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ARTICLE

Temporal and Distance Effects on Land Values – Examples from the Mecklenburg Lake County in Germany

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ABSTRACT

In the past decade the land market in Eastern Germany was characterized by a relatively high level of land mobility and severe land price hikes. Land prices in individual regions differ considerably, however. This paper has examined whether obtaining a higher sales price for a utilised agricultural area in particular bounds has a spillover effect on neighbouring bounds so that higher prices can be secured there, too. The region selected for this study was the Mecklenburg Lakeland administrative district, the largest administrative district in Germany. The local team of land value appraiser provided a feature based description of all individual land sales for the period from 2001 to 2016 covering a total of 12,045 anonymised records; this did not include cases of acquisitions of whole enterprises and/or share deals however. From these data, ultimately 3,046 sales of arable land have been analysed by means of geographic information systems and panel regression analysis. It was examined whether the achievement of higher prices in a certain district radiates to neighboring districts, so that higher prices are also achieved there. It can be concluded that information is exchanged between market participants, although many perceive the land market as relatively non-transparent. Distance decay effects on land values were found, which means that high land values of one spot radiate at least to neighboring districts up to a distance of 30 km. The analysis underlines therefore that spatial effects have influence on agricultural land markets. "Hot spots" in one area influence neighboring areas. Local hot spots arise through the derived demand of biogas plants, the

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activities of investors or the local competition conditions.
Keywords: Land Values; Arable Land; Temporal Influences; Distance Effects

1. Introduction

1.1. Theoretical Remarks

Spatial and temporal models for the land market have a long tradition. Johann Heinrich von Thünen (born June 24, 1783 in Canarienhausen, Wangerland, died September 22, 1850 in Tellow), a prominently nineteenth century economist and a landowner in Mecklenburg-Schwerin in northern Germany, was one of the first to address questions of location theory and examine spatial influences, e.g., land use and the economic dependence on the distance to the market. Coincidentally, he lived and researched in the region from which the data of the present study came.

Thünen's model of agricultural land use, described in the first volume of his treatise The Isolated State [1], developed the first serious treatment of spatial economics and economic geography, connecting it with the theory of rent. The mono-centrist approach in this study refers to the model of the Thünen circles in that the spatial data of the exogenous variables are designed in circle segments of distances from the center up to 10, 20, 30, and 50 km, and beyond, for each district.

In addition to the spatial dimension, in particular, the distance effects, the analysis of the price development of land markets has a long tradition. There has been a tremendous evolution in theories regarding spatial economic effects. The development of these theories - up to the Krugman's New Geographic Economy [2], which is linked to two traditions, firstly to the location theory, he has developed and differentiated since Johann Heinrich von Thünen and secondly to the Foreign trade theory founded by Adam Smith and especially David Ricardo. Recent works by Zhang and Beek [3] provide analysis, e.g., Trends and Determinants of US Farmland Values Since 1910: Evidence from the Iowa Land Value Survey [3].

Various models have been developed and used for the simultaneous analysis of temporary and spatial effects; Brady and Irwin [4] provide an overview. It is of particular interest to map possible distance decay functions. Identification of spatial interactions must also be taken into account, e.g., Grimes and Liang [5] detected a ten-fold price effect for areas inside and outside Auckland's Metropolitan Urban Limit.

Many analyses deal with urban land values, e.g., Du Debin and Xu Jiangang [6] for Shanghai, or housing markets and residential, recreation, and natural protection areas, such as public parks or preserved open space [4]. Such effects are also found in the study area of this work, in the Mecklenburg Lake County, e.g., through the Müritz National Park; here they are taken into account by the variable soil quality, which determines the prevailing marginal soil of the area, and is a reason for the establishment of the national park. Numerous works also deal with land use, whereby the geo-location (distance to urban centers and the infrastructure network), income, and population density are important, as the work of Bencardino and Nesticò [7] shows for the Salerno region.

Recently, Yang et al. [8] also created a temporal-spatial study of land prices for the neighboring federal state of Lower Saxony using a spatial vector error correction model (SpVECM) [9]. They were able to show that the land prices of neighboring districts are co-integrated and therefor linked by long-run equilibria. In addition, they found that there are regions which take a price lead. The analysis carried out there was based on circular data for the period from January 1985 to December 2015, with data gaps being linearly interpolated. In contrast to Yang et al. [8], in our work a region in Eastern Germany is analyzed in the present work, whereby the spatial differentiation is much smaller. While Yang et al. [8] selected the level of a federal state and its counties as the smallest investigation region, in our work the superior level is the county and the district level is the investigation region. Since there are relatively large data gaps—arable land is not sold in every region every year—no SpVECM could be used, but panel regression equations were estimated. The Eastern Germany land market with his strong developments during the last three decades has been subject to many analysis; one of the latest is the analysis of farmland values and bidder behaviour in first-price land auctions [9]. However, no study is known that examines the spatial price effects, especially the distance effects, on the basis of a full survey of all arable land sales for an entire county over a relatively long period of time.

1.2. Introductory Remarks to Own Work

In the present work, a section of the land market, the market for arable land, is examined. The focus is on analysis of the distance effects, whereby the temporary development due to enormous price increases in recent years has overlaid the distance effects at first glance. The temporal effect has already been analyzed in detail by other authors [10] and is recorded in the present analysis primarily by the trend.

For some years now, the agricultural land markets in German, in particular, have become significantly more important in both public and scientific discussions [11]. This can essentially be attributed to two aspects: firstly, the high level of land mobility[1] as a result of the privatization of state land and private sales, and secondly, due to the sharp rise in purchase and lease prices for agricultural land. Strong competition with high prices for agricultural land raised fears that this could lead to economic problems and displacement of local farmers. While the possible development of a price bubble is largely considered unlikely [12, 13], the commitment of non-agricultural investors is often viewed critically, since it contradicts the traditional goals of further agricultural structural development [11]. The price increase in recent years (essentially since 2005) is attributed to various influencing factors and can also be proven empirically: the temporarily increased producer price level, the derived demand from biogas plants and intensive livestock farming, the privatization of state-owned agricultural land, which according to a public tender has been launched, and not least because of the conditions in financial markets after the financial, economic, and euro crisis since 2009 [12, 14].

In East Germany, after the fall of the Berlin Wall (1989), farms initially leased most of the land (approx. 90%) from the state, churches, and private individuals [15 various years]. Subsequently, a wave of sales began: state owned land was privatized, and many private persons sold their mostly smaller properties. After lease contracts expired, they were often not extended, but the areas affected were offered for sale. Farmers who wanted to keep or even enlarge their farm areas were forced to buy these former leases. The land market, particularly with regard to the purchase of land, has in the beginning of the 1990ies gradually developed in Eastern Germany. Public tenders and price publications online by the state-owned agency responsible for the administration and privatization of state-owned farm and forest land in Eastern Germany (Bodenverwertungs-und-verwaltungs GmbH - BVVG) made land markets more transparent [16].

East German land markets have some specific characteristics which lead to differences compared with West German land markets, which persist even 30 years after reunification. Starting with a very low price level in the 1990s, which may be explained by the economic conditions of transformation, prices have since increased, particularly during the past 15 years. Actual average prices of 15,700 €/ha are still below the German average of 25,500 €/ha in 2019, but in some East German federal states, such as Mecklenburg-Vorpommern and Sachsen-Anhalt, the regional level exceeds that of low-level West German federal states, such as Hessen and Rheinland-Pfalz [17]. Price growth rates are not only much higher in the East compared to the West; the same is also true to land mobility. Even if land selling of the state agency BVVG is excluded, land mobility in the East is more than twice that in the West. This may also be observed in the high price regions Mecklenburg-Vorpommern and Sachsen-Anhalt.

The statistically recorded land purchases do not cover all ownership changes. The buying of complete farms of legal entities—mainly cooperatives or limited companies—through large external investors adds to land

1 The variable "land mobility" is here defined as the share of traded arable land in the period 2003 to 2016 with respect to total arable land of the district.

purchases. These transactions do not have to be reported by law in official statistics and only estimations exist regarding the amount of land ownership change. Tietz [14], in his work, estimates a volume of up to 30 %. Until now the intended closing of this gap in statistical reporting has not happened. Another part of the market in agricultural holdings and their land is the sale of entire holdings or shares of holdings (share deals). There is no entry in or changes to the land register for these purchases, nor are they subject to notification or approval under the Real Estate Act [18]. In Eastern Germany, such takeovers have been taking place since the early 1990s and the total share of these transactions is estimated to be around 20% of the total agricultural area, which amounts for as much land as that of single piece land purchases in East Germany [19]. Historically, these company takeovers started with the sale of state-owned farms (Volkseigene Güter, VEG), because the takeover of a former VEG could usually only be afforded by financially strong investors [16]. Due to the global banking and financial crisis [20], stock markets have become less attractive and agricultural land has become an investment opportunity. With low interest rates - the key interest rate in the euro area has been zero since March 2016 [21] - this trend has been further intensified with the search for alternative safe investment options for capital. The increasing interest of non-agricultural investors, particularly in East Germany, has also clearly influenced price developments, but recent studies have not been able to measure this effect [22]. The passing-on of subsidies (direct payments) to the lessors and sellers also contributes to increasing prices [23, 24].

The sharp price increase (albeit from a low level), the high land mobility, and the activities and influence of large investors are therefore specific factors of the East German land markets.

To analyze price determining factors, a regional disaggregation of prices at the level of districts[2] may identify these variables. Land purchases does not take place in every year and in every subregion simultaneously. Selling and buying of land are economic acts with an uneven spatial distribution. Furthermore, dominating large farms operate across several districts. Therefore, the hypothesis that the price level in one district is influenced by the price level in surrounding districts, a variable that has not been included in previous research, will be tested. The price achieved by the sale of individual properties is the subject of the present investigation. The question of the work is whether individual buyers have particularly contributed to price increases in the neighboring districts (hotspots).

For this purpose, data are used which are based on a complete survey of all (electronically stored) land sales in the period from 2003 to 2016 in the Mecklenburg Lake County [25].

Prices in the land markets differ significantly locally and regionally. This may be due to various market imperfections (low transparency, personal preferences among sellers and lessors, and the heterogeneity of the purchase and lease conditions), the preference of tenants and buyers for properties near a farm site, or other competitive conditions. Therefore, the local conditions (hotspots) presumably have a significant impact [26].

In the following analysis, a spatially strongly differentiated analysis of the price development for purchase cases is carried out using the example of the "Mecklenburgische Seenplatte" county (Mecklenburg Lake County) for the period 2003 to 2016 on the basis of the data available from the regional appraiser committee for real estate in the county. In particular, the price influence of the "neighborhood" will be analyzed, i.e., to what extent prices in one district influence prices in neighboring districts. Since the study region is mainly characterized by large-scale farm structures [27][3], the management of agricultural land in different districts is very common, so that potential buyers can be active in the vicinity of several districts.

Should prices of neighboring districts influence each other, this can be attributed to various factors. The "neighborhood" can reflect both the specific regional conditions, e.g., the existence of one or more biogas plants, and the local and regional competitive conditions. Ultimately, the land markets are very likely to be oligopolies of demand or, if applicable, a de facto monopoly on demand, which influences the strategies of the buyers.

The aim of the present work is to show the temporal

2 in German: Gemarkungen, which is below village level
3 The average farm size in the Mecklenburg Lake County is approx. 275 hectares (287,000 hectares of agricultural land with 1,044 farms).

and spatial dependencies, and thus including distance effects, of the price development on the arable land market. The goal is to examine how and whether the price level of a district is influenced by rising prices (hotspots) in the neighboring districts. In addition to the distance between the individual districts, other exogenous variables, such as the size of a lot, the quality of the arable land, and the land mobility are used to explain the price development [28].

2. Empirical Investigation

2.1. Investigation Region and Data Basis

The largest county in Germany, the Mecklenburg Lake County (Landkreis Mecklenburger Seenplatte, LK MSE), serves as the study region. It lies in the northeast federal state Mecklenburg-Western Pomerania near the Baltic Sea. The Mecklenburg Lake County is located in the triangle of the three cities—Hamburg in the west, the Polish metropolitan Szczecin (Stettin) in the east and south, the German capital Berlin[4]. The county MSE covers an area of 5470.70 km^2. The MSE county has existed since the most recent municipality reform in 2011. In total, this county contains 613 districts (at the village level) in 155 municipalities and 14 regional offices [25].

For this investigation, the regional appraiser committee for real estate in the Mecklenburg Lake County provided the purchase price collection of all individual agricultural land sales between 2001 and 2016, comprising 12,045 anonymized data records.[5] The purchase land price collection provided contains information on the district (name, district code, and coordinates), information on the types of buyers and sellers, the contract date, the size and predominant use of the land, the land quality, and the total purchase price.

The arable land sales were selected from this data set and corrected for outliers[6]. After this correction, a total of 3046 data records were available between 2003 and 2016. The beginning of the data series is ostensibly due to the time of the electronic data acquisition at the individual offices. In fact, the purchase of land did not much increase until the decade after 2000, since existing long-term lease agreements that had been negotiated after the fall of the Berlin wall did not make a purchase appear urgent until a period of up to 12 years or often longer. Often the low land price level prevailing in many places was not perceived as such; only with the increase around 2007 did the land market start to move. The number of sales of arable land was highest in LK MSE in 2009 with 363 contracts, whereas the area of arable land sales in 2011 stood out at 5.228 hectares (**Figure 1**).

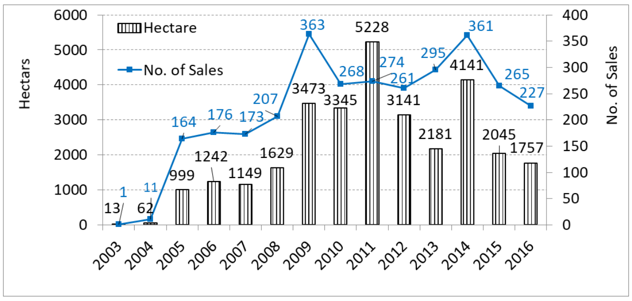


Figure 1. Available data on arable land sold in the Mecklenburg Lake County (LK MSE) and number of transactions (n = 3046). Source: Regional appraiser committee for real estate in the Mecklenburg Lake County, own illustration.

A total of 30,406 hectares of arable land traded was covered over all years. This corresponds to a share of 13% of the total arable land in the Mecklenburg Lake County of approx. 232,000 hectares, assuming that lots were not sold more than once during this period. Approx. 10% of the sales related to areas larger than 20 hectares. Accordingly, an area of arable land of around 10 hectares was sold on average per contract. Arable land was not sold in every district each year but, in some years, there were several contracts for one district. The average sales area, per year and per district, was 16.31 hectares.

On the one hand, the data basis is very detailed and data are available on a large scale. On the other hand, however, there are a few points that affect a complete rep-

4 For German conditions, the region under consideration is relatively far away from the three major urban centers (Berlin, Hamburg, Stettin); they have been named here to let the reader know, where the location is.

5 From the total number of land sales (12k) only arable land sales have been selected. Incomplete records were discarded and sales of grassland was not considered, so that almost half of the data could not be taken into account.

6 Data records were identified as outliers in which residuals (difference from price forecast as f(time of sale, size, soil quality and actual price achieved) exceeded three standard deviations.

resentation of the land market in the districts selected in the Mecklenburg Lake County:

- Only after the district reform in 2011 was the management of the data standardized; data from the three former counties were at different levels, and only electronically available data was provided by the regional appraiser committee for real estate in the Mecklenburg Lake County for this investigation to be used in the present analysis. Due to the different implementation periods for automated purchase price recording in the former counties, comprehensive data delivery was only possible from 2009. Therefore, observations in 2003 (one sale) and 2004 (eleven land sales) are very low. The decisive analysis period therefore mainly includes the years 2009 to 2016.
- The cross-border effects are not shown at the county borders, i.e., the influence of land values in neighboring districts from neighboring counties could not be recorded or was neglected.
- The acquisition of entire businesses or company shares (share deals) is not recorded by the regional appraiser committee for real estate and the influence that this submarket has on land values is therefore not part of the analysis.
- From the reports of land sales, the annual average values for the price per square meter (sqm) respective price per hectare (variable PRICEha), the area sold (hectares), and their soil quality (soil points[7] SP) were determined for each district. This resulted in 1836 data records, i.e., annual averages for individual districts.
- Land mobility (MOB) is defined as the share of traded arable land in the period 2003 to 2016 with respect to total arable land of the district.[8] Land mobility with a range of 4% per year is extraordinarily high compared with the West German average of about 0.5% per year.

Data aggregation and transformation was done as follows:

The structure of the original pre corrected database consists of 3046 records of sold arable land:

- record 1/1/2003 (plot 1): district 1 (North and East coordinate), date of selling (year 2003), price, size, soil quality

- record 2/2/2004 (plot 2): district 2 (North and East coordinate), date of selling (year 2004), price, size, soil quality

- record 3/2/2004 (plot 3): district 2 (North and East coordinate), date of selling (year 2004), price, size, soil quality

- …

- record x/2/2005 (plot x): district 2 (North and East coordinate), date of selling (year 2005), price, size, soil quality

- record y/2/2005 (plot y): district 2 (North and East coordinate), date of selling (year 2005), price, size, soil quality

- …

- record z/3/2004 (plot z): district 3 (North and East coordinate), date of selling (year 2004), price, size, soil quality

- …

- record 3046/509/2016 (plot 3026): district 509 (North and East coordinate), date of selling (year 2016), price, size, soil quality

In the year 2003 we had only one observation (record), therefor no averaging was possible nor necessary. In the following years the variables for price (PRICEha) and soil quality (SP) within one district and one year have been calculated weighted averaged, for example record 2/2/2004 and record 3/2/2004 or record x/2/2005 and record y/2/2005 and so on. The remaining data set is two dimensional due to 1. the districts (panel or distance dimension) and 2. the observations in the different years (temporal dimension or time series). In addition new endogenous variables have been calculated; yearly weighted averages of plot size in ha and soil quality (soil points). Further new endogenous variables are the average land mobility over all years in each district. Besides that the soil value in different distances (up to 10 km, 20 km, 30 km, 50 km and over 50 km; see Table 1) for each year as well as the overall average land mobility in these circles

7 German nomenclature to evaluate and measure soil quality is via a rating system from the lowest measured value 7 to the highest 104 points for the best land according to the Soil Taxation Act of 16 October 1934 (*Gesetz über die Schätzung des Kulturbodens in Deutschland,* Bodenschätzungsgesetz)

8 If the same property was sold several times during this period, land mobility can exceed 100% in exceptional cases.

has been calculated. The aggregated panel data set has then the final structure "# number/ distance dimension / temporal dimension" with [variables of the district itself] and [variables of the surrounding districts in certain distances (10, 20, 30, 50 over 50 km)]:

#1 / Panel 1/ year 2003: [PRICEha, size in ha, SP, MOB], [PRICE10, MOB10, PRICE20, MOB20, …, PRICE51, MOB51]

#2 / Panel 1 / year 2004: [PRICEha, …

…

#1836 / Panel 509 / year 2016: [PRICEha

Due to missing values, the data has gaps in the time series. The linear regression was done with RATS[9].

Table 1. Classification of the distance classes and description of the variables for the land price and land mobility.

Distance classes	Distance to the district	Abbreviation of the variables
0	Within a district	rPRICEha, MOB
1.	0–9.9 kilometers	rPRICE10, MOB10
2.	10–19.9 kilometers	rPRICE20, MOB20
3.	20–29.9 kilometers	rPRICE30, MOB30
4.	30–49.9 kilometers	rPRICE50, MOB50
5.	>50 kilometers	rPRICE51, MOB51

Source: Own assumptions.

2.2. Methodological Approach and Hypotheses

The geographic information software QGIS [29, 30] was used to provide an initial evaluation and description of the relationships in the land market in the Mecklenburg Lake County.

In the regression analysis the factors influencing the average land value in a district were the exogenous variables: 1. temporal course of price development (trend, year 2003 equal to one); 2. extent of arable land sold (hectares); 3. soil quality (soil points); 4. land mobility; and 5. the price level of the neighboring districts with increasing distance.

The rationale for choosing the coefficients is that:

1. land values have increased over time in the period under review, which is a special feature because of the historical situation of the introduction and establishment of the market economy in East Germany and the privatization of large areas during this period;
2. larger sales plots achieve higher land prices per unit (sqm or hectare) [10] and
3. the soil quality of the fields determines their market value[11].

The following hypotheses were examined for the land market, using regression analysis; while individual regression coefficients of the regression equations should be checked to confirm the hypotheses, e.g. for land mobility for H1, land values in surrounding districts for H2 and H3:

H1 - Increased land mobility, i.e., a larger volume of land sales in the surrounding districts, has a price-dampening effect.

H2 - Achieving higher land prices in one district radiates from the surrounding districts.

H3 - This influence of H5 decreases with increasing distance.

The development in the Mecklenburg Lake County (LK MSE) is first of all explained in detail before an analysis at the district level is carried out in the next chapter.

3. Analysis at District Level

In the Mecklenburg Lake County (LK MSE), the prices for arable land increased approximately four-fold between 2005 and 2016. In the subsequent procedure, the nominal land prices were deflated and regressions were carried out with the real prices. The real price development also indicates the prices increased since 2008. The median real price for arable land in the period 2003 to 2016 was € 10,889/hectare. The real land values (€/hectare) of the panel data have been transformed by subtracting individual means to reach fixed effects estimation (**Figure 2**).[12]

The distribution of seller types and sellers in arable land sales in the Mecklenburg Lake County (LK MSE)

9 Estima (2020) RATS (Regression Analysis of Time Series)

10 In individual cases, it can be the other way round; for example, when a marginal lot fits perfectly with the company extension plans, the prices per unit can be higher.

11 It is not obvious to which extend, because there are arguments that due to hectare premiums, marginal land could be overpriced.

12 RATS-procdure: panel(entry=1.0,indiv=-1.0) rPREISha 1//2003:1 509//2016:1 rPREISha_tilde ENTRY is the weight on the original data (yit)

between 2003 and 2016 was also examined. Most of the 3046 sales contracts were sold by private individuals, accounting for a share of around 60%. Companies (excluding the state agency BVVG) are in second place with approx. 30% of sales, and the federal government is in third place with approx. 6%. A similar picture emerges among the buyers; private individuals are also most frequently represented in this section (approx. 40%) and then companies (approx. 25%). Farmers (as far as they have not already been recorded as private individuals) follow as buyers with a share of approx. 18%, and agricultural cooperatives with approx. 10%. Finally, it should be noted that the contract type is dominated by the sales contract, accounting for 97.18%, and the exchange contract follows in second place with almost 2%.

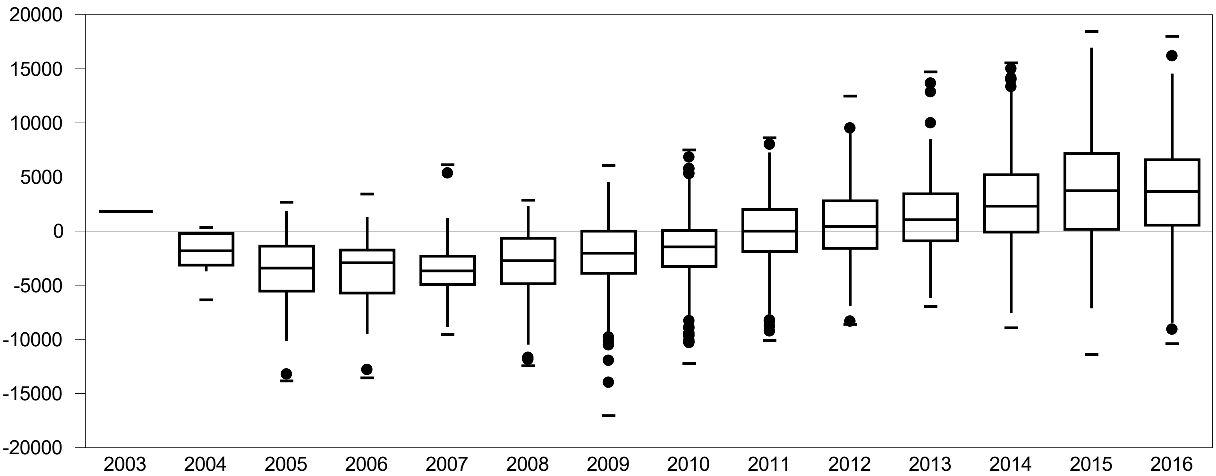
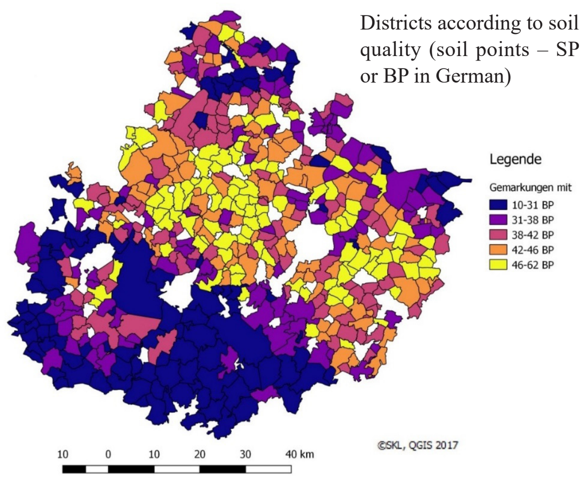


Figure 2: Transformed real land values (€/hectare); box plot with median, interquartile range (IQR) 25% and 75% (box), outlier (*, values that fall outside 1.5 times the IQR), minimum and maximum values. Source: Regional appraiser committee for real estate in the Mecklenburg Lake County, own illustration.

3.1. Evaluation with a Geographic Information System

The average soil quality of arable land in the districts of the Mecklenburg Lake County is 38 soil points[13]. The soil quality differs substantially by region, with the geologically better soils from 42 to 62 soil points in the north and east of the Mecklenburg Lake County, and poorer soils to the west of Lake Müritz and in the southern region (**Figure 3**)[14]. In **Figure 3**, the classes are divided into quantiles with the same number of entities. In 509 of the 613 districts in the LK MSE, there was at least one transaction during the period under review.



and INDIV is the weight on the individual mean (average across t at for individual i), so YTILDE will be created from Y by subtracting individual means.

13 In Germany the yield potential for arable land is rated in a range from 7 soil points for marginal land up to 104 soil points which represents the best quality soils.

14 Due to the historic glacial formation, the soil quality often changes very strongly within a district, which is why there can be larger deviations in the soil quality within a district for individual plots and thus the data records and low multicollinearity among the explanatory variables district and soil quality.

Figure 3. Soil quality on average for the sold arable land at the district level in the Mecklenburg Lake County, 2003–2016 (n = 509). Source: Regional appraiser committee for real estate in the Mecklenburg Lake County, own illustration with QGIS [30].

Land mobility is calculated as the quotient of "traded area" and "size of arable area" [31] in the individual districts (Equation (1)):

Land mobility = Sum of traded arable land in hectares / Total arable land in hectares * 100 (1)

Land mobility is calculated as an average for every year per district and this value is then summed up for all years of the investigation period. Land mobility in the Mecklenburg Lake County was around 16% between 2003 and 2016, i.e., 16% of the arable land has changed owners as a result of an indicated purchase contract. The also calculated weighted value for land mobility, weighed with the size of the purchased plots, is 38% (**Table 2**).

As already mentioned in the introduction, share deals are not included. The range of land mobility determined at the district level was between zero and 192%. Values above 100% indicate that some properties changed ownership several times in the 2003 to 2016 survey period. There have been done more analyses using QGIS, but with some graphs, data privacy is not guaranteed, because one can identify certain landowners, who own a whole district, and what are the prices they payed.

Table 2. Summary statistics of the sample time series; 509 districts; time period 2003 to 2016 (n = 1836).

Series	Mean	Standard Error	Skewness **	Kurtosis **	Jarque–Bera **
Exogenous variable:					
▪ rPRICEha	10,889 €/ha	6,184	0.93	0.55	284
▪ rPRICEha_tilde	0 €/ha	4,638	0.48	0.91	139
Endogenous variables within a district:					
• Size in ha	16.3089 ha	36.7380	6.60	58.87	278,454
• Soil points (soil quality)	38	9.81	-0.52	-0.39	93
• MOB (average land mobility)	16.43%	19.01	3.75	22.56	43,246
• MOB (weighed with size in ha)	37.87%	39.09	2.14	4.96	557
Endogenous variables of neighboring districts:					
• rPRICE10	12,724 €/ha	6,309	0.52	-0.26	87
• rPRICE20	13,377 €/ha	6,317	0.32	-0.53	53
• rPRICE30	13,742 €/ha	6,320	0.20	-0.73	54
• rPRICE50	13,895 €/ha	6,291	0.18	-0.73	50
• rPRICE51	12,376 €/ha	5,358	0.22	-0.75	57
• MOB10 (weighed with size in ha)	25.56%	22.33	3.19	12.69	15,412
• MOB20 (weighed with size in ha)	30.07%	21.70	2.35	5.77	4,241
• MOB30 (weighed with size in ha)	31.41%	20.87	2.11	4.27	2,752
• MOB50 (weighed with size in ha)	35.24%	20.47	1.42	0.85	670
• MOB51 (weighed with size in ha)	27.66%	15.16	1.88	3.54	2,044
** all parameters show a highly significance level (Sk = 0), (Ku = 0) and (JB = 0) < 5%					

Source: Regional appraiser committee for real estate in the Mecklenburg Lake County, own calculations.

3.2. Statistical Evaluation Using Panel Regression Analysis

With the help of the panel regression analysis, statistically significant influencing factors can be determined. The dependent variable was the price per hectare, whereby only the results for the function of the price per hectare are shown here. Land mobility, the soil quality of the area, and land prices were included in the neighboring districts as independent variables. The neighboring districts were divided into five distance classes with distances of up to 10, 20, 30, 50, and over 50 km (**Table 1**). The distance classes are selected due to the size of some districts, which are longer in extension than 10 km. The following distance classes are a multiple of this size. The distances between the districts were determined from the north and east coordinates as a linear distance of the respective towns or villages.

In the 509 districts considered (panel data), the price per hectare of arable land in real terms (rPRICEha) was € 10,889 per hectare, calculated as an arithmetic average between 2003 and 2016. The mean for the transformed variable rPRICEha_tilde is then zero. The statistical parameters of skewness, kurtosis, and the Jarque–Bera test significantly indicate a normal distribution of this exogenous variable and all of the endogenous variables (**Table 2**).

The endogenous model variables of all purchase contracts in one year within a district were the amount of arable land sold (size in hectares), which averaged 16.31 ha per district and year, and the soil quality, with an average of 38 soil points (SP; BP in German). In the 509 districts under consideration, land mobility (MOB) was 16.43%, i.e., in the period from 2003 to 2016, about one-sixth of the arable land changed hands, whereas the weighed value for land mobility (MOB) is 37.87%.

Within a radius of up to 10, 20, 30, 50 km, and above (51 or more km), the prices per hectare of arable land (rPRICE10, rPRICE20, rPRICE30, rPRICE50, rPRICE51) and weighed land mobility (MOB10, MOB20, MOB30, MOB50, MOB51) were determined. The prices per hectare fluctuated on average between € 12,376/hectare (rPRICE51) and € 13,895/hectare (rPRICE50), and land mobility ranged on average from 25.56% (MOB10) to 35.24% (MOB50).

Using a linear panel data model, the influencing variables on the deflated price per hectare for arable land in a district (rPRICEha) were estimated. Both temporal and distance interdependencies were examined. The coefficients of the model parameters were estimated by panel regression method[15] where fixed effects allows for heterogeneous intercepts, while assuming homogeneous slope coefficients.

A total of four different equations are presented, each in pairs as a linear regression, once with all model variables (Equations (1) and (3), and secondly only with the significant parameters (Equations (2) and (4)). The two basic variants are varied without (Equations (1) and (2) and with logarithmic data (Equations (3) and (4)). Other regression equations considering time lags and first differences have been tested, but results could not be improved, therefor the results will not be shown in this article.

The regression analysis for estimating the deflated price per hectare gave the following results. For all four estimation equations, the coefficient of determination (adjR2) was approx. 30%. The trend (2003 equal to one) was an important influencing factor in the investigation period. Accordingly, the average soil price rose by € 518/hectare per year (**Table 3**, Equation (2)).

The size of the arable land sold in a district in one year was taken into account in square meters in order to avoid values below 1 when taking logarithms. The more arable land was traded, the higher the price. If the arable land sold was one hectare[16] larger, price increased by an average of € 38/ha (**Table 3**, Equation (2)). Therefore, it can also be deduced that higher price could be achieved with increasing lot sizes. The variable land mobility (MOB) as it describes "proportion of sold arable land in a district" appears to have no explanatory value for the price formation during the entire investigation period.

In contrast, high land mobility in the surrounding areas (MOB10 to MOB30) leads to rather lower land PRICE in the center district. All significantly determined confidents of these variables have a negative value (**Table 3**). This means that a higher share of traded arable land in the surrounding districts tends to dampen PRICE and that, per percentage point of land mobility in the area, the soil PRICE for arable land in the center district should be 2.58 to 21.88 €/ha lower . Exceptions with positive signs are the exogenous variables MOB50 and MOB51 in Equation (1) (**Table 3**), however both coefficients are not significant.

The soil quality of arable land is a significant explanatory variable for the sales PRICE in all model variants. For

15 Estima (2020) RATS (Regression Analysis of Time Series): preg(method=fixed) rPREISHAtilde # … (list of endogenous variables). Panel Data Workbook.pdf, Draft Version June 5, 2012, p. 23.

16 1 ha = 10,000 sqm

each additional soil point (SP), the PRICE would therefore be evaluated to be higher of about € 100 (**Table 3**).

Table 3. Regression analysis for the endogenous variable "average real price for arable land in € per hectare in a certain district" for the period 2003 to 2016 depending on land mobility, soil quality, and the land prices in neighboring districts; estimation by least squares; n = 1836.

Regression No.	**(1)**	**(2)**		**(3)**	**(4)**
Method	all variables	selected choice		all variables	selected choice
Endogenous, dependent variable	rPRICEha tilde	rPRICEha tilde		Log_rPRICEha tilde	Log_rPRICEha tilde
adjR2	0.2953	0.3049		0.2594	0.2672
Exogenous independent variables	Coefficient value (T-Statistics)	Coefficient value (T-Statistics)	Exogenous independent Variable	Coefficient value (T-Statistics)	Coefficient value (T-Statistics)
TREND (2003 = 1)	565,6463 (3,67) ***	518,2536 (5,28) ***	Log_TREND	0,2846 (2,77) ***	0,2983 (3,72) ***
Size of sold arable land in sqm	0,0038 (11,05) ***	0,0038 (11,0513) ***	Log_Size of sold arable land in sqm	0,0528 (7,72) ***	0,0519 (7,68) ***
SP (soil points)	101,9634 (5,15) ***	102,8792 (5,28) ***	LOG_SP	0,3251 (5,02) ***	0,3309 (5,16) ***
rPRICE10	0,1033 (2,50) **	0,1094 (3) ***	LOG_rPRICE10	0,1075 (1,99) *	0,1381 (2,8) ***
rPRICE20	0,1824 (3,29) ***	0,1961 (3,7) ***	LOG_rPRICE20	0,1741 (2,25) **	0,2318 (3,27) ***
rPRICE30	0,0099 (1,73) *	0,0858 (1,99) **	LOG_rPRICE30	0,1602 (1,91) *	0,1564 (2,47) **
rPRICE50	-0,0720 (-1.00)		LOG_rPRICE50	-0,0124 (-0,13)	
rPRICE51	0,0562 (0.96)		LOG_rPRICE51	0,1188 (1,56)	
MOB	0 (0)		LOG_MOB	0 (0)	
MOB10	-3,8935 (-0,60)		LOG_MOB10	-0,0007 (-0,03)	
MOB20	-21,8895 (-3,08) ***	-22,3159 (-3,32) ***	LOG_MOB20	-0,0396 (-1,42)	-0,0567 (-2,19) **
MOB30	-2,5870 (-0,35)		LOG_MOB30	-0,008 (-0,27)	
MOB50	3,5603 (0,44)		LOG_MOB50	-0,0175 (-0,58)	
MOB51	4,4048 (0,51)		LOG_MOB51	-0,0257 (-0,93)	

Significance level: * >90%; ** >95%; *** >99%. Source: Regional appraiser committee for real estate in the Mecklenburg Lake County, own calculations.

There is a significantly positive correlation between the PRICE level in a district and the surrounding districts. The higher the PRICE level in the next districts in the area up to about 30 km's distance, the higher the PRICEes in the considered center district. In all four Equations (1) to (4), the influence of the PRICE level of the closest districts within a radius of up to 30 km (rPRICE10, rPRICE20 and rPRICE30) is significant (**Table 3**). The most weight has the coefficient for rPRICE20, which determines the influence of land values in districts in a distance between 10 to 20 km's. This shows the market forces of supply and demand on the land market, because other determinants for land value e.g. soil quality has been recognized in a separate variable. High PRICEes (hotspots) of neighboring districts up to 30 km appear to have an impact on the regional PRICE level for arable land.

By taking logarithms, one can estimate the elasticities based on the coefficients. They indicate which percentage change in an exogenous variable result in a percentage change in the price for arable land. For example, higher price districts within a radius of 10 to 30 km (LOG_rPRICE10, …20, …30) may have a cumulated price effect of 44% in the considered district (**Table 3**, Equation (4)).

4. Discussion

4.1. Testing the Hypotheses

The price development in the land market in East Germany has been very dynamic during the past two decades. The strong increase in land values is also confirmed for the investigation region, the Mecklenburg Lake County. This dynamic is taken into account in the model either by a trend variable (**Table 3**, Equations (2) and (4)).

The positive sign of the regression coefficient for the variable trend confirms with statistical significance that land values have increased in the investigation period 2003 to 2016. The extent to which this trend will continue, however, cannot be determined in the context of this analysis.

The prices of arable land depend on the size of the sales plot. On the one hand, a larger sales volume indicates that there is a corresponding demand that supports the land prices, and on the other hand, larger units of land are as well economically more interesting. The variable “size of sold arable land in sqm” is statistically valid in all determined regression equations. This approves that larger sales lots achieve higher land prices.

The price of arable land continues to depend heavily on its quality, which determines the productivity of the soil. In all model variants shown here, this variable, which is measured on the basis of the soil points, represents a statistically significant value.

The availability or the supply of land or, more precisely, of arable land in a district itself, is directly related to the volume of sales in the district in question. This relationship has already been tested and explained with the variable “Size of sold arable land in sqm”. The average land mobility in the period 2003 to 2016 in a relevant district itself (MOB) describes in principle the same context, namely, that with a high share of sales there is a high level of land mobility. As the variable “Size of sold arable land in sqm” is significant, the other related variable “Mobility of the land in a district (MOB)” is not longer considered. On the other hand, evidence was found that a larger supply of land in the vicinity of a district has a dampening price effect. All significant coefficients of the variables MOB10, MOB20, MOB30, or their logarithms and in addition LOG_MOB50 and LOG_MOB51 have a negative sign. This confirms hypothesis H1: “Increased land mobility, i.e., a larger volume of land sales in the surrounding districts, has a price-dampening effect” on land values in the center district.

However, if a high price level is achieved in the vicinity of a district, these hotspots radiate and high land values in the neighboring districts up to 30 km’s lead to higher land prices in the considered district. This is reflected in positive and highly significant coefficients for the variables of land prices (real, as well logarithmic values). Overall, hypothesis H2, “The achievement of higher land prices in one district also has an impact on the surrounding districts” can be confirmed.

The price level of the arable land sales of close districts, e.g., within a 10 to 20 km radius, appears to have the greatest impact on the prices in the center district than sales in more distant districts. This is suggested by the high significant coefficient of the variable rPRICE20 or its logarithmic value. With increasing distance, e.g. up to 30, 50 km and more from a considered district, the corresponding coefficients of the deflated sales prices for arable land (rPRICE) tend to become smaller or are no longer significant. Hypothesis H3 can thus be confirmed: “With increasing distance, the influence of the price level in the surrounding districts on the amount of arable land prices in a certain district decreases”.

In the equations with logarithmic values (**Table 3**, Equation (4)), the regression coefficients also provide information about the level of elasticity, i.e., the percentage change of the land price due to a percentage change of the respective independent variable. All coefficients are less than 1, i.e., there are inelastic relationships. The variable for soil quality (Log_SP) has the largest value, namely, 0.3251 (**Table 3**, Equation (4)). The elasticities also provide information to estimate effects of price changes in neighboring districts; the values of these elasticities are (Equation (4), **Table 3**) for LOG_rPRICE10 10%, LOG_rPRICE20 17% and LOG_rPRICE50 16%. It should be noted that these values add up, e.g., for Equation (4) (Table 3) to the value of 44%. Thus, if a steady increase in land prices is assumed, relatively high sums of elasticity result.

4.2. Simulation of the Influence of Exogenous Variables on the Price of Arable Land

To estimate how variations of the exogenous variables could have affected the price level for arable land in the investigation region and in the investigation period, a simulation was finally carried out by deriving the regression Equation (2) (**Table 3**). This also pursues the goal of ascertaining the different meaning of the model parameters for the result of the price determination.

First, the average price for arable land is calculated based on the averages of all variables; this amounts to approx. € 11,000/hectare for an average arable land in 2010 with a size of the sales lot of 16 hectares and soil quality of 38 soil points. Thus, land prices in the surrounding districts should also be approx. € 11,000/hectare. The simulated value for land mobility (MOB20) varies between 10% and 50%. To estimate the effects of changed parameters, starting from this middle level (i.e., level 2), two further levels with low values (level 1) and high values (level 3) are shown (**Figure 4**).. If all parameters of simulation level 1 are used simultaneously in regression Equation (2), the deflated market value is approx. € 4,753/hectare. Given the assumed higher values in simulation level 3, the price for arable land would increase to € 20,139/hectare.

To represent the isolated effects, only one variable is subsequently changed, while the other basic values are held constant at the level of the mean values (level 2)[17]. This results in the changes in land values in a certain district for the reference period 2003 to 2016. The exogenous variables here are land mobility, soil quality, and the three distance classes with significant coefficients from the regression equation in **Table 3** (10, 20, and 30 km). The range of the variation is based on the fluctuation ranges, as could be observed in the districts in the Mecklenburg Lake County (LK MSE) between 2003 and 2016 (**Figure 4**).

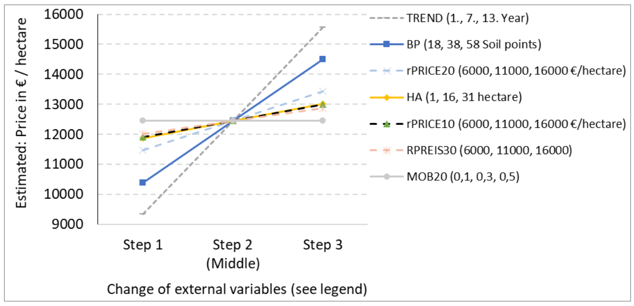


Figure 4. Isolated influence of changes in time (TREND), sales lot size (HA), and soil quality (BP), as well as land prices (rPRICE..) and land mobility (MOB20) in neighboring districts on the arable land price in a certain district. Source: Own illustration; calculated according to Equation (2) (**Table 3**).

Even if the parameters used in the simulation are only accurate at the mean and become less precise at the edges, the results of the simulations show quite interesting price effects:

1. The dominant isolated effect is the general price development in the land market (trend) in the years between 2003 and 2016 with an increase of about € 6,200/hectare in these years (**Figure 4**).

2. This is followed by the isolated influence of soil quality of the arable land; here the difference of 40 soil points (18 to 58 SP) results in an isolated price effect of approx. € 4,100/hectare.

3. The size of the sales lots per year in a district also lead to changed land prices. If, for example, the lot sizes increase from one hectare to over 30 hectares, then, ceteris paribus (c.p.), land prices would rise by around € 1,150/hectare.

4. There are three parameters that deal with the price development for arable land in the surrounding 10 to 30 km of a certain district. These three variables combined led to an (isolated) land price increase in the observation period of approx. € 4,000/hectare, thus proving that rising land prices in neighboring districts have a price-increasing effect.

5. Finally, it becomes clear that a higher level of sales (land mobility) in the vicinity of a certain district causes the prices for arable land to drop only slightly, if at all (**Figure 4**).

17 For each simulation run only one exogenous variable have been changed c.p.

5. Conclusions

Our research shows the influence of variables on the price development of arable land in the analyzed region. Land markets in this area are characterized by highly dynamic development during the past 15 years due to economic conditions in the agricultural sector, and particularly to conditions in financial markets in general. Based on a very broad empirical study with over 3,000 data records for arable land in the period of 2003 to 2016, statistical analysis was undertaken.

Since land purchases will be electronically recorded and available in the future, a much larger data set in its temporal and spatial dimensions will be available for future analyzes. However, as long as the share deals are not recorded by the authorities, important parts of the land market are missing from the official statistics. The presented method of data preparation for spatial disaggregation made it possible to measure distance effects with regard to land values. Among other things, it was intended to clarify to which extent hot spots, i.e. very high local land prices, affect the land values in neighboring regions. It was shown that high land prices in one district influence land prices in the surrounding districts. As expected, this effect decreases with increasing distance.

Author Contributions

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Conflicts of Interest

The authors declare no conflict of interest.

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