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Spatial integration of agricultural land markets

The focus of this paper is on spatial market integration in agricultural land markets. We scrutinize the applicability of the law of one price to land markets and distinguish between absolute and relative versions of this "law". Panel data unit root and stationarity tests are applied to land sale prices in the German state Lower Saxony. Three main clusters with different price developments are detected. Our results indicate that the law of one price holds only locally due to structural differences among regions.

Keywords: Agricultural land market; law of one price; spatial price convergence

1 Introduction

Recent spikes in food prices and the high liquidity on international financial markets have boosted the demand for land. As a result, agricultural land prices have steadily increased over the past decade in many parts of the world. These developments have triggered a debate on whether current legislation is still appropriate or whether there is a need for revision. Apart from increasing land prices, policy makers and other stakeholders are concerned about an "unsound" or "unfair" concentration of land property rights. As a response, various measures have been proposed to address the aforementioned objectives, e.g., giving farmers priority in case of land purchases or relieving young farmers' access to land by facilitating farm succession and start-ups. At the same time, market access for agents treating land as an investment asset without an interest in farming, so-called non-agricultural or financial investors, should be restricted. Restricting the transfer of capital shares of agricultural cooperatives ("share deals") to such investors has been suggested on a regulatory basis since these deals bypass the current legislation in Germany (Land Transaction Act, *Grundstücksverkehrsgesetz*). Similar discussions about the necessity of tightening land market regulations also take place at the EU-level (Kay et al., 2015). This demonstrates the international dimension and broad relevance of the problem.

From an economic viewpoint, land market regulations that go beyond a general institutional framework ensuring functioning markets, such as defined property rights, should fulfil two preconditions. First, a (potential) market failure exists that may lead to economically and/or socially inferior land market outcomes. Second, envisaged regulations are supposed to lead to superior results. Actually, policy makers and stakeholder groups, such as farmers, often refer to market failures when justifying the need for policy interventions. Thus, we want to explore if empirical evidence of failures in agricultural land markets exists. In a first approach to this topic, we refer to the notion of market efficiency. Land market efficiency can be considered from at least two perspectives. The first approach focuses on the relation between land sale prices and land rental prices, and tests the validity of the present value model of land prices (e.g., Gutierrez et al., 2007). Test results can be used to identify the presence of speculative bubbles or boom and bust cycles in land markets (Falk, 1991). The relationship between land sale prices and land rental prices, however, is more complicated than presumed by simple present value models (Turvey et al., 2003). The second approach is to study market efficiency using the concept of spatial market integration. If markets are integrated, the law of one price (LOP) holds, that is, price differences of homogenous products or factors in spatially separated markets should not exceed transportation costs and other transaction costs; otherwise, arbitrage opportunities would exist.

The general objective of this paper is to investigate the efficiency of agricultural land markets via spatial market integration. According to the LOP, all goods on integrated markets are sold at the same price, apart from transportation or transaction costs. While the concept of spatial market integration has been extensively applied to agricultural product markets (e.g., Barrett and Li, 2002) and agricultural labour markets (Richards and Patterson, 1998), applications to land markets are rare. This may arise from special characteristics of the production factor "land". First, land is an extremely heterogeneous asset, which complicates price comparisons. Spreen et al. (2007) have shown that the non-homogeneity of goods can lead to a false rejection of the LOP. Second, land is immobile and hence it is not obvious how trade and arbitrage processes will actually work. Compared with other markets, transaction costs are high (Shiha and Chavas, 1995). As a result, the convergence of land prices will take place much more slowly, if at all, and markets may appear separated though they are spatially integrated. Finally, and related to the second point, regional market power may exist that prevents land prices in different regions from convergence. Thus, transaction costs should be interpreted in a broader sense and also cover costs related to asymmetric information due to the market structure, such as price agreements among neighbours, or unequal access to subsidies, leading to market imperfections (Ciaian and Swinnen, 2006). However, despite of these peculiarities, Waights (2014) emphasizes that the LOP, in general, also applies to real estate prices. This is due to the fact that farmers and capital are mobile. In agricultural land markets, for example, the mobility of non-agricultural investors could lead to a price convergence.

The contribution of our paper to the existing literature is twofold. First, this is one of the first attempts to examine the spatial market integration of agricultural land markets empirically. By investigating the spatio-temporal behaviour of land prices, we enhance the scope of spatial econometric models that are commonly used for hedonic land price studies. Second, we test the applicability of statistical tools that have been developed for commodity markets in the context of land markets. The work closest to our paper is a study by Carmona and Rosés (2012) that investigates the spatial integration of Spanish land markets between 1904 and 1934. Apart from the different contextual setting, their analysis is based on aggregated data and does not take into account heterogeneity of land characteristics in the price series that may bias the test results.

The rest of the paper is structured as follows: Section 2 provides a brief overview of the econometric methodologies used in this study, particularly how to test for the (local) validity of the LOP with stationarity tests; Section 3 describes the study area and available dataset, as well as the necessary price adjustments and choice of a benchmark region; Section 4 presents and interprets the results of the empirical application; Section 5 provides final conclusions and a discussion of the limitations of the study.

2 Methodology

According to the (relative) LOP, land prices in two regions should differ only by transaction costs and quality differences in the long-run, i.e., $q_{ijt} = p_{it} - p_{jt} = \tau_t + \xi_t$ where p_{it} and p_{jt} are the (log) prices of land in region i and j at time t, respectively. τ_t and ξ_t denote transaction costs and product quality differences, respectively. The absolute version of the LOP requires the price differential to be zero, but in the short-run, stochastic deviations from this relationship may occur. However, if quality adjusted price differences exceed transaction costs, arbitrage processes will be triggered and pull back relative land prices to their long-run equilibrium relationship. This implies that the difference of (log) prices is stationary under the LOP given that transaction costs are stationary, which can be tested by unit root tests. The low power of univariate unit root tests has been improved by the development of panel unit root tests (e.g., Levin et al., 2002; Im et al., 2003). Whereas the Levin-Lin-Chu (LLC) test assumes a common convergence parameter β for all regions i, the Im-Pesaran-Shin (IPS) test allows for region-specific convergence rates β_i. To mitigate the serial correlation of the error term, Im et al. (2003) additionally add lags of the dependent variable:

$$\Delta q_{ijt} = \alpha_i + \beta_i q_{ij,t-1} + \sum_{k=1}^{p} b_{ik}\, \Delta q_{ij,t-\mathrm{k}} + \varepsilon_{ijt} \tag{1}$$

where the term $\sum_{k=1}^{p} b_{ik}\, \Delta q_{ij,t-\mathrm{k}}$ captures the short-run dynamics of the land price process. The speed of convergence is reflected by the size of β_i. If the coefficient β_i is smaller than zero, relative land prices follow a stationary process. In that case, shocks are temporary and Δq_{ijt} converges to a constant value so that the LOP holds. If Eq. (1) has a unit root, i.e., $\beta_i = 0$, then Δp_{ijt} is non-stationary and the two land markets are separated. In the context of commodity markets, this finding is usually interpreted as evidence of market inefficiency.

Another important criterion for the selection of the appropriate test is the composition of the error term ε_{ijt}. If the individual time series in the panel are cross-sectionally independent, the IPS test is adequate. In the presence of cross-sectional dependence, however, the IPS test results will be biased. To cope with cross-sectional dependence, Pesaran (2007) suggests a CIPS test based on the following regression:

$$\Delta q_{ijt} = \alpha_i + \beta_i q_{ij,t-1} + \gamma_i \bar{q}_{t-1} + \sum_{l=0}^{p} c_{il}\, \Delta\bar{q}_{t-l} + \sum_{k=1}^{p} d_{ik}\, \Delta q_{ij,t-\mathrm{k}} + \varepsilon_{ijt} \tag{2}$$

Eq. (2) augments the individual regressions in Eq. (1) by the cross-sectional average $\bar{q}_t = N^{-1}\sum_{n=1}^{N} q_{nt}$ and the lagged differences, $\Delta\bar{q}_t, \Delta\bar{q}_{t-1}, \dots, \Delta\bar{q}_{t-p}$. Since in the case of cross-sectional independence the CIPS test has lower power than the IPS test, we apply the cross-sectional dependence (CD) test of Pesaran (2004) to test for the presence of cross-sectional dependence and hence to choose the most appropriate panel unit root test.

Though panel unit root tests increase the statistical power of univariate unit root tests, they are still not very powerful with respect to the alternative hypothesis of stationarity, i.e., the null hypothesis of non-stationarity may not be rejected even if prices are slowly converging. To increase the reliability of our testing procedure, we combine the (C)IPS test with a stationarity test, the Hadri Lagrange Multiplier (LM) test (Hadri, 2000), which is an extension of the univariate stationarity test by Kwiatkowski et al. (1992) (KPSS test) to panel data. The data generating process that underlies the Hadri test is given by:

$$\Delta q_{ijt} = r_{ijt} + \varphi_i t + \epsilon_{ijt} \tag{3}$$

where r_{ijt} is a random walk, $r_{ijt} = r_{ij,t-1} + \mu_{ijt}$; $\varphi_i t$ denotes fixed effects and individual trends, and μ_{ijt} and ϵ_{ijt} are zero-mean i.i.d. normal errors across i and over time t. The null hypothesis is given by H_0: $\lambda = \sigma_\mu^2/\sigma_\epsilon^2 = 0$ with σ_μ^2 and σ_ϵ^2 being the variances of μ_{ijt} and ϵ_{ijt}, respectively. The null hypothesis corresponds to Δq_{ijt} being stationary because in the case of $\sigma_\mu^2 = 0$, the random walk r_{ijt} reduces to a constant. Hence, a non-rejection of H_0 will be interpreted as evidence for the LOP.

On real estate markets, there exists the phenomenon of so-called "convergence clubs" (Abbott and De Vita, 2013). Convergence clubs enclose regions that share similar price dynamics and show diminishing price differences in the long-run. This concept has been introduced because one can rarely expect that the LOP holds for an entire country. Nevertheless, land prices in sub-regions with similar economic conditions may converge. In other words, testing the LOP in land markets does not only imply testing a single hypothesis as in commodity markets. Instead, it involves a more complex procedure targeting the identification of homogenous regions that show a long-run equilibrium relationship. To this end, we follow the Sequential Panel Selection Method (SPSM) (Chortareas and Kapetanios, 2009), which carries out a sequence of panel unit root tests on panels of decreasing size. Adapted to our context, the procedure involves the following steps (see Figure 1):

(i) The basis of the sequential detection of convergence clubs are log prices of N counties, which were adjusted for differences in average soil quality. These price series are then sorted according to the test statistic of univariate KPSS stationarity tests. The county with the minimum value of the KPSS statistic, i.e., the county with the highest probability of being stationary, is chosen as the benchmark region to calculate relative prices. Alternative benchmarks will follow later.

(ii) The resulting panel of relative adjusted log prices of $N' = N - 1$ counties (one county is the benchmark) is tested for stationarity by the Hadri test. If the null hypothesis of stationarity is rejected (i.e., we do not have overall convergence), the county with the maximum KPSS test statistic of univariate KPSS tests of the *relative* prices is removed. This county has the highest probability of being non-stationary and the highest contribution to the rejection of the Hadri test – a test which is a panel version of univariate KPSS tests.

(iii) This results in a subpanel of $N' - 1$ counties is tested again for stationarity by the Hadri test. If the null hypothesis of stationarity is rejected again, the county with the second-highest KPSS test statistic is removed as well. This procedure is repeated k times until the Hadri test cannot anymore reject the null hypothesis of the subpanel being stationary.

(iv) The remaining subpanel of $N' - k$ counties (stationary according to the Hadri test) is then tested for a unit root using a (C)IPS test to confirm the result of the Hadri test using opposite hypotheses. If the (C)IPS test cannot reject the null hypothesis of unit roots, the county with the highest chance of having a unit root is removed. This county is determined by performing univariate (C)ADF unit root tests and choosing the one with the highest test probability. The univariate (C)ADF tests form the basis for the panel (C)IPS unit root tests. This procedure is repeated j times until the (C)IPS rejects the null hypothesis of unit roots.

(v) The remaining subpanel of $N' - k - j$ counties and the benchmark form a homogenous region with price convergence and therefore market integration (Solakoglu and Goodwin, 2005).

As mentioned before, this procedure is then repeated for other benchmarks. After having chosen the county with the minimum value of the KPSS statistic of absolute log prices as the benchmark in the first place, we now take the one with the maximum value. This county shows the clearest non-stationary development and is supposed to form the basis of another convergence club. For this purpose, the relative prices of all counties that were not assigned to the first homogenous region are calculated with respect to the new benchmark. Then, the composition of the second convergence club is derived according to Figure 1. After detecting two "extreme" convergence clubs, we take the middle one of the remaining counties, sorted by the KPSS statistic of absolute log prices, as a third benchmark. Repeating the selection procedure leads to a third convergence club whose development stands between the other two. Theoretically, this procedure might be continued until all counties are assigned to a convergence club, but we limit the number of clubs to the three aforementioned ones to simplify their interpretation. Please note that the method for how we constructed the convergence clubs guarantees that each county is assigned to at most one club.

3 Study area and data

Lower Saxony is located in northwest Germany and consists of 37 counties. It is the second largest state in Germany covering an area of 47,600 square kilometres. About 60 percent of this area is used for agricultural production. In terms of production value, Lower Saxony is one of the leading states, contributing more than 20 percent to Germany's revenues from agriculture. However, natural conditions, production structures, and farm size structures differ largely across regions within Lower Saxony. In fact, Lower Saxony reflects much of the diversity of agrarian production that can be found in Germany. Roughly, four agrarian zones can be distinguished in Lower Saxony. The former administrative districts Hannover and Brunswick, located in the Eastern and South-Eastern part of Lower Saxony, respectively, are characterized by fertile soils. In this region, farms are rather large and specialized in cash crops and have a livestock density of less than 0.5 livestock units (LSU) per hectare. The former district Lüneburg breaks down into two agrarian zones: a southern part with poor soil quality that hosts mainly large specialized potato producers and a northern coastal part with a large share of pasture land. The latter region is dominated by dairy production, but also has a large pomiculture cluster. The distinguishing feature of the fourth agricultural zone, Weser-Ems in the western part of Lower Saxony, is its intensive livestock production. In view of rather poor soil quality and relatively small farm sizes, livestock production shows comparative advantages and its intensity has steadily increased over the last few decades. Actually, 70 percent of Lower Saxony's hog production and more than 80 percent of its poultry production is concentrated in this region. More recently, biogas production became an important alternative business in this region. Currently, 50 percent of

Lower Saxony's total agricultural revenues are generated in the Weser-Ems region. The aforementioned facts document the heterogeneity of agricultural production within Lower Saxony. Since natural and economic conditions have an impact on the productivity of land, we expect that differences in land use intensity translate into differences in land rental and sales prices.

The empirical analysis is based on sale prices of arable land on a county level in Lower Saxony. These data are available for 25 years (1990–2014) and 37 counties of Lower Saxony, provided by the Statistical Office of Lower Saxony. This results in a balanced panel data set of 925 annual observations. Besides the annual average price of arable land in €/ha for each county, the data set also contains the number of transactions, the average soil quality of the sold lots as a yield index (*Ertragsmesszahl*), and the total area of transacted land in ha.

This aforementioned conjecture of different land prices due to different economic conditions is confirmed by Figure 2, which displays the development of (nominal) land prices for Lower Saxony as a whole and for the three counties representing different price dynamics within this state (these counties will be the benchmarks later). We observe a boom in prices in Osnabrück (from 18,816 €/ha in 1990 to 55,827 €/ha in 2014, +179%) and a moderate increase in Heidekreis (from 10,565 €/ha to 19,186 €/ha, +82%), whereas prices in Hildesheim increased slightly (from 25,483 €/ha to 33,596 €/ha, +32%). Not only has the price level differed significantly across counties, but also has the appreciation of land values. This illustrates the large regional differences in Lower Saxony and raise considerable doubts about the validity of the LOP for the whole of Lower Saxony.

One prerequisite for the validity of the LOP is the homogeneity of the analysed good. Land, however, is rather heterogeneous. In our analysis, a large degree of heterogeneity is already taken out since we apply average prices per county provided by the statistical office: The statistical office already excluded unusual transactions of land to prepare representative values and the values on the county level reduce heterogeneity compared to transaction data. One of the most important factors of land prices, the soil quality of the sold plots, however, still varies over the counties, which is shown by the numbers reported above. Furthermore, within a county, soil quality can vary over time depending on the quality of the single plots sold in different years. Without an adjustment for soil quality, the absolute LOP cannot be assumed to hold.

A standard approach to analyse the LOP for heterogeneous good is to run a hedonic price regression first to correct for different characteristics (Goldberg and Verboven, 2005; Lutz, 2004; Waights, 2014). For our dataset, we model the county log price $\ln p_{it}$ assuming a constant effect of soil quality, a county-specific linear time trend, and individual fixed effects. If the estimated coefficient of the soil quality is found to be statistically significant, we adjust the county log prices to the average yearly soil quality and obtain adjusted log prices $(\ln p_{it})'$.

After the log prices are adjusted for soil quality, the other issue is the choice of a benchmark. Previous researchers noticed that convergence results are possibly sensitive to the choice of the benchmark unit (Abbott and De Vita, 2013; Cecchetti et al., 2002; Goldberg and Verboven, 2005; Solakoglu and Goodwin, 2005). One way to address this criticism is to use more than one benchmark. Alternatively, the pairwise approach can be applied, which performs pairwise univariate tests instead of panel tests (Abbott and De Vita, 2013; Pesaran et al., 2009). To avoid the lower power of univariate tests, we still utilize the panel approach and choose the benchmark based on stationarity tests of the individual series. As described in Section 2, we take the counties with the extreme KPSS test statistics as well as one intermediate county to represent different development trends. The county with the lowest KPSS test statistic and hence the highest probability to be stationary is Hildesheim, whereas the highest KPSS test statistic is obtained for Osnabrück. For the county with an intermediate value, we chose Heidekreis. The development of the raw prices of these counties was already depicted in Figure 2. These counties reflect three different development paths in Lower Saxony and hence are well-suited as benchmarks.

The variables entering the panel convergence tests are the adjusted log prices in relation to an overall benchmark, denoted as Δq_{iBt} and defined in the following way:

$$\Delta q_{iBt} = (\ln p_{it})' - (\ln p_{Bt})' \tag{4}$$

This means that the adjusted log prices of all counties i, $(\ln p_{it})'$ are considered with respect to the adjusted log prices in the benchmark region, $(\ln p_{Bt})'$.

4 Results

The first step of the testing procedure comprises of an adjustment of heterogeneous prices for differences in soil. The results of the hedonic regression (not reported here) show significant time effects, significant county effects in most counties, and a significant coefficient of soil quality (all at the 5 percent level) with the expected positive sign, i.e., higher soil quality generally leads to higher prices. Hence, we adjust the log prices in the aforementioned way.

To determine the appropriate panel unit test (IPS or CIPS), we first test for the presence of cross-sectional dependence. We apply the CD test first for the adjusted log prices without a benchmark and then for the adjusted log prices relative to the three benchmark regions (Hildesheim, Heidekreis, and Osnabrück). Irrespective of analysing absolute or relative prices, there is substantial cross-sectional dependence according to the CD test. We control for this cross-sectional dependence by using the CIPS test, which we explain below.

We begin by analysing the convergence of land prices among all 37 counties. Visual inspection of the individual price series in Figure 2 suggests that at least some counties within Lower Saxony exhibit different price dynamics. This conjecture is confirmed by a Hadri test (Table 1). The Hadri test rejects the null hypothesis of price convergence irrespective of the chosen benchmark region if all counties are included in the panel. On the other hand, a CIPS test clearly rejects the null hypothesis that all (relative) land price series are nonstationary. Thus, we can conclude that the LOP does not hold for land prices in Lower Saxony as a whole, but may hold for some sub-regions. To identify these sub-regions, we carry out the SPSM described in the previous section. By means of this approach, we are able to identify three “convergence clubs”. The first consists of five counties, namely Hildesheim, Goslar, Helmstedt, Hannover, and Holzminden. A common feature of these counties is the stationarity of their (log) land prices according to a univariate KPSS test. In these counties, we observe only a slight increase in land prices within the last two decades, despite the overall land price boom in Germany. Hence, we designate this group as a “stagnating” convergence club. The lower panel of Table 1 shows that the null hypothesis of stationarity cannot be rejected by a Hadri test at the 5% significance level, whereas the null hypothesis of nonstationarity is rejected by a CIPS test. Figure 3 reveals that most members of the stagnating group are located in south east Lower Saxony and form a regional cluster. Note that counties that are merged in this cluster may show rather unequal land price levels. In the benchmark region Hildesheim, for example, land prices are considerably higher, than in Helmstedt (33,596 €/ha versus 17,909 €/ha in 2014). However, this difference does not contradict the outcome of the convergence tests. First, price levels become more similar after adjusting for differences in soil quality: For example, the adjusted prices in Hildesheim and Helmstedt in 2014 are 18,327 €/ha and 13,577 €/ha, respectively, after adjusting for a soil quality of 71 points in Hildesheim and of 52 points in Helmstedt. Both prices are adjusted to a soil quality of 44 points, which is the average soil quality for all counties in 2014. Even more important is the fact that stationarity refers to the land price ratio rather than to absolute price differentials. That is, membership in one convergence club implies that land prices grow (or shrink) with a similar rate. This does not rule out divergence in absolute price levels.

To investigate convergence among the remaining 32 counties that exhibit non-stationary land prices, we choose Osnabrück as a benchmark region because the hypothesis of stationarity is rejected with the highest probability according to the KPSS test. Applying the SPSM identifies 14 counties which share a similar price development with Osnabrück: Diepholz, Harburg, Rotenburg, Stade, Ammerland, Aurich, Cloppenburg, Friesland, Bentheim, Leer, Oldenburg, Vechta, and Wittmund. These counties are characterised by a significant boom in land prices during the last decade of the observation period. It is noteworthy that this convergence club forms two regional clusters with different natural conditions and production systems (Figure 3). One cluster is located in the mid-western part of Lower Saxony (in the Weser-Ems region) and covers an area of intensive livestock production. The highest land prices within Lower Saxony are in this region. Moreover, the price increase over the last two decades is rather pronounced. This reflects the high marginal productivity of land that can be typically realized in labour and capital intensive production systems, such as pig and poultry farming. Tightening environmental regulations, particularly limiting the disposal of manure, have further increased the scarcity of land in this region. The second cluster is located in the north-eastern part of this state which is dominated by dairy farms operating on grassland. Land price levels are considerably lower than in the Weser-Ems region. Again, we find that counties showing different absolute land price levels are collected in one convergence club. The heterogeneity of the club members suggests that different economic factors may have caused the observed land price boom, such as increased environmental regulations, the liberalization of the EU milk market, or urban sprawl (e.g., around the city of Osnabrück).

A final iteration of the SPSM carves out a third convergence club that is comprised of ten counties: Gifhorn, Osterode, Nienburg, Celle, Cuxhaven, Lüchow-Dannenberg, Lüneburg, Verden, Uelzen, and Heidekreis. The latter county was chosen as a benchmark for this group because it ranks in the middle of the residual counties according to the KPSS test statistic. The evolution of land prices in this convergence club range between those of the stagnating and the booming group, i.e., land prices are characterised by a moderate increase. Most counties are located in the eastern part of Lower Saxony. Figure 3 further shows that the SPSM cannot assign all counties to one of the three convergence clubs. In total, eight counties (Göttingen, Emsland, Hameln-Pyrmont, Northeim, Schaumburg, Osterholz, Peine, and Wolfenbüttel) do not belong to any of the three groups. With the exception of Osterholz and Emsland, these counties are concentrated in the south of the state, i.e., adjacent to the stagnating convergence club. Regarding Emsland, it is puzzling why this county is not a member of the booming convergence club since it shares many characteristics with neighbouring counties, such as Vechta and Cloppenburg. A closer look at the land price dynamics in this county, however, reveals that the price increase during the observation period is even higher than in the benchmark county Osnabrück, so that its price ratio appears to be nonstationary.

It is important to note that the exact classification of counties into one of the three convergence clubs depends on a few of parameters that have to be specified by the researcher. First and foremost, the classification result depends on the choice of the benchmark county. Our idea was to determine two counties with extreme values of the KPSS test statistics as the benchmark for the stagnating and the booming convergence club. Choosing counties with less extreme KPSS values changes the size and the composition of the resulting groups slightly. Second, the order in which the counties are successively removed from the set of non-classified counties depends on the KPSS test statistic in our procedure. However, this way of ordering is not unique and other rankings lead to feasible solutions as well. Finally, the significance level of the Hadri test, at which the stationarity hypothesis is rejected, has an effect on the group size. Since the identification of the convergence clubs follows an iterative procedure, changes in one convergence club may have an influence on the structure of other clubs as well. Though changes in the aforementioned parameters have an impact on the exact composition of the convergence clubs, the qualitative results of our analysis are rather robust.

Table 2 provides further information on the outcome of the testing procedure that is useful to characterize the price dynamics in the three convergence clubs. For each county, OLS estimates of the coefficients α_i and β_i in Eq. (1) are presented. From these estimates, half-lives given by $-\ln 2 / \ln(1+\beta)$ can be derived, i.e., the time period in which half of the deviation from the long-run equilibrium relationship between a specific region and the benchmark region will be eliminated.

The last column of Table 2 displays the deviation of the long-run adjusted land price level of a county relative to the benchmark region, which follows from the relationship $-\alpha_i/\beta_i$. In line with the outcome of the panel unit root tests and stationarity tests, all estimates of β_i have negative values. These estimates are not significant for only three counties in the booming region. Note that for seven counties, estimated convergence rates are smaller than -1, which means that land prices in these counties fluctuate around the price level of the benchmark region. In general, the convergence rates are rather large in absolute values and translate into half-lives shorter than one year. The price adjustment is rather fast compared to agricultural commodity markets, where half-lives usually vary between three and five years (e.g., Cecchetti et al., 2002; Seong et al., 2006; Sonora, 2005). However, our results are in line with findings in Carmona and Rosés (2012), who report half-lives of less than one year for the Spanish land market in the previous century.

The fixed effects α_i capture time-invariant factors that go beyond differences in soil quality, for which land prices have been corrected. We find that these county-specific effects are significant for most counties, implying that the price difference between a specific county and the benchmark county converges towards a nonzero constant. In other words, the absolute version of the LOP does not hold for the majority of all counties, even if differences in soil quality are taken into account. The long-run price differential can be of considerable size and ranges between -75.5 percent and 31.2 percent.

5 Conclusions

This paper contributes to the literature by examining how to measure market efficiency and market integration empirically in the case of agricultural land markets. This paper uses standard methods of commodity market analysis to investigate spatial integration on agricultural land markets. Spatial market integration techniques allow the analysis of spatio-temporal behaviour of land prices and go beyond standard analyses with spatial econometric models. A combination of panel unit root tests and panel stationarity tests is applied to a time series of land prices in 37 counties in Lower Saxony. The test procedures clearly reject the prevalence of the LOP for Lower Saxony as a whole, even in its relative version and after adjusting for soil quality differences. Nevertheless, we are able to identify regions that exhibit similar land price dynamics in a sense that the relative prices of included counties are stationary and converge toward a constant. These regions, which we term convergence clubs following the real estate literature, are to some extent composed of neighbouring counties that have similar natural and socioeconomic conditions, but may also comprise of rather unequal counties exhibiting the same price dynamics, albeit for different reasons. Membership in a convergence club implies that land prices co-move and do not drift apart; it does not mean that differences in absolute price levels vanish over time. While the exact composition of the convergence clubs can vary with the choice of the benchmark region, the qualitative results of our study are robust.

The finding that the LOP does not hold for agricultural land markets even on a state level should not instantaneously be interpreted as an indicator of land market inefficiency that calls for policy intervention and market regulation. Slow convergence of prices may simply reflect the immobility and heterogeneity of this production factor. Even temporal price divergence can be rationalized in a competitive market environment, similar to real estate markets where house prices drift apart between urban and rural areas. In fact, the ‘new economic geography’ asserts that clustering forces, such as economies of scale and knowledge spillovers, can foster the concentration of economic activities in space, which, in turn, can cause disparities of factor prices in different regions (Fujita et al., 1999; Fingelton, 2009). In this setting, high land prices constitute a centrifugal force, counteracting the further concentration of intensive agricultural production, which otherwise may come along with negative environmental effects.

This paper is only a first step towards a comprehensive understanding of the spatio-temporal behaviour of agricultural land prices and there are several directions for extending our analysis. First, it would be relevant to examine the impact of regional scale on the outcome of the clustering procedure.

Due to data availability, our study was based on counties, i.e., administrative entities that include rather heterogeneous socioeconomic areas. A finer regional resolution will likely ease the identification of homogeneous convergence clubs. Second, from a methodological perspective, it would be desirable to increase the robustness of the classification results with respect to the choice of the benchmark regions. Abbott and De Vita (2013) bypass this problem through testing pairwise convergence across all regional combinations. Finally, our study focuses on the measurement of land price convergence, but is rather silent about the underlying economic determinants. Thus, a direction for further research is the identification of common factors, such as land rental prices, interest rates, or farm exit rates that drive the development of land prices within convergence clubs.

6 References

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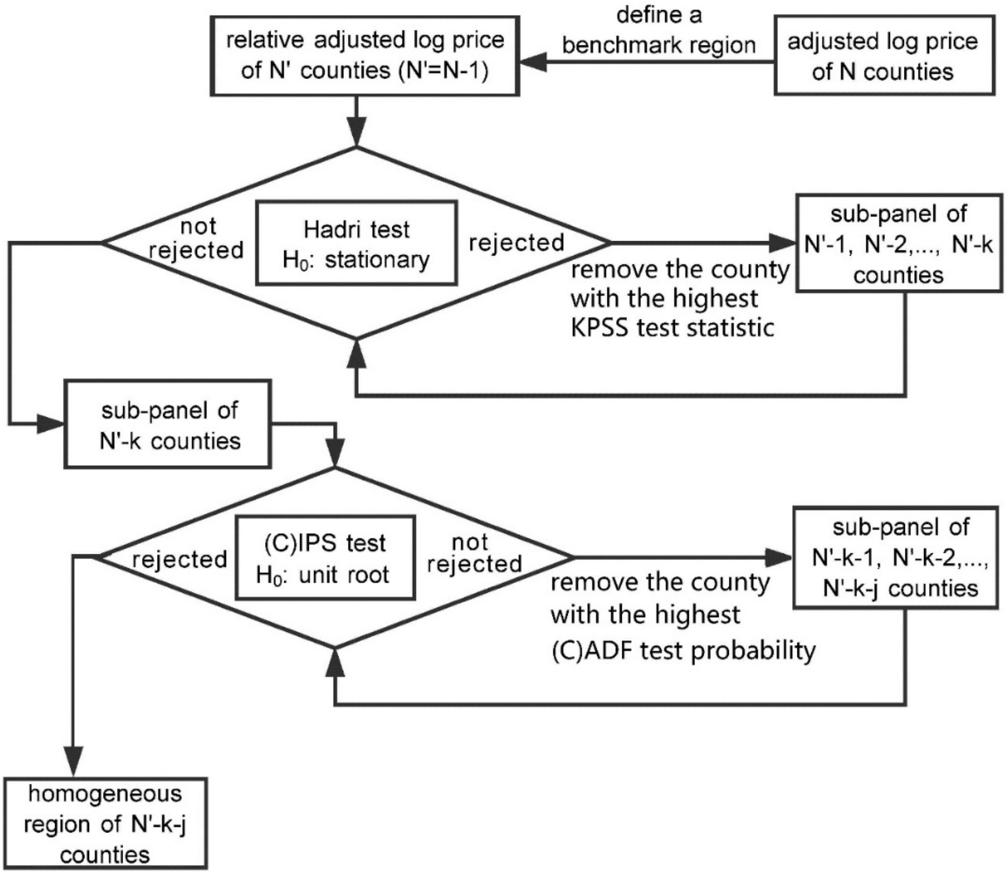
define a
benchmark region
relative adjusted log price of N' counties (N'=N-1)
adjusted log price of N counties
not rejected
Hadri test
H0: stationary
rejected
remove the county with the highest KPSS test statistic
sub-panel of N'-1, N'-2,..., N'-k counties
sub-panel of N'-k counties
rejected
(C)IPS test
H0: unit root
not rejected
remove the county with the highest (C)ADF test probability
sub-panel of N'-k-1, N'-k-2,..., N'-k-j counties
homogeneous region of N'-k-j counties

Figure 1. Flow chart of the procedure for testing price convergence

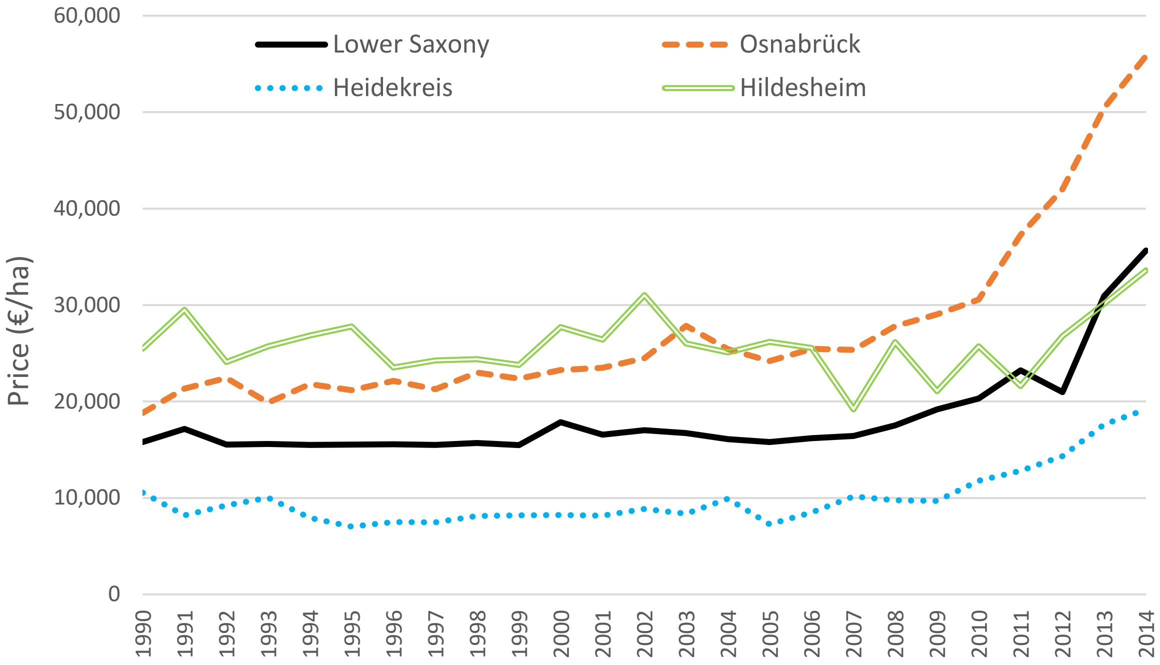

Figure 2. Prices for arable land (€/ha) in Lower Saxony and the three selected counties

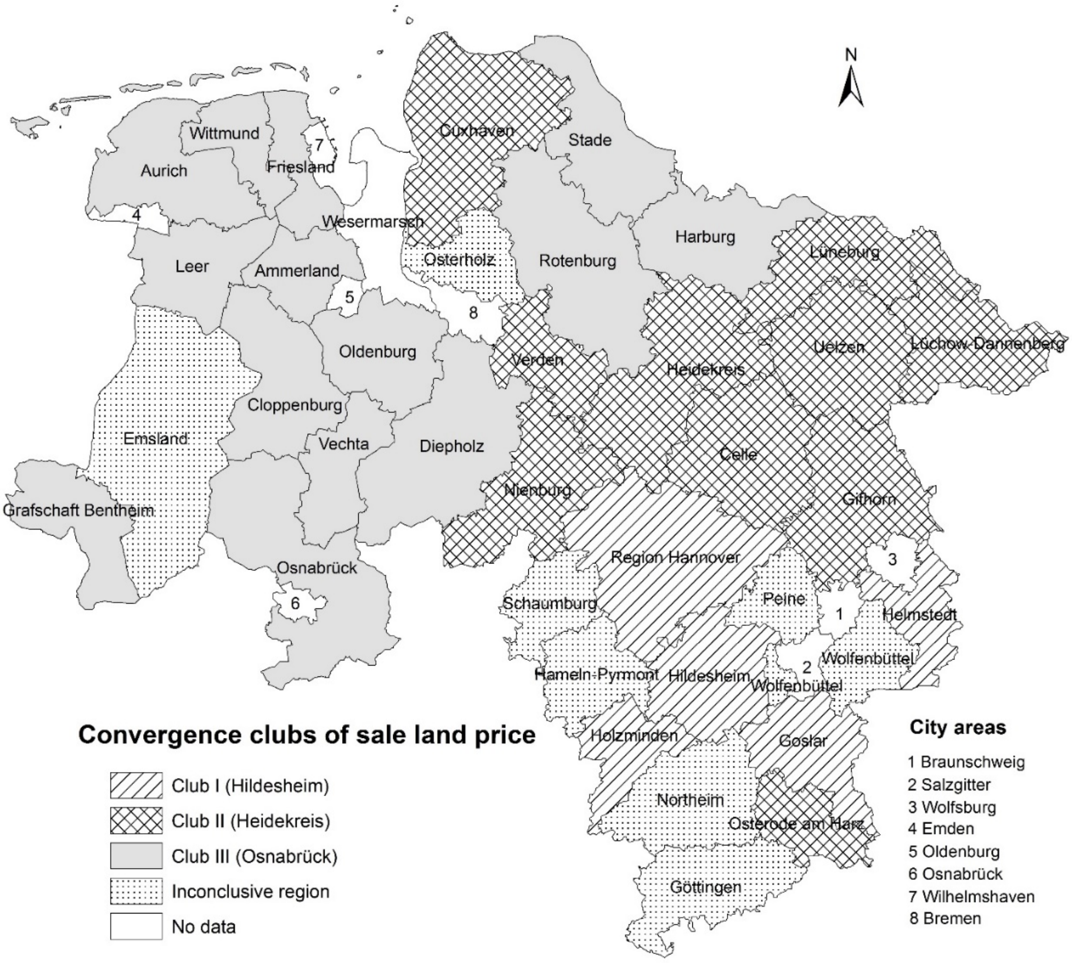
N
Wittmund
Aurich
Friesland
7
4
Wesermarsch
Cuxhaven
Stade
Leer
Ammerland
5
Osterholz
Rotenburg
Harburg
Lüneburg
8
Oldenburg
Verden
Heidekreis
Uelzen
Lüchow-Dannenberg
Emsland
Cloppenburg
Vechta
Diepholz
Celle
Grafschaft Bentheim
Nienburg
Gifhorn
Osnabrück
Region Hannover
3
6
Schaumburg
Peine
1
Helmstedt
Hameln-Pyrmont
Hildesheim
2
Wolfenbüttel
Holzminden
Goslar
Northeim
Osterode am Harz
Göttingen
Convergence clubs of sale land price
Club I (Hildesheim)
Club II (Heidekreis)
Club III (Osnabrück)
Inconclusive region
No data
City areas
1 Braunschweig
2 Salzgitter
3 Wolfsburg
4 Emden
5 Oldenburg
6 Osnabrück
7 Wilhelmshaven
8 Bremen

Figure 3. Convergence clubs

Table 1. p-values of cross-sectional dependence (CD) test and convergence tests

Test		**Benchmark region**	
	Hildesheim	**Heidekreis**	**Osnabrück**
CD	0.0000	0.0000	0.0000
All counties			
Hadri	0.0000	0.0000	0.0000
CIPS	0.0000	0.0000	0.0000
Homogeneous sub-regions			
Hadri	0.0524	0.0734	0.0657
CIPS	0.0000	0.0000	0.0000

Table 2. Characterisation of convergence clubs

Convergence clubs	**Counties**	$\boldsymbol{\beta_i}$	$\boldsymbol{a_i}$	**Half-lives**	**Long-run relative price deviation from the benchmark**
Stagnating counties (benchmark Hildesheim)	Goslar	-1.1231***	-0.245***	-	-19.6%
	Helmstedt	-0.8378***	-0.390***	0,381	-37.2%
	Hannover	-0.8144***	0.135***	0.412	18.0%
	Holzminden	-1.1834***	-0.578***	-	-38.7%
Moderately increasing counties (benchmark Heidekreis)	Gifhorn	-0.7117***	0.019	0.557	2.7%
	Osterode	-0.9268***	-0.334***	0.265	-30.3%
	Nienburg	-1.2099***	0.287***	-	26.8%
	Celle	-0.8745***	-1.239***	0.334	-75.7%
	Cuxhaven	-1.2388***	0.176***	-	15.3%
	Lüchow-Dannenberg	-1.4112***	-0.312***	-	-19.8%
	Lüneburg	-0.8023***	-0.060	0.428	-7.2%
	Verden	-1.1829***	0.285***	-	27.2%
	Uelzen	-0.7711***	0.095**	0.470	13.1%
Booming counties (benchmark Osnabrück)	Diepholz	-0.2124	-0.083	2.902	-32.3%
	Harburg	-0.7689***	-0.520***	0.473	-49.2%
	Rotenburg	-0.3079	-0.211*	1.883	-49.7%
	Stade	-0.8225***	-0.512***	0.401	-46.4%
	Ammerland	-0.5526*	-0.201**	0.862	-30.4%
	Cloppenburg	-0.3974	0.056*	1.369	15.1%
	Friesland	-0.6847**	-0.489***	0.600	-51.0%
	Grafschaft Bentheim	-0.9463***	0.132***	0.237	15.0%
	Leer	-0.9348***	-0.543***	0.254	-44.0%
	Oldenburg	-0.5338*	-0.084*	0.908	-14.6%
	Vechta	-1.0981***	0.298***	-	31.2%
	Wittmund	-0.6938*	-0.552***	0.586	-54.9%
	Aurich	-0.4080*	-0.334**	1.322	-55.9%

*, **, and *** denote statistical significance at the 10 percent, 5 percent, and 1 percent levels, respectively.