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Abstract

This paper applies the concept of a term structure to agricultural land rental prices. Based on theoretical considerations, we develop a hedonic pricing model that allows for different shapes of the term structure curve while controlling for other price-relevant characteristics. We apply this model to land lease contracts in Saxony-Anhalt concluded between 2002 and 2010. We find an upward-sloping term structure at the beginning, that is, market participants expected increasing rental prices. For the subsequent years, however, we detect a single-humped term structure. Hence, market participants revised their expectations and assumed a decline of land rental prices in the long-term.

Keywords: Farmland, lease rate, term structure, hedonic price model, privatization
JEL codes: E 43, D 44, Q 15

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1 Introduction

Land is an indispensable factor for agricultural production. Most farms gain access to this production factor via rental markets, and the share of leased farmland typically increases when farms are growing (e.g. Ciaian et al. 2012). As a result, leasing rates constitute an important part of farms' expenses. Moreover, land rental prices are used to determine farmland values. Thus, it is not surprising that price formation on agricultural land leasing markets has received considerable attention. Myriads of hedonic pricing studies have been conducted that reveal the impact of farmland characteristics, the location of environmental variables, and subsidies and regulatory measures on land leasing rates (e.g. Swinnen et al. 2008, Kirwan 2009, Breustedt and Habermann 2011). One issue, however, remains relatively unexplored in the empirical literature, namely the role of the term, for example the length of the leasing contract. In practice, the term of land rental contracts varies between short-term contracts of up to one year and long-term contracts of twenty years or more. It is intuitively clear that the contract term must be a determinant for the price of the contract, because it immediately affects the duration of future payments to be exchanged between tenant and landlord. The leasing rate upon which tenant and landlord agree when the contract is concluded reflects the spot rent that is expected to prevail during the contract period. This spot rent, in turn, will be determined by the cash flow that can be generated by using this asset, as well as by the availability of land in the future. In other words, the prices of land rental contracts with different maturities should contain information about expected conditions on land rental markets that are quite similar to the term structure of interest rates or commodity futures. Thus, it seems natural to exploit this analogy and to investigate whether land rental prices exhibit a term structure. This is tempting because the maximum maturity of land rental contracts is much longer compared with agricultural commodity futures, possibly allowing for insights about market expectations in the distant future. An upward-sloping term structure, for example, indicates that demand for land is expected to grow in the future, while little or no additional supply of land is expected, thus resulting in an increase of the short-term lease rate. In that case, the equilibrium lease rate must be an increasing function of the length of the contract because otherwise landlords would roll over a series of short-term contracts. A similar but converse interpretation holds for a downward-sloping term structure.

The idea of analysing the term structure of leasing rates is not new. In a seminal paper, Grenadier (1995) provides a theoretical framework for the valuation of general leasing contracts and the term structure of lease rates. Following the procedure of term structure models of interest rates, Grenadier first derives a stochastic process for short-term lease rate in an intertemporal rational-expectations competitive equilibrium. Second, using this short-rate process, he determines an equilibrium term structure for lease rates. Grenadier's paper has triggered a number of empirical studies on the term structure of lease contracts in real estate markets. For example, Gunnelin and Söderberg (2003) analyse the term structure in the office rental market in Stockholm. Using a hedonic rent equation, these authors find significant term structures in seven out of fifteen years in their observation period. Moreover, they identify different shapes for the term structure during a boom-and-bust cycle of the property market. Bond et al. (2008) find an upward-sloping term structure curve for office rents in London, but this shape does not vary over time. In contrast, Fang and Ruichang (2009) report a downward term structure for the office rental market in Shanghai.

Considering the attention that has been given to the term structure in real estate markets, it is surprising that no attempts have been made to estimate the term structure for agricultural land rental markets. The objective of this paper is to take a step in that direction. In particular, we pursue three questions: First, does a term structure even exist in land lease rates? Second, what shape does the term structure have? Third, does the term structure vary over time? Naturally, these questions can only be answered in the context of a specific land market. Here, we analyse a comprehensive data set of land rental contracts in Saxony-Anhalt, Germany, that are administered by the Bodenverwertungs- und -verwaltungs GmbH (BVVG), a land utilisation and administration company. The BVVG is responsible for privatising formerly state-owned farmland in the new German federal states, and is one of the key players on the land market in East Germany. Most importantly, the BVVG pursues a profit-maximising strategy, and land rental as well as land sales contracts are negotiated on a competitive basis (Dells 2008). This feature makes the data suitable for our research question.

The remainder of the paper is organised as follows. In the next section, we review the theoretical background of the equilibrium term structure of leasing contracts. The presented model justifies various possible shapes of the term structure. Moreover, we discuss some critical assumptions that underlie the analysis. Section 0 describes the market under study. Since our data is provided by BVVG, the state agency responsible for the management and privatisation of the land under scrutiny, we first introduce the land market in Saxony-Anhalt, and emphasize its history of privatisation (0), and then introduce and describe the utilised data (0). Thereafter, we present the empirical approach for estimating the term structure and present the main results (Section 0). The paper ends with conclusions on the term structures of land leasing rates, as well as a discussion on the predictability of future land rents.

2 Theoretical Background

We start by introducing a land lease contract with maturity T beginning at time 0 in which the landlord receives a flow of fixed (constant) rental payments $R(T)$ from the tenant. Formally, this is equivalent to a fixed dividend paid out by an asset to its owner. Our objective is to derive R as a function of T, i.e., the term structure. We achieve this by applying no-arbitrage arguments as in Stanton and Wallace (2009). The (single) stochastic factor of this model is the spot lease rate X. The latter can be understood as the price of the flow of services from using the land (e.g. a gross margin). When the length of the lease contract goes to zero, we have $R(0) = x$, where x is the current level of X. The spot lease rate can be modelled endogenously as, for example, in Grenadier (1995) or exogenously as in Clapham and Gunnelin (2003). To keep the model as simple as possible, we assume that the spot lease rate follows an exogenous geometric Brownian motion:

(1) $$dX = \mu X dt + \sigma X dz \, .$$

The value V of any contingent claim whose payoff depends on X and time t can be written according to Itō's Lemma as

(2) $$dV(X,t)=\left(\frac{\partial V}{\partial t}+\mu X\frac{\partial V}{\partial X}+\frac{1}{2}\sigma^2X^2\frac{\partial^2 V}{\partial X^2}\right)dt+\sigma X\frac{\partial V}{\partial X}.$$

In this context, we can think of V as the value of a land rental contract. Stanton and Wallace (2009) show that—to avoid arbitrage opportunities—the value of a contingent claim on an asset paying a dividend R must satisfy the following partial differential equation:

(3) $$\frac{1}{2}\sigma^2X^2\frac{\partial^2 V}{\partial X^2}+(\mu-\lambda)X\frac{\partial V}{\partial X}+\frac{\partial V}{\partial t}-rV+R=0$$

where r is a riskless interest rate, λ is an excess return defined by $\lambda=\sigma\cdot q$, and q is the market price of risk, which is assumed to be constant. The value for a land rental contract with term T can be derived from (3) by accounting for the boundary condition that its value is zero at maturity. The solution is then:

(4) $$V(x,0)=\frac{R}{r}\left(1-e^{-rT}\right).$$

Instead of offering a long-term lease contract with a constant rate R, the owner of the asset could equivalently roll over a sequence of instantaneous leases. The present value of the payments accruing from this transaction equals the value of an asset that pays a dividend X and has a value of zero at T. In this case, the differential equation (3) modifies to

(5) $$\frac{1}{2}\sigma^2X^2\frac{\partial^2 V}{\partial X^2}+(\mu-\lambda)X\frac{\partial V}{\partial X}+\frac{\partial V}{\partial t}-rV+X=0$$

which has the following solution (Stanton and Wallace 2009):

(6) $$V(x,0)=\frac{x}{r+\lambda-\mu}\left(1-e^{-(r+\lambda-\mu)T}\right).$$

The value of the long-term lease and the value of the roll-over-lease must be the same. Thus, by equating (4) and (6), one can solve for the equilibrium lease rate:

(7) $$R(T)=x\left(\frac{r}{r+\lambda-\mu}\right)\left(\frac{1-e^{-(r+\lambda-\mu)T}}{1-e^{-rT}}\right).$$

Equation (7) shows that the term structure curve starts at the current level of the short-term lease rate, x, and converges to the level $x\cdot r/(r+\lambda-\mu)$.[1] That is, depending on the sign of

[1] To see this, note that the ratio in the third term on the RHS in Eq. (7) converges to 1 if T becomes large, while it converges to $(r+\lambda-\mu)/r$ if T goes to zero.

the risk-adjusted drift rate, $\mu - \lambda$, the term structure will be upward- or downward-sloping. If the risk-adjusted drift rate of the spot lease rate is positive, the lease rate of a land rental agreement will increase with the term of the contract. The opposite is true in the case of a negative risk-adjusted drift rate. An upward-sloping term structure indicates a market where agricultural output prices are expected to grow in the future. Increasing returns from farming will, in turn, increase the demand for land rentals. At the same time, the supply of new land is expected to grow at a lower rate. On the other hand, a downward-sloping term structure indicates a land rental market that is currently "hot", but where prices are expected to decline, either because future prospects for the agribusiness are bad or because the new supply of land is expected in the long run.[2]

Unlike in the housing market, where new supply is triggered if lease rates become large compared with investment costs, land supply is mainly the result of structural change in agriculture. Farms quitting agricultural production provide their land either on sales or rental markets. In principle, it would be possible to model the exit rates of farms as a function of their profitability and their opportunity costs (e.g. Pieralli et al. 2013). Deriving an equilibrium stochastic process for the spot rental price, however, is rather complex since farms basically bid and ask for land at the same time.[3]

The two possible shapes of the term structure of lease rate that are supported by equation (7) are tied to the specific assumptions that have been made at the outset. If, for example, another stochastic process for the spot lease rate is assumed, different shapes of the term structure may arise. Specifically, in the context of fixed income markets Vasicek (1977) shows that if the stochastic factor follows a mean-reverting process, the term structure of interest rates may exhibit a single hump. A similar finding is reported by Grenadier (1995) for the term structure of lease contracts; a single-humped term structure characterises an intermediate case in which the new supply of land does not cover the expected demand in the short run but rather in the long run. As a result, the term structure is first upward-sloping and then downward-sloping. In our empirical analysis, we will allow for upward-sloping, downward-sloping and single-humped term structures.

3 The Market under Study: Land Rentals in Saxony-Anhalt

3.1 The Land Rental Market in Saxony-Anhalt and Privatisation

We focus here on Saxony-Anhalt, one of the federal states in East Germany, with the aim of exploring the role of terms in land rentals. Generally speaking, land rentals are important in East Germany's agriculture: the share of rental land per farm in Saxony-Anhalt (as in East

[2] The forward rental price $R(T)$ is an unbiased estimator of the expected future spot rent $E\ (X(T))$ only under restrictive assumptions. Clapham and Gunnelin (2003), for example, prove that a stochastic interest rate r may bias the expectation hypothesis.

[3] For a more detailed discussion of this issue, we refer to Kersting et al. (2013).

Germany in general), was 77 per cent, on average, in 2010 and is substantially higher compared to whole Germany, which had an average share of about 60 per cent in 2010 (Statistisches Landesamt Sachsen-Anhalt 2011).

Similar to all the federal states in East Germany, Saxony-Anhalt's agricultural structure is influenced by the Eastern German history of expropriation, land collectivisation and socialist policy between 1945 and 1989. Today's land market (sales and rentals) is also substantially characterised by the privatisation of the formerly state-owned land. After the German reunification in 1990, a privatisation agency (Treuhandanstalt) administrated and started the privatisation process of the formerly state-owned properties, including agricultural and forest assets (Dells 2008).[4] In 1992, the Bodenverwertungs- und -verwaltungs GmbH (BVVG) was established and took over the tasks of the Treuhandanstalt privatisation agency with regard to the management, privatisation and restitution of the agricultural / forest land on behalf of the Federal Ministry of Finance. The privatisation was organised in three phases (Dells 2008): leasing, selling at reduced prices under the land purchase program, and selling at market prices through public tenders.

In the first years, the BVVG preferably rented out (but also sold) the land to local farmers, those attempting to become local farmers (Neueinrichter), and to formerly local farmers attempting to resume their farming business (Wiedereinrichter). Interested parties unrelated to the local farm business and without local connections (e.g. non-agricultural investors) were formally excluded from buying or leasing land at that time (Forstner et al. 2011). The preference for leasing was mainly because of unclear property, ownership and restitution rights, but also because of the desire to keep the land in farming business until the property rights were clarified.[5] During the first phase, after a short period of only short-term contracts with administrative prices due to missing market structures, mainly long-term contracts with a term of 6–12 years (sometimes more) were negotiated to buy time for the clarification of property rights. In 1999, the tenants had the opportunity to extend the rental term by request up to a total term of approximately 18 years. According to the BVVG (2012), this option was used by the majority of tenants.

From mid-2004 onwards, the BVVG negotiated new short-term lease-contracts, and long-term contracts only in special cases (Müller 2004). Land sales are carried out using first price auctions with a public tender; however, bidders may either bid for buying or for leasing the land where the highest bid wins. Thus, long-term rentals are possible but the length of a rental contract is limited to 9 years (Deutscher Bundestag 2008). In 2007, a new privatisation concept was introduced: selling the land was strictly preferred over leasing. The concept was renewed in 2010 and privatisation should be completed by 2025. From 2010 on, the current

4 See Koester and Brooks (1997) for further details.

5 According to Koester and Brooks (1997), some estimates suggest that a large share of the land administrated by the Treuhandanstalt privatisation agency did not in fact have any pending claims. The preference to rent out the land might have been due to other reasons such as fear of depressed land prices.

tenants have the opportunity to directly re-negotiate their rental contract with a term from 4 to 9 years without public tender (Müller and Kittler 2012).

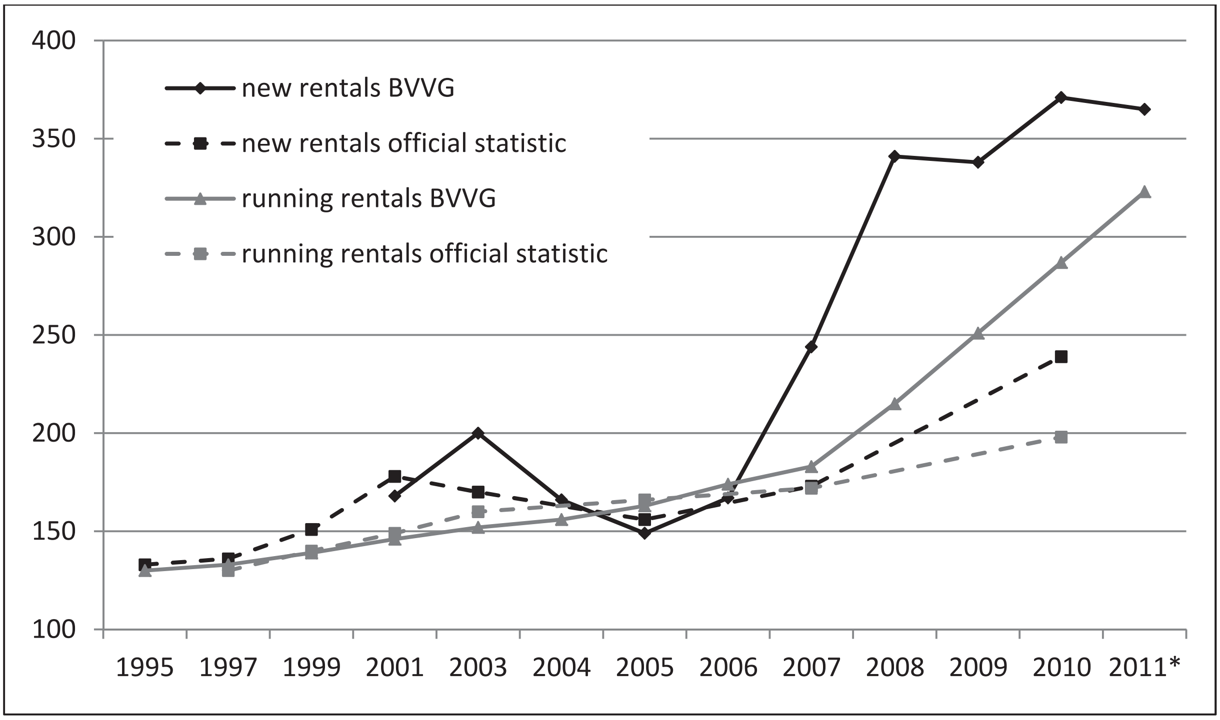
In addition to the BVVG, the Landgesellschaft Sachsen-Anhalt mbH (LGSA) is another institution that supplies formerly and currently state-owned land. The main difference to the BVVG is that the rental rates for land rented out by the LGSA are purely administrative and negotiated in favour of the local farmers; thus, on average their rates are much lower than market-based prices. Besides the institutional suppliers of land, the so-called private land market also seems to play a role in Saxony-Anhalt: retired farmers or former de-possessed owners act as suppliers and the price is either negotiated or found by auction-based procedures with locally-published calls for tenders.

The BVVG rental prices can be characterised as competitive. Prices are formed either through bilateral negotiations with the current lessee or by tendering (Müller and Kittler 2012). Moreover, the BVVG uses a price information system (Vergleichspreissystem) for its price negotiations that allows one to assess the price of a plot based on realised prices of plots with comparable characteristics. In general, rental prices are regularly renegotiated and from 2005 onwards, this was formally introduced into the standard rental contracts showing price adjustment clauses with a bi-annual renegotiation.

Figure 1 depicts the development of land rental prices in Saxony-Anhalt obtained by the BVVG and what is reported by the official statistics in Saxony-Anhalt. The latter should contain all contracts running or being newly-negotiated in the respective years, including those from the BVVG.[6] Figure 1 also distinguishes between the prices of running contracts that have been negotiated earlier and the prices of newly-established contracts in the respective year. A substantial increase is observed after 2005, particularly for new BVVG contracts. One possible reason might be that in this year, the 2003 reform of the EU Common Agricultural Policy (CAP) became active; its intention was to fully decouple the direct payments stepwise until 2015. It has been reported that many contracts for low-quality land were also fixed during this period, mainly to receive EU direct payments, which require active land use (Müller and Kittler 2012). After 2007, another price increase is observed for new and running rentals in both data sources. While in the majority of the years the BVVG prices lie above the official statistics price, from 2003–2005 the prices for new contracts were higher in the official statistic data compared to the new contracts of the BVVG, and also to the prices of the running BVVG contracts. This is perhaps because only few contracts were negotiated by the BVVG at that time due to the long-term rentals starting in the mid-1990s (Müller and Kittler 2012). In 2004 and 2005, a small decrease in the BVVG prices could be observed, which might be partly explained by the temporary exposure of the tendering procedure with the option to either bid for buying or renting.

[6] According to the German law of land transactions (Grundstücksverkehrsgesetz), the committee of land transactions (Oberer Gutachterausschuss für Grundstückswerte) must be notified of each new or adjusted rental contract.

Figure 1. Average rental prices in Saxony-Anhalt, 1995–2011



* until Oct-31, 2011

Data: BVVG and Statistical Office in Saxony-Anhalt.

3.2 Data

The empirical analysis is based on a data set of individual land rental contracts signed by the BVVG. Focusing on this data set only has the advantage that the rental contracts are rather homogeneous and have been negotiated in a comparable way. The original data set covers all *running* land lease contracts from 2006–2010 signed between 1954–2010. This implies that contracts ending before 2006 were not in the original sample. Considering all observations would imply that long-term contracts are over-represented in the sample. As a compromise between the number of observations and the bias of missing short-term contracts, we exclude observations with contracts negotiated before 2002.

The original data contain contracts with various land types (arable land, grassland, other) that appear in different proportions and have different prices. The homogeneity of the contract subject is an important issue (cf. Gunnelin 2003) for ensuring comparability over time. Hence, we only consider contracts that include arable land and analyse only the respective prices for arable land. We furthermore select comparable contract types, that is, we exclude rentals of whole farms or manors as well as contracts with other noted peculiarities, for example without price adjustment. Thus, the considered contracts contain all similar price adjustment clauses: before 2005, the price has been renegotiated every 4 years, and from 2005 on the prices are adjusted on a bi-annual basis (cf. Section 3.1).

The term structure incorporates farmer expectations regarding future transformations of the spot rent. These expectations change over time and as a result, the term structure may change accordingly. To ensure that expectations about future price developments are conditioned on the same information set, we restrict our analysis to contracts that were negotiated at the same time each year. Fortunately, 94 per cent of the contracts were concluded in October, so we can focus on these contracts without losing much data.

In addition, we remove outliers that are possibly due to incorrect documentation below the 1st percentile and above the 99th percentile of the price–soil quality ratio. To summarise, each observed contract includes information on the size of the rented out plot and its composition (i.e., the shares of arable land, grassland, and other types of land), payment by land type, the soil quality index[7], the starting date of the contract, the duration of the contract and the location of the plot at the county level. Further regional information about the respective location of the lot is unfortunately not available. The data set used in the end contains 2,504 observations and the summary statistics are provided in Table 1.

Table 1. Descriptive statistics BVVG data, 2002–2010 (N=2,504)

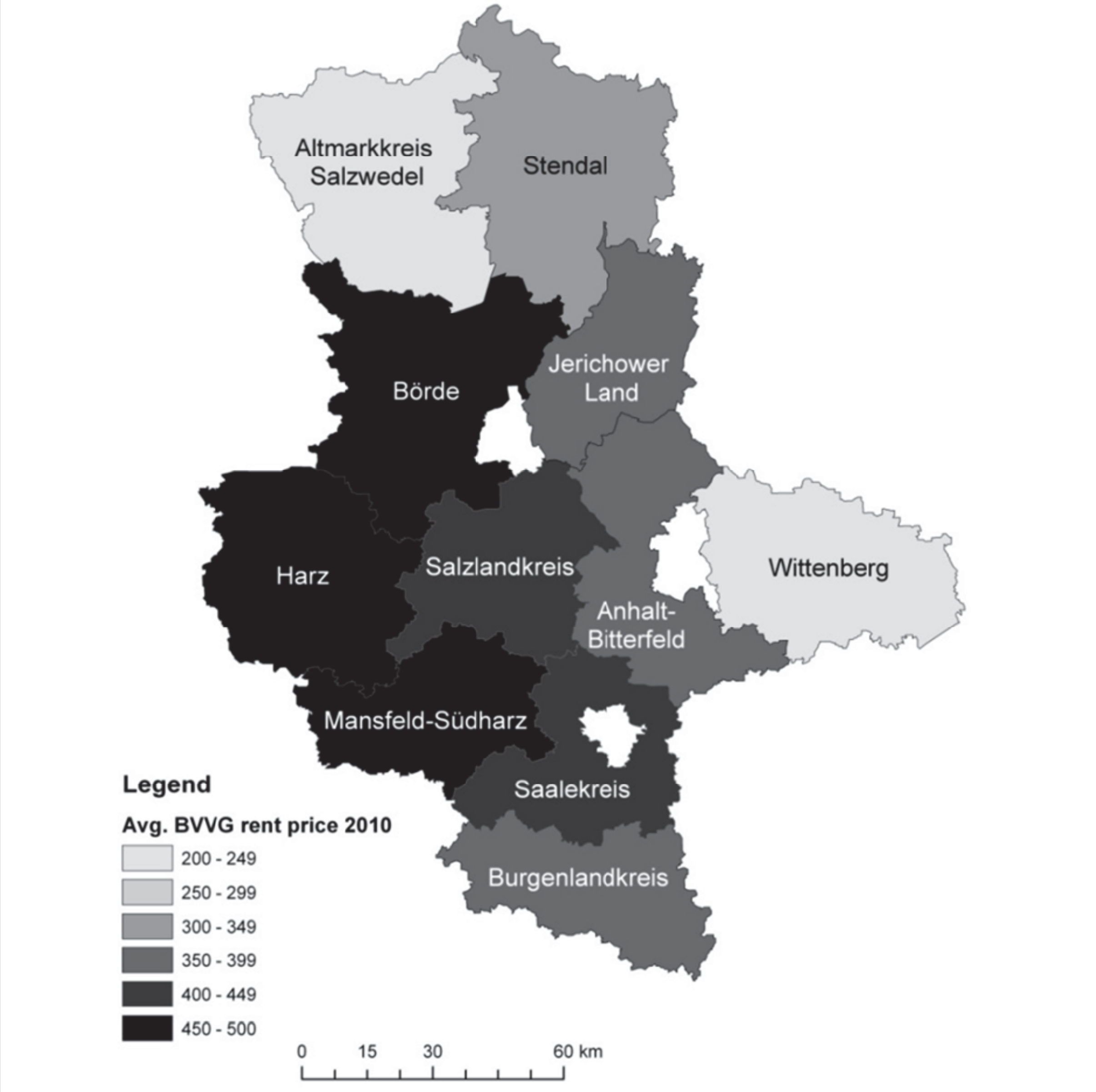
Variable	Mean	Standard Deviation	Min.	Max.
Plot size (ha)	17.44	31.1	0.02	554
Arable land (ha)	14.14	25.7	0.001	364.65
Grassland (ha)	2.41	7.4	0	124.96
Other land (ha)	0.90	4.29	0	190.75
Share of arable land (per cent)	80.92	26.5	0.170	100
Soil quality* (points [0,102])	61.34	21.0	9	100
Length of contract (years)	3.43	2.1	0	18
Price of arable land (Euros per hectare)	318.66	167.2	54	1075

*See footnote 7.

Due to the selection procedure, the plots mainly consist of arable land (81 per cent) and vary from 0.2 per cent to 100 per cent. The average soil quality of 61 points in our data set accurately reflects the average soil quality of 60 points in Saxony-Anhalt. The average rental price per hectare of arable land is 319 Euros, with a standard deviation of about 167. The rental price varies from 54 to 1,075 Euros per ha. The prices, furthermore, vary at a regional level. As illustrated in Figure 2, the counties in the western part of Saxony-Anhalt reflect higher prices compared to the northern and very eastern counties. This variation can be explained in large part by the regionally differing soil quality and weather conditions.

[7] The soil quality points are an official index in Germany that has been constructed so as to unify pedologic, scientific and (agro-)economic measures within one measure, and 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 102, and the lowest value was 7.

Figure 2. Average BVVG rent price 2010 by county in Saxony-Anhalt (in Euros per hectare)



Source: own illustration of BVVG data

Table 2 depicts the distribution of rental contracts according to their lease length over the sample period 2002–2010. The average length of the contracts is 3.43 years and the maximum length in the data set is 18 years. The table shows that most contracts have a length between 1 and 5 years. It also reflects the aforementioned policy change of the BVVG from long-term rentals towards sales of land plots.

Table 2. Distribution of the number of rental contracts over lease length and years in the observation period

Year	Term (years)												
	<1	1	2	3	4	5	6	7	8	9	10	≥ 11	*Total*
2002					1	8	10	2	0	2	1	2	26
2003				2	9	24	7	5	1	0	1	3	52
2004			7	52	79	39	21	8	5	2	1	2	216
2005		3	75	31	17	6	0	2	0	0	1	0	135
2006	0	55	183	37	24	27	4	1	1	0	0	1	333
2007	3	61	86	14	24	106	1	1	1	0	1	0	298
2008	11	135	93	127	54	135	6	0	0	2	2	0	565
2009	0	77	109	87	34	101	4	0	0	49	0	0	461
2010	0	61	51	75	74	42	44	10	2	54	4	1	418
Total	14	392	604	425	316	488	97	29	10	109	11	9	2,504

4 Empirical Analysis: Term Structure in the Land Lease Market in Saxony-Anhalt

4.1 Econometric Model Specification

To measure whether a term structure exists in the price formation of land rentals, and how it may affect prices, we refer to a hedonic price regression model. The price is modelled as a function of land- and plot-specific characteristics such as soil quality, share of arable land and plot size. Since we consider a rather long time period (2002–2010), we further account for a time trend.

No plot-specific coordinates are available and the lowest given regional level is the county level, NUTS 3.[8] Thus, we consider county ("Landkreise") dummy variables to capture regional unobservable effects such as local infrastructure. Spatial correlation, however, very likely remains in the error terms since it will not be fully captured by the plot-specific and regional (and time) dummy variables. Since the lack of information does not allow us to control for this correlation using spatial econometric techniques, we consider the regional average of the rental price from the previous year, in addition to the county dummies (cf. Pace et al. 1998 for more details about modelling spatio-temporal effects).[9]

[8] According to the Nomenclature of territorial units for statistics (NUTS), the classification used by Eurostat, Federal States ("Laender"), correspond to NUTS 1, and counties ("Landkreise") correspond to NUTS 3 (NUTS 2 does not exist in Saxony-Anhalt).

[9] To calculate the average county prices for 2001, the observations from the original data set for 2001 were used. No average price was available for Stendal and Wittenberg for 2001, or Salzlandkreis for 2002. These values were replaced by the average prices reported by the Statistical Office Saxony-Anhalt for these counties and years (valid for 17 observations).

Moreover, we consider the term as another price determinant modelled in linear as well as quadratic form, and in interaction with year dummy variables. Through this specification, we allow for different shapes of the term structure: linear increasing or decreasing and single-humped depending on the sign and significance levels of the respective coefficients. Furthermore, interacting the linear and quadratic term with year dummies allows us to estimate time-varying term structures.

Since we focus on quantifying the term-effects, it is important to consider all relevant price-determining variables to avoid an omitted variables bias (OVB). The functional form of the hedonic price regression is of further importance since a misspecification may also lead to biased estimates similar to the OVB. Thus, we apply the Box-Cox testing procedure. 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 or logarithmic–logarithmic model specification. According to Osborne (2010), the estimated parameter should be used pragmatically, that is, the exact estimates should not be used. Rather, one should decide whether the parameter is close to 1 (no transformation), to 0.5 (square root transformation) or to 0 (logarithmic transformation). Further, it is possible to exclude variables from the transformation testing, that is, not all variables need to be transformed. 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).
The estimated model is thus given by:

$$\begin{aligned}\log(R_i^{\text{arable}}) = {} & a_0 + a_1 A_i^{\text{arable}} + a_2 \left(A_i^{\text{arable}}\right)^2_{\text{scaled}} + a_3 \log\left(Q_i^{\text{arable}}\right) + a_4 \log\left(S_i^{\text{arable}}\right) \\ & + a_5 trend_{(i)} + a_6 \log\left(\overline{R}^{lagged,county}\right)_i + \sum_{c=2}^{11} b_c County_{ci} \\ & + \sum_{t=2002}^{2010} c_t \cdot Year_{ti} \cdot \text{Term}_i + \sum_{t=2002}^{2010} d_t \cdot Year_{ti} \cdot \text{Term}_i^2 + e_i \end{aligned} \tag{8}$$

where e_i denotes the error term, R_i^{arable} is the rent paid per ha of arable land in Euros, A_i^{arable} is the lot size in ha, and $\left(A_i^{\text{arable}}\right)^2_{\text{scaled}}$ area is the squared lot size in ha. The latter variable is scaled by the county average for normalisation and convergence reasons. Further, Q_i^{arable} denotes the soil quality points for arable land (soil quality index, see footnote 7) and S_i^{arable} is the share of arable land on total land of the lot [0,1]. We also include a yearly time trend variable $trend_{(i)}$ starting with 0 in 2002, $a_1 - a_6$ denote the corresponding coefficients to be estimated, and b_c indicates the respective coefficient for each county dummy variable $County_{ci}$, where c indexes the counties.

Overall, we account for 11 counties since no observations exist for the cities of Halle (Saale), Magdeburg or Dessau. The county "Altmarkkreis Salzwedel" is chosen as a reference. Moreover, $\left(\bar{R}^{lagged,county}\right)_i$ denotes the respective regional average price from the previous year in the respective region the tendered lot belongs to.

The length of contract *i* (in years), denoted by Term_i, enters the model in linear as well as in quadratic form, both in interaction with year dummies. If only the coefficient of the linear form, c_t, is significant and positive (negative), the estimated term structure is upward- (downward-) sloping. This reflects increasing or decreasing rental prices that increase (decrease) with the length of the contract. In this case, the prices are expected to increase (decrease) in future so that the buyer pays more (less) for a long-term contract compared to several short-term contracts. If the coefficient of the quadratic form, d_t, is also significant and negative, the term structure is single-humped, that is, it portrays increasing influence of the term but at a decreasing rate.[10]

4.2 Results

The estimates of the empirical model as portrayed in (8) are shown in Table 3. We find that plot characteristics such as size, share and quality of arable land have a significant impact on the price per hectare of arable land. Soil quality has a positive impact on the rental price, that is, an increase of 1 per cent in soil quality points raises the land rental price by 0.91 per cent. The linear term of the plot size has a positive sign, whereas the squared plot size scaled by the county average shows a negative sign, that is, the size has a diminishing marginal influence on the price. Also the plot size of the arable land positively influences the price: if the share of arable land increases by 1 per cent, so does the price by 0.05 per cent. These findings are in line with results found in the literature, for example, Breustedt and Habermann (2011).

The lagged regional rental price has a positive coefficient, meaning that a rise of the regional price in the previous year also increases the price in the current year. This shows that information in the local market is relevant. Likewise, Maddison (2009) has shown that the land price is influenced by observed prices of adjacent plots serving as references. The county dummies are significant in 6 out of 10 cases and capture the effects of unobserved information such as local infrastructure or neighbourhood relationships. For instance, the prices are found to be significantly higher in Jerichower Land County compared to Salzwedel County, which cannot be explained by soil quality and regional price levels.

[10] A significant positive coefficient of the quadratic form would be possible, in principle, but it has no straightforward economic meaning and is not supported by theoretical term structure models.

Table 3. Results

Land lease rate determinant	Estimated Coefficient	P-value
Land characteristics		
Arable land (absolute, ha)	0.002	0.000***
Arable land squared (scaled by county)	-0.011	0.001***
Share of arable land (per cent, logarithmised)	0.050	0.000***
Soil quality (logarithmised)	0.908	0.000***
Regional variable		
Lagged regional rental price, by county (logarithmised)	0.056	0.047**
Time trend	0.085	0.000***
Location dummies		
Altmarkkreis Salzwedel (reference location)	-	-
Anhalt-Bitterfeld	-0.007	0.822
Burgenlandkreis	-0.007	0.857
Börde	0.033	0.272
Harz	0.039	0.183
Jerichower Land	0.076	0.009***
Mansfeld-Südharz	-0.134	0.000***
Saalekreis	-0.156	0.000***
Salzlandkreis	-0.135	0.000***
Stendal	0.050	0.046**
Wittenberg	-0.098	0.002***
Term Structure		
D_{2002} Term	0.062	0.009***
D_{2003} Term	0.067	0.005***
D_{2004} Term	0.016	0.497
D_{2005} Term	0.025	0.319
D_{2006} Term	-0.029	0.134
D_{2007} Term	0.071	0.000***
D_{2008} Term	0.148	0.000***
D_{2009} Term	0.117	0.000***
D_{2010} Term	0.083	0.000***
D_{2002} Term²	-0.002	0.164
D_{2003} Term²	-0.003	0.156
D_{2004} Term²	-0.001	0.814
D_{2005} Term²	-0.001	0.785
D_{2006} Term²	0.004	0.175
D_{2007} Term²	-0.003	0.481
D_{2008} Term²	-0.012	0.000***
D_{2009} Term²	-0.011	0.000***
D_{2010} Term²	-0.008	0.000***
Constant	1.017	0.000***

Note: Asterisks *** and ** denote significance at the 1 and 5 per cent levels, respectively.

The variables related to time and contract term are the most relevant to our research question. The time trend is significantly positive, confirming the price increase that we found by visual inspection of Figure 1. Regarding the term structure, we find the following results (lower part of Table 3): The coefficients for the linear term variables are significantly positive for the years 2002, 2003 and from 2007–2010. Additionally, we have significantly negative coefficients for the quadratic term variable from 2008–2010. This means that we detect a positive linear, that is, upward-sloping term structure for 2002, 2003 and 2007, and a negative quadratic, that is, single-humped term structure from 2008–2010. In all other years, no term structure could be discovered. Even though the linear and the quadratic part are insignificant for a specific year, they might still have a joint effect (cf. Gunnelin and Söderberg 2003). Hence, we perform Wald tests for each year to test whether the respective coefficients c_t and d_t are both significantly different from zero. The results displayed in Table 4 support significant term structures in six out of nine years.

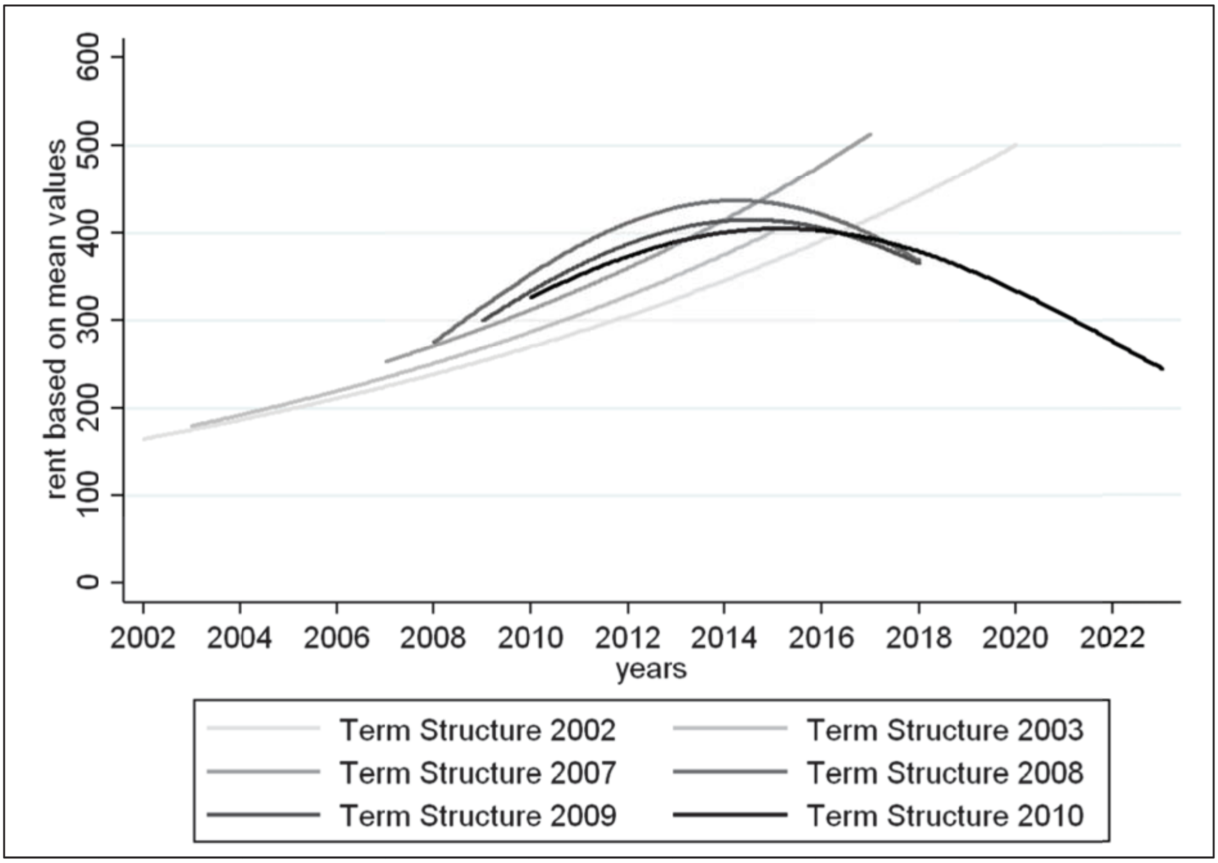
Table 4. Term Structure of Land Rental Prices

Year	p-values Wald test ($c_t = d_t = 0$)	Term Structure
2002	0.005***	upward-sloping
2003	0.001***	upward-sloping
2004	0.410	n.s.
2005	0.328	n.s.
2006	0.325	n.s.
2007	0.000***	upward-sloping
2008	0.000***	single-humped
2009	0.000***	single-humped
2010	0.000***	single-humped

These different shapes of the term structure, which are portrayed in Figure 3 for an average lease, can be interpreted as follows: In the first years of the observation period, lessees expected future rental price growth, and hence they accepted higher rents for longer maturities. This expectation can be rationalised by the fact that at the beginning of the last decade, land rental prices in East Germany were still considerably lower compared to West Germany. At that time it was rather likely that land rental prices in East Germany would rise to West German levels. In fact, this price gap became smaller over time so that the upward-sloping term structure should fade out unless further reasons come into play. This was actually the case in 2007, when agricultural commodity prices began to soar. This price boom increased the attractiveness of investing in agribusiness in general, and also created new demand for land in Saxony-Anhalt by local farmers and non-residential investors (cf. Forstner et al. 2011). This optimistic view of returns from agriculture is reflected by the upward-sloping term structure in 2007.

The single-humped shapes, which we find in subsequent years, indicate a kind of mean reversion of prices. Tenants now expect the hot market to cool down in the near future so they accept rental prices higher than the current spot rate only for medium-term contracts. The maximum prices by that time were expected for the years 2014–2016 (cf. Figure 3). After reaching the maximum, rental prices are supposed to sink again, resulting in lower rents for long-term contracts. According to the 2008 health check of the CAP, the direct payments should be fully de-coupled by the time when farmers expected the maximum. The following downward trend might reflect the unclear agricultural policy post-2015 with uncertain price developments and potential profit setbacks for farmers. Furthermore, the anticipation of farmers that coupled direct payments could have been directly transmitted to the land rentals so far might support the single-humped shape.

Figure 3. Estimated significant term structures



Note: The graphs are plotted for the maximum lease length of the respective year.

5 Conclusions

This paper adapts the concept of a term structure to agricultural land rental prices. So far, this notion has only been applied to agricultural commodity prices. Though conceptually similar to other assets, the term structure of land rental prices captures expectations about the profitability of farmland use that go beyond the time horizon of other traded financial instruments in agriculture, for example futures contracts. Thus, it is tempting to utilise the term structure of land rental prices for an assessment of farming's long-term economic prospects. We develop a hedonic pricing model that allows for different, possibly time-varying shapes of the term structure curve while controlling for other price-relevant characteristics of leased land. We apply this model to land lease contracts that have been concluded by the major supplier of agricultural land in Saxony-Anhalt, the BVVG, between 2002 and 2010. We find an upward-sloping term structure in 2002, 2003, and 2007, that is, market participants expected growing rental prices and hence agreed on higher rents for longer maturities. In the subsequent years of our sample, however, we detect a single-humped term structure. This finding indicates that the optimistic view on returns from farming has been tempered.

Apart from the novelty of this type of empirical analysis on land rental prices, our results have some implications for agricultural policy and structural change in agriculture. An increasing share of agricultural land is leased by farmers in Germany as well as in other countries. The expenses for this production factor constitute the most important cost driver in farming. Thus, any change in the land rental price will have consequences for farms' competitiveness and the income distribution between land owners and tenants. Increasing land prices particularly endangers less efficient farms and may force them to quit agriculture. Moreover, higher land rental prices capitalise into higher sale prices, making it more difficult for farmers to buy the land they operate. Thus, it is not surprising that the increase of land prices that farmers experienced in East Germany over the last decade has triggered a debate on the necessity of regulating land markets. Measures that have been proposed to dampen a further price surge include, for instance, price boundaries or restricted access to land for non-local farmers, as well as investors not being related to the farming business (cf. Siegmund et al. 2012). Against this background, it is very desirable to know about the future development of land prices. Based on our results, we argue that extrapolating land rental price changes without accounting for their term structure may lead to biased predictions. In fact, a naïve price index that simply averages lease rates and ignores the time of the contract formation and/or the contract length will overestimate the increase in land rental prices at the end of the last decade, where a significant hump of the term structure has been found.

However, a word of caution is necessary when interpreting the term structure curves for land lease rates. As mentioned before, it is not certain that the lease rate of a long-term contract is an unbiased forecast of the rental prices that will prevail at maturity because the price of the long-term contract may include a risk premium. Moreover, generalising empirical results is much more difficult compared to other financial assets since land markets are less liquid and price formation may be influenced by local peculiarities, for example the market power of regional buyers or suppliers. Thus, a next step should be to conduct similar analyses for land markets in other regions and countries. Finally, an empirical validation of the forecasting capability of term structure models in the context of land markets is suggested as an area for further research.

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