Letters in Spatial and Resource Sciences (2024) 17:32
https://doi.org/10.1007/s12076-024-00396-6

ORIGINAL PAPER

Rental and sale prices of agricultural lands under spatial competition

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Received: 16 May 2024 / Accepted: 6 November 2024

Abstract
Much of the land economics literature has largely ignored the spatial nature of competition and related differences between farmland rental and sales markets when assessing return rates from farming, the capitalization of agricultural, environmental and energy policy into land values, and climate change impacts. We propose a model for price formation in both markets under a spatial competition framework. We demonstrate that price formation differs, particularly under policy-induced output price shocks.We suggest that using the rent-price ratio as an approximation for expectations in the net returns of farming, based on the net present value model, may produce biased results. In consequence, studies relying on land prices need to control for local land competition, farming structure, and policies.

Keywords Land markets · Rent-price Ratio · Spatial competition · Policy capitalization · Price formation

JEL Classification L13 · Q12 · Q18

1 Introduction

In this note, we investigate the land market from an industrial organization perspective. Land is a scarce resource with declining overall supply, fixed location and other heterogeneous attributes. As a consequence, every transaction is specific, location matters and in a typical constellation a single seller meets several potential buyers.

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Published online: 28 November 2024

In the following, we elaborate the difference between the short-run leasing market and the long-run sales market.[1]

The spatial aspects of competition and associated distinctions between the rental and sales markets for agricultural lands are as important as location specific characteristics and spatial dependencies (cf. Nickerson et al. 2012). For instance, rents may be the results of less competitive market settings compared to sales markets, since local farms compete primarily in the rental market, while non-local agricultural and non-agricultural investors compete primarily in the sales market. Ignoring the spatial nature of competition may challenge the results given by the net present value model of farmland prices (cf. Deaton and Lawley 2022), i.e. relying on the land-price ratio to approximate the returns from farming (e.g. Borchers et al. 2014; Plogmann et al. 2020; Schaak and Mußhoff 2022). This may for instance explain the noted divergence in policy capitalization rates in rental and sales markets (e.g. Salhofer and Feichtinger 2020; Ciaian et al. 2021). Assessments of climate change on agriculture which use Ricardian approaches based on rental rates or land values ignoring spatial aspects of the markets may also give biased results (e.g. Ortiz-Bobea 2020; Bareille and Chakir 2023).

To demonstrate how changes in marginal revenues may affect equilibrium rental and sales prices, we develop a model for price formation in farmland markets under a spatial competition framework. Unlike existing models of spatial competition under farm policies (Graubner 2018) and approaches attempting to explain the behavioural differences of agricultural and non-agricultural bidders in farmland markets (Curtiss et al. 2021; Seifert et al. 2021; Balmann et al. 2021; Deininger et al. 2023), our model is better able to account for previous empirical findings of the differences in policy capitalization rates on land prices and rental rates, respectively, and the bidding behaviours of owners, buyers and renters. This leads us to propose the following hypothesis: given the spatial nature of competition in rental and sales markets for agricultural lands, compounded rents differ systematically from sales prices, but particularly under an output price shock and alternative future use of land.

This note is organized as follows. Section 2 describes our theoretical framework, introduces the graphical models of spatial competition in the rental and sales farmland markets as well as our hypothesis. In Sects. 3 and 4 we demonstrate the effects of shocks in downstream markets and alternative uses of land on rental and sales prices, respectively. Section 5 discusses the results, and Sect. 6 concludes with suggestions for future research.

[1] While the paper focuses on agricultural land markets, the model and its results can be relevant for markets with similar characteristics, e.g., the forestland, housing, and urban land market in particular or other markets of horizontal product differentiation and the possibility for price discrimination in general.

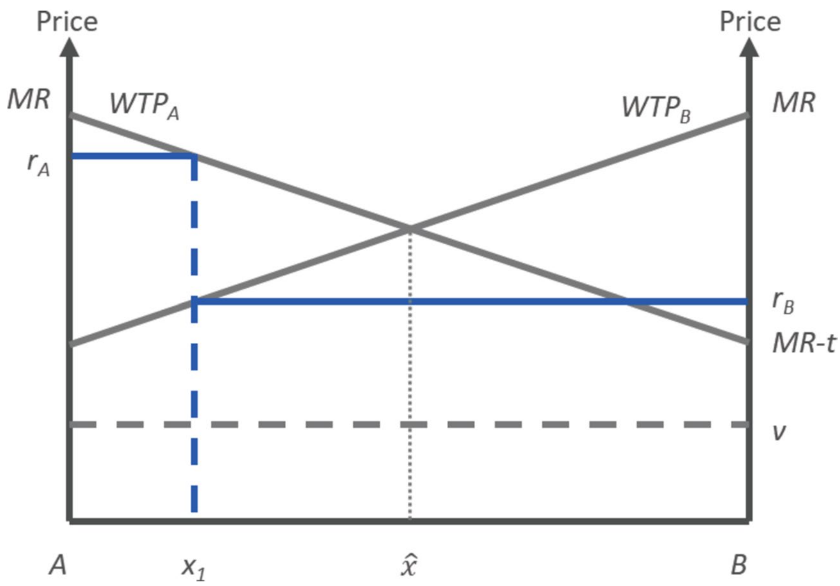

Fig. 1 A spatial model of the land rental market

2 A spatial competition framework of land markets

2.1 Land rental market

Following Graubner (2018), we assume two farms, A and B, located at the end-points of a line market with unit length and uniformly distributed land along this segment. Both farms operate under distance cost t reflecting their decreasing willingness to pay (WTP) for land with increasing distance to the farmstead.[2] Under perfect competition in the agricultural output market, they receive a net marginal revenue from land MR, i.e. the marginal revenue for land net of production costs but the rental price r for land.

At each location $x = [0, 1]$, a landowner supplies one unit of land to the farmland rental market, given the rental price $r(x)$ exceeds the landowner's reservation price v. Farms can set the rental price for land at each location, i.e. for each individual plot. This decision is influenced by their linear distance costs t and gives: $WTP_A(x) = MR_A - tx$ and $WTP_B = MR_B - t(1 - x)$. Depending on their cost and production structure, their net marginal revenue might differ, i.e. $MR_A \neq MR_B$. We find the location $\hat{x}$ where A and B have the same willingness to pay for land in the rental market by:

[2] Distances depicted in our model do not necessarily measure the distance between farmstead and field but, more broadly, include any reference location relevant for farm operations such as staples or produce magazines as well as the distance to similarly farmed land owned or rented by the same farm.

$$\hat{x} = \frac{MR_A - MR_B + t}{2t}. \tag{1}$$

With sufficiently low v, the market is covered and A and B can profitably rent land neighbouring the farmstead of their competitor as shown in Fig. 1, formally $v + t \leq \min[MR_A, MR_B]$.

Given the distance cost, farm A (B) on the left (right) of $\hat{x}$ has a higher WTP, e.g. if $MR_A = MR_B = MR$, $\hat{x} = 1/2$ and the maximum WTP for land is $WTP_A(x_1)$ at location x_1 for farm A, but B is only able to pay $WTP_B(x_1)$ and the landowners' willingness to accept (WTA) at x_1 is v (see Fig. 1).

Because of the (perfectly) price-inelastic local land supply, uniform pricing is the profit maximizing price strategy for farms (Espinosa 1992; Graubner et al. 2011). Under uniform pricing, a farmer offers the landowner an identical rental price irrespective of the distance from the landowner's plot to the farmstead as long as it generates (local) surplus to the farm. In a non-cooperative setting, no Nash equilibrium under uniform pricing exists (Schuler and Hobbs 1982; Zhang and Sexton 2001).[3]

If farms A and B decide their rental prices according to an average of the prices of neighbouring farms (Balmann et al. 2021), spatially-cooperative price matching competition emerges (Gronberg and Meyer 1981; Graubner et al. 2011). In equilibrium, farms set rental prices at the landowners reservation price (Graubner 2018) to capture all of the suppliers' (landowners') surplus (Zhang and Sexton 2001). For instance, at location x_1 the owner's surplus is zero because $r_u = v$, but both farms could yield non-zero profits if they offer $r_u = v$ and rent that land (see Fig. 1). The potential surplus of farm A is $MR - tx_1 - v$ and larger compared to farm B: $MR - t + tx_1 - v$. Tie-breaking rules determine which farm rents land at location x_1 (Gronberg and Meyer 1981; Iozzi 2004). Since both farms offer the same price r_u, one could assume that landowners randomly select the tenant, but farmers (e.g. in Eastern Germany) often exchange rented land to round off their farmland area (Margarian 2008). The practice corresponds to the efficient tie-breaking rule (Iozzi 2004), i.e. the farm with the lowest distance costs rents the plot. Hence, farm A obtains the surplus from the plot at x_1.

If all land in the market is rented so that no farm owns (at least part of) its operated land, the equilibrium rental price $r_u = v$ yields landowners surplus in the market of

$$\int_0^1 (r_u - v)dx = 0 \tag{2}$$

while the surplus of the farmers is

[3] For instance, Farm A could offer r_A (see Fig. 1) and rent all land left of x_1. Farm B's maximum WTP at x_1 is r_B, which facilitates to rent all land right of x_1. Neither price is an optimal response to the competitor's price though. Farm B is better off with $r_B = v$, which incentives Farm A to lower its price as well and to marginally overbid B.

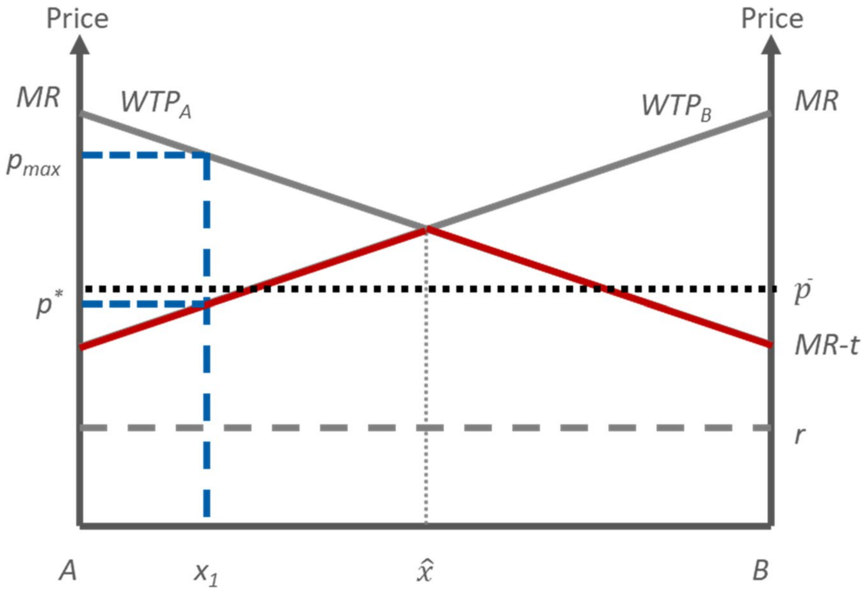

Fig. 2 A spatial model of the land sales market

$$\int_0^1 (\max[WTP_A(x), WTP_B(x)] - v)dx = MR - \frac{t}{4} - v \tag{3}$$

with $x_i = [0, 1]$.

2.2 Land sales market

Instead of renting land, farmers may prefer buying it due to the transaction costs of negotiating rental contracts, the search costs associated with losing contracts and related risks. Seeking hedges against inflation, storing wealth, stabilizing portfolios, etc., may motivate also non-farmer buyers to acquire farmland. Liquidity reasons or other investment options are incentives for landowners to sell land.

The common approach to model land values R is the net present value (NPV) model, which discounts a stream of expected returns over an infinite time horizon (Goodwin et al. 2003); cash rents are an observable option for such returns (Borchers et al. 2014). Accordingly, any rental price $r(x)$ in Fig. 1 represents the potential annual returns from owning land. Using the NPV model yields a local sales price:

$$p(x) = \sum_{n=1}^{\infty} \frac{r(x)}{(1+d)^n} \tag{4}$$

where d is a constant discount factor.

Lands immobility, local specificity, spatial distribution and low market liquidity (Bigelow et al. 2020; Kionka et al. 2022) characterize farmland sales markets as a static, one-shot game. In this setting, farms have less incentives for collaboration (Espinosa 1992). In terms of local returns, the lowest WTP at any location determines the non-cooperative, Nash-equilibrium sales price $p^*(x)$(Graubner et al. 2021; Lederer and Hurter 1986; Thisse and Vives 1988). The red lines in Fig. 2 show the resulting local land price schedule.

Farm A (B) can profitably purchase land left (right) of $\hat{x}$. At location x_1 the surplus of farm A, pricing marginally above $WTP_B(x_1)$, is $WTP_A(x_1) - p^*(x_1)$ and the landowner's surplus is $p^*(x_1) - v$. Under perfect information, all landowners and potential buyers can observe the local prices. The cost of search and information gathering, however, may be asymmetrically distributed among market participants; sellers and buyers might not be able to acquire all the information about market conditions and specific attributes of the respective land plot (Meissner and Musshoff 2022). For instance, local farmers can be better informed than non-local farmers and other buyers (Seifert et al. 2021). Accordingly, these groups only observe the average sales price $\bar{p}$ in a region shown as the dotted line in Fig. 2 given by:

$$\bar{p} = \frac{MR(0) + MR(\hat{x})}{2}\hat{x} + \frac{MR(\hat{x}) + MR(1)}{2}(1 - \hat{x}) = MR - \frac{3}{4}t. \tag{5}$$

We observe that $\bar{p}$ increases with increasing marginal revenue from the land but decreases with distance costs. We can make qualitatively similar observations for the farmer's WTP and thus the equilibrium sales prices, but not for the equilibrium rental prices that are independent of MR or t (2). The landowner surplus in the sales market is

$$\int_0^1 [p(x) - v]dx = \frac{1}{4}(4MR - 3t - 4v) > 0, \tag{6}$$

where $p(x) = \min\{WTP_A(x), WTP_B(x)\}$. The surplus of the farmers is

$$\int_0^1 |WTP_A - WTP_B|dx = \frac{t}{2}, \tag{7}$$

which is always smaller compared to the (discounted) surplus of farms in the rental market (3). In other words, renting is preferable to buying in an atomistic landownership structure and under the assumption that the rental market is less competitive than the sales market.

3 Shocks in farm output markets

Many empirical studies identify substantial capitalization of price shocks in farm output markets caused by farming policies or other factors on land rentals. However, capitalization is lower than theoretically expected (Ciaian et al. 2021; Latruffe and Le Mouël 2009). This has been attributed to imperfect competition in local land rental markets (Kirwan and Roberts 2016): if the marginal revenue for land MR changes due to external price shocks, farms' WTP changes as well. But if the

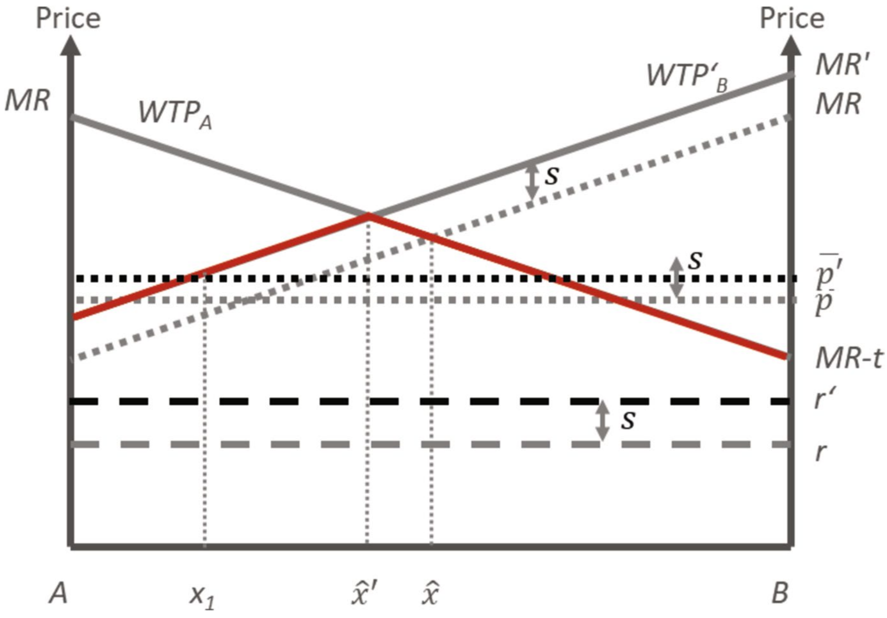

Fig. 3 Effect of shocks in the output market on rental and sales prices

landowners' reservation price v is independent of a plot's marginal revenue, the equilibrium rental price r does not change, and no price transmission from the farm output market shock to the rental market occurs (Graubner 2018). If, however, landowners believe that an external shock or policy may affect a plot's future use and its return the reservation price does change.[4]

The resulting effects on the land sales prices p will depend on whether all or only a part of the farm population benefits or loses by the external shock.[5] Figure 3 shows that when farm B benefits by a higher net marginal revenue of land, its WTP shifts by s for each location.

Not receiving a higher return, farm A's WTP does not change, but does alter the local price $p(x)$ it has to pay to obtain land (for $x = [\hat{x}', \hat{x}]$) and also increases the area where farm B has a cost advantage over farm A to $1 - \hat{x}'$. The corresponding

[4] The reservation price reflects alternative uses (opportunity costs) of agricultural land, e.g. forestation, subsistence or hobby agriculture, building land or renewable energy production. In the short run and depending on a plot's location, some alternative uses may be limited, and the reservation price may not account for changes in external conditions of farming (Graubner 2018). In the long run, however, landowners may adjust their reservation price by incorporating government payments, potential alternative land designations, and the like, in expectations of future earnings (Hendricks et al. 2012; Kirwan and Roberts 2016; Hüttel et al. 2016).

[5] For instance, price shocks in certain markets may affect farms differently depending on their production portfolio. Under farming policies, benefits might unevenly be distributed among farms given their willingness to participate in such programs or if the policy supports specific location characteristics, e.g. peatlands for carbon sequestration. Another example poses renewable energy subsidies, where farms investing in biogas receive subsidies for their energy crops.

Nash-equilibrium sales prices $p^*(x)$ also causes the average observed sales price $\bar{p}'$ to increase but the difference $\bar{p}' - \bar{p} < s$ due to the asymmetric effect on local prices, i.e. in Fig. 3, left of $\hat{x}'$ the price effect is s but right of $\hat{x}$ it is zero.

4 Location specific effects of alternative uses of land

We assume landowners expect land will be used for urban or infrastructural purposes, renewable energy production, etc., and that future returns will exceed agricultural returns, i.e. the WTP of potential buyers and the landowners' opportunity cost (WTA) increase. Figure 4 shows the locations for alternative uses and the respective sales prices $p(x)$ in area $x_R \in [x_1, x_2]$; these prices typically do not depend on the distance to either farm.

More profitable alternative use at some location also increases the average observable sales price in the region, but the level of increase depends on the difference in returns and the size of x_R relative to the size of the region. Similarly, the rental price $r(x)$ increases in x_R to v_R according to Eq. 4 but remains at v everywhere else. The effect on the average rental price in the region then depends on the difference of $v_R - v$ and, again, the size of x_R relative to the size of the region.

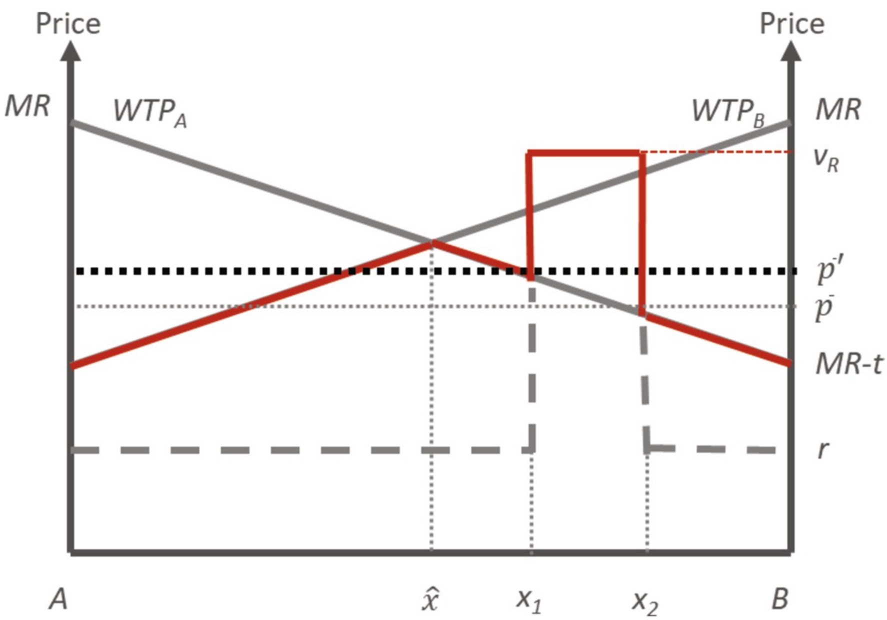

Fig. 4 Location specific effects

5 Discussion

The results of our proposed model outweigh those from models assuming that the rent-price ratio reflects average returns from farming, and that land values sufficiently capitalize current policies and future expectations. Our results suggest another potential for bias in Ricardian estimates based on average regional rental rates or sales prices presumed to be the outcome of perfect competition (cf. Ortiz-Bobea 2020; Bareille and Chakir 2023).

If landowners' reservation prices do not change due to external shocks in farm output markets, the shocks do alter sales prices but not rental prices. We find that rental rates are poor predictors for (changing) sales prices, and vice versa land-price ratios are poor estimates of farming returns. Should a farmland market become more competitive, e.g. more competitors in the specific region, and/or a decrease in the region's distance costs - both signs of competition flatten the WTP-curves as shown in Fig. 1 - rental rates are not affected when farmers behave cooperatively. Cooperative behaviour increases the discrepancies between rental and sales prices because the latter price increases according to Eq. (5). When there is non-cooperative behaviour in the rental market, an increase in rental rates will reflect a portion of the output price shock or policy, and the price transmission will increase as more farms compete (Graubner 2018).

Finding that the observable (average) sales price $\bar{p}$ in a region increases with increasing market competition, i.e. by decreasing distance costs or lower distances to other farms, suggests the need to control for the number of (potential) competitors and other liquidity measures in empirical farmland rental and sales price analyses (Balmann et al. 2021; Kionka et al. 2022), particularly when analysing the capitalisation of public farm support policies (Ciaian et al. 2021; Salhofer and Feichtinger 2020). Our proposed model explains the wide range and the discrepancy of estimated capitalisation rates for agricultural subsidies on rentals and land prices (Ciaian et al. 2021), and why expectations of changing (non-farm) land uses increase capitalisation in land sales prices compared to rental rates (Ortiz-Bobea 2020). The model also provides a theoretical foundation for differences in the present values of renting and buying land, which supports experimental evidence that farmers have a higher willingness to buy than to rent farmland (Buchholz et al. 2022).

In our model, we do not explicitly consider other important price determinants such as differences in field sizes, soil quality, or precipitation. However, our results will apply to non-homogenous land as long as any characteristic differentiating land other than location is not functionally related to the distance to the farmstead. Land heterogeneity can be considered in the model in two ways: a) in terms of location specific effects as described in Sect. 4 (caused by any characteristic of land including soil quality or closeness to output markets), or b) we can interpret the WTP curve to depict the willingness to pay for a certain quality index of land.

6 Conclusions

This note provided additional explanations for the variations in previous studies investigating the capitalisation of agricultural subsidies, energy policies, urbanisation, and zoning regulations. The proposed model identified distinct price formations based on the behavioural differences and expectations, between buyer and seller types, e.g. non-agricultural buyers seeking to hedge, or farmers seeking to expand their business, etc.

We believe that future empirical research continues to identify different outcomes and effects in farmland rental and sales markets under imperfect competition and we recommend controlling for local farming, policies, and land market structures. The effects of global heating on farm and agricultural lands and their rental and sales require additional research.

Author contributions Marten Graubner contributed to the conception, design, and analysis of the work and has drafted the manuscript and its revision. Silke Hüttel contributed to the conception and analysis of the study and to writing and revising the manuscript.

Funding Open Access funding enabled and organized by Projekt DEAL. This research was supported by the German Research Foundation via FORLand 2569 and SFB1502 (grant numbers 317374551 and 450058266, respectively).

Data availability The manuscript has no associated data.

Declarations

Conflict of interest The authors state that there are no conflict of interest to disclose.

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