0322 | 0.0667 | 0.145 | 0.1023 | 0.562 |
| Share forest land [0;1] | -0.1662 | -0.6055 | 0.000*** | -0.5848 | 0.000*** |
| Share building area [0;1] | 0.0585 | 0.1203 | 0.000*** | 0.1982 | 0.301 |
| ***Dummy*** | | | | | |
| Seller = farmer | -0.0070 | -0.0144 | 0.196 | -0.0195 | 0.456 |
| Buyer = farmer | -0.0015 | -0.0009 | 0.825 | -0.0012 | 0.897 |
| Buyer = tenant | -0.0138 | -0.0285 | 0.000*** | -0.0318 | 0.002*** |
| Seller = BVVG | 0.0592 | 0.1217 | 0.000*** | 0.1788 | 0.000*** |
| ***Structural & environmental*** | | | | | |
| Precipitation [average mm by year] | 0.0000 | 0.0001 | 0.053* | -0.0000 | 0.920 |
| Value added excl. agriculture [€ per inhabitant*ha UAA] | -0.1038 | -0.2133 | 0.007*** | -0.4646 | 0.125 |
| Bioenergy density [kW per ha UAA] | 0.0001 | 0.0002 | 0.850 | 0.0033 | 0.679 |
| Farm exit share [0;1] | 0.2955 | 0.6158 | 0.001*** | 1.0752 | 0.022** |
| ***Time*** | | | | | |
| Dummy 2010 | 0.0399 | 0.0194 | 0.000*** | 0.1149 | 0.000*** |

***, ** and * denote significance at the 1 %, 5 % and 10 % level, respectively. Marginal effects for the spatio-temporal model are evaluated at the mean of the explanatory variables and the reduced form prediction for both models. STATA command "lincom" has been used and standard errors are based on the Huber/White/sandwich estimator of the variance.