111 EAAE-IAAE Seminar 'Small Farms: decline or persistence'

University of Kent, Canterbury, UK

26th-27th June 2009

The Role of Small Farms in Structural Change

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Abstract:
This paper explains regionally differentiated patterns of structural change based on a theoretical framework dealing with strategic interaction of farms on the land market. The main research question focuses on the causes of regionally persistent structures. An empirical Markov chain model is defined for the West German agricultural sector. Thereby it is possible to explain the probabilities of farm growth, decline or exit in terms of the current and former regional farm size structure. Further, the impact of variables describing the regional farm structure, thereby indicating market power of the large, the potential of high competition for land within a region and possibly high rents of the status quo in combination with sunk costs, is quantified. The results confirm the relevance of strategic interaction as a crucial determinant of regionally different structural change and persistent regional differences in the farm size structure over time.

Keywords: structural change, strategic competition, land market, Markov chain

* The authors gratefully acknowledge financial support from Deutsche Forschungsgemeinschaft (DFG) through Research Unit 986 SiAg 'Structural Change in Agriculture'.

1 INTRODUCTION

A frequently observed phenomenon in the agricultural sector is that farms persist in a specific size category (Balmann, 1997; Boehlje 1992). Consequently persistent differences in regional farm size structures, as for instance between the North and South of West Germany are observed. In northern Germany, mainly large scaled farms exist whereas the southern structure is characterized by small scaled farms. These phenomena may be summarized by path dependency (Balmann, 1997). In general, such reluctance of farms to exit or to grow is explained in the relevant literature by sunken investment costs (Balmann et al., 2006), uncertain future revenues (Chavas, 1994) and the presence of imperfect markets for labour and/or capital (Huettel et al., 2007). These factors cause a rent of the status quo and cause a range of where inactivity is optimal. Generally, these issues impose economic restrictions on single farms such that reluctance to grow, decline or exit is a result of economically ‘correct’ behaviour (Balmann, 1997).

From a more general perspective, initial differences in the farm size lead to different organisation structures of farms (Ciaian and Swinnen, 2008; Foltz, 2004). For instance, divergent opportunity costs induce different local optima with respect to scale efficiency. Thus, persistent regional differences may also be explained by differing initial conditions. These persistent differences in the farm size structure are further accompanied by differing patterns of farm growth. Likewise, differing regional processes of concentration and de-concentration with respect to the number of farms in respective size categories are observed (Glauben et al., 2006). For instance, the phenomenon of a disappearing middle class has been detected in some regions (Weiss, 1999).

Therefore, the presence of the more or less stable share of small farms and the particular role of them within structural change is still an enigma. It is commonly known that the net farm exit rate strongly depends on the current share of small farms’ exit rate. However, to our knowledge, the literature does not provide a clear explanation whether small farms represent a transitory state or a stable size category with the ability to survive motivated by considerations other than current profits. Small farms may also benefit from low opportunity costs of fixed factors due to sunk costs. Further, the shadow price of labour mainly determined by off-farm work opportunities is of importance (Roeder et al., 2006; Goetz and Debertin, 2001). Thus, we expect that the share of small farms plays a crucial role in the regional structural evolvement.

A exclusive focus on isolated behaviour of single farms does not suffice in order to explain the different patterns of regional structural change. Quite the contrary, the continuous interaction among agents and failures of coordination need to be taken into account. The interconnectedness of farms is well represented on the regional land market. Land is the most important production factor for growth, because without land farm growth is only possible to a limited extent. The immobility and shortage of this factor causes a strong interdependence of farms within a region. The shortage of production factors such as land increase the competition among farms (Chavas, 2001). Due to this interconnectedness of farms, it becomes obvious that the reluctance of one farm hinders growth of other farms as shown for instance by Weiss (1999), Harrington and Reinsel

(1995) or Balmann et al. (2006). Only few studies deal with strategic competition among farms. The influence of market power on land transactions is shown with respect to very large farms in Hungary (Vranken and Swinnen, 2004).[1] The long lasting continuous interaction between participants as for instance shown by Kellermann et al. (2008) or Hurrelmann (2005) influences the character of this strategic behaviour. Since experiences shape expectations, these keep the development within the once selected path and regional path dependency results. As a result, the farms' development depends on the initial structure and the farm size distribution at the regional level. Therefore we expect that strategic competition on the land market is a key element to understand the dynamics of regionally differing structural change.

The resulting endogenously evolving heterogeneity is further affected by exogenous factors. Thereby two principal mechanisms that coordinate farms' behaviour can be differentiated: (1) The harmonising effect of macroeconomic conditions affects all farms in the same manner and enables a parallel development of farms. (2) The counterbalancing competition effect differentiates the reaction of farms according to their different strategic options.

Analyses and explanations of regionally differentiated patterns of structural development are so far mainly based on ad hoc assumptions. Within this work we make use of existing theoretical models to identify the interaction among farms on the land market and the respective impact on farm growth, decline and exit. The aim is to show how the identified region-specific interactions can explain regionally differing structural evolvements. Based on these theoretical considerations, our aim is to identify empirically differing dynamics of regional structural change. The crucial hypothesis that these patterns rely on strategic interaction of farms on the market for land is aimed to be tested empirically. We rely on a Markov chain model to calculate individual farm moves between defined size classes from now available farm individual data from the agricultural census. In a further step, we aim to explain the moves' probability at the NUTS III level by historical and actual distribution of land among farms and additional exogenous factors.

The remaining part of this paper is structured as follows. We start with a sketch of the relevant theory, followed by the hypotheses. The empirical model is explored subsequently, followed by the application to the West German agricultural sector. The discussion of the results and the conclusion finish this paper.

2 THEORETICAL BACKGROUND AND HYPOTHESES

Balmann (1997) stressed the relevance of path dependency for the development of agricultural structures. For the microeconomic motivation of this argument, often single farm level theories like hysteresis or sunk costs have been used (Balmann et al., 1996;

[1] Further details can be found for instance in Amir et al. (2006).

2006). These arguments do not suffice to explain differing behaviour of comparable farms in different regions, a phenomenon that can be summarized as regional path dependency. In the following we stress the importance to consider the *interaction* of farmers. The issues of strategic interaction can be handled formally within the theoretic framework of strategic competition of microeconomics. Classical oligopoly theory offers a starting point to analyse the interaction among farms on the land market.[2] Strategic behaviour results from the existence of status quo rents. These are caused for example by sunk costs and organisational adoption to the existing farm structure, causing low opportunity costs.

Given that the land market is oligopsonistic, the single demander directly influences the price of land. If there is no short-term technical or organisational restrictions implying constant returns to scale, the same market equilibrium as in the polypsonistic market would result. In this case of constant marginal products of land we would expect price competition, known as the Bertrand competition and equals a situation, where land is traded in an auction and distributed by competitive bidding (Varian, 1992, p. 292). As in the polypsonistic market in the Bertrand equilibrium land rents will go to land owners. This is often assumed in agricultural economics (Ciaian and Swinnen, 2008).

However, in the agricultural sector, we expect diminishing returns to scale at least in the short or medium term due to existing market imperfections. Thus, the rule that the marginal cost of land should equal its marginal production value dictates the demanded quantity. Since a higher demand raises the price for land, the farmers react with lower demand towards anticipated rising demand of others. If farms act rational and expectations are symmetric a Cournot equilibrium results (Varian, 1992, p. 286). Farms grow less than they would in an environment with price competition and the price for land is lower. From this scenario, we deduce our *first hypothesis:* *If land is distributed equally between farms, we expect a constant but slow growth for a considerable share of farms which is accompanied by a rather low exit mobility.* We deduce as a second hypothesis: *Sunk costs and high capital intensities raise rents of the status quo. Hence, we expect an even more pronounced passive behaviour of farms on the land market. This holds in particular for regions characterised by a capital intensive production, e.g., livestock production.*

If we assume diminishing returns to scale and at the same time farms are heterogeneous due to historical reasons, one can justify the assumption that one farm follows the strategy of quantity leadership, while others abandon this option (Varian, 1992, p. 298). The irreversibility of investments is important in that it allows the quantity leader to signal believably the strategy of inevitable growth (Woeckener, 2007, p. 22). Therefore, quantity followers assume an inelastic reaction of quantity leaders. They reduce their demand stronger than in the case of a Cournot equilibrium. A so-called Stackelberg equilibrium results (Varian, 1992, p. 296). From this scenario, we deduce our *third hypothesis:* *If only*

[2] In models concerning strategic competition the sales quantity is restricted. However, in markets for land the sources are limited and restrict the expansion of production capacities. This has to be considered.

few large farms exist in a region, these are expected to grow rather rapidly. At the same time, the smaller farms grow even less, causing the effect of a "disappearing middle".

So far linear reaction curves have been assumed. However, under rents of the status quo it seems more plausible to assume non-linear reaction curves. A quantity leader has to pick his optimal demand for land with respect to the non-linear reaction curve of the quantity followers. Thereby different scenarios are possible:

(1) The quantity leaders raise their demand moderately. They can expect the follower to lower their demand, albeit a little beyond the rise in demand.

(2) A further extension of demand in the presence of status-quo rents might not cause a further reduction of demand on the followers' side. This would be a threat for the farms' stability and therefore for the realisation of status quo rents.

(3) If the quantity leaders expand their demand for land even further, a strong reaction of the followers might be expected: the followers lose trust in the midterm-stability of their farm due to the jeopardised competitiveness on the market for land. As a result, the followers switch their role towards suppliers for land and this relaxes the situation on the land market.

Due to the diminishing returns to scale and imperfect markets for labour and capital the quantity leader is expected to be restricted with respect to his individual growth strategy. If a group of quantity leaders simultaneously raises its demand, a strong reaction as depicted under (3) is expected. Based on that, we deduce our <u>*fourth hypothesis:*</u> *If in regions with few large farms in times of favourable economic conditions these farms simultaneously raise their demand for land, they might clear the market for land. For these regions in favourable economic conditions, a high exit mobility for smaller farms and a high upward mobility for larger farms is expected.* The last hypothesis deals with different historic farm size structures. According to our <u>*fifth hypothesis*</u> *in regions with a restricted number of small farms, growth of farms is restricted initially. In years with favourable economic conditions, though, the market for land can be easily cleared. This results in a higher mobility that fosters a further differentiation of medium farms.*

3. THE EMPIRICAL MODEL

In this chapter, we describe how we attempt to test our hypotheses. In a first step, we analyse the transitions between the size categories using a Markov chain model. Based on the transition probabilities we aim at testing the dependency on several structural variables in a second step.

3.1 The Markov Chain Model

We refer to an intertemporal value function maximization approach. It is assumed that a representative farm maximizes its expected utility over an infinite planning horizon. The usual constraints involve agricultural production, income and uncertainty of future revenues. Based on such a model it can be shown, presumed that all farms behave according to this optimal stochastic control problem, that the development of the farm size structure within a region could be characterized by a Markov chain (Stokes, 2006).

The Markov chain model characterizes a stochastic process in terms of a sequence of random vectors that have the Markov property. The Markov model is defined by a set of states, i.e., the size classes, and the respective transition probabilities. The transition probabilities reflect the probability of a farm to move from one size class to another within one period or alternatively to stay. Such moves reflect farm growth, decline, exit or persistence in the respective size category. The Markov chain approach allows investigating responses at the micro level in an aggregate manner without directly modelling them. It combines growth, decline and exit of farms and allows further analysing the interaction among farms within a pre-defined region.

We assume that firm size in the agricultural sector can be divided into three size categories measured by land and an additional exit category. Time is indexed by t, the regions by i and the respective size classes at time t-1 and t are denoted by j=0,1,…,J and j'=0,1,…,J. The vector of the regional farm size distribution at time t is described by the farm size distribution at time t-1 and the probabilities of each farm to move from one size class to another or to stay. The Markov chain model is given by

$$n_{itj'} = \sum_{i=1}^{J} n_{t-1,i\,j} \cdot p_{ijj'}; \quad j = 0,...,J \tag{1}$$

where n_{itj} denotes the number of farms in the j^{th} category at time t in region i where $i = 1,...,\mathrm{N}$ and $t = 1,...,T$. The probability of transition from size class j at time t-1 to size j' at time t is denoted by $p_{ijj'}$; all probabilities fulfil the following properties

$$\sum_{j=0}^{J} p_{ijj'} = 1 \quad \forall i = 1,...,\mathrm{N} \tag{2a}$$

and

$$0 \le p_{ijj'} \le 1 \tag{2b}$$

The maximum likelihood estimator of the transition probabilities coincides with the direct derivation of the probabilities if the individual transitions are observed (Gourieroux 2000). The resulting regional transition probability matrices are subject to further analysis. We derive mobility indicators to test for the presence of regional differences. These are explored in the subsequent section.

Further, we assume that the transition probabilities are non-stationary. The used data allow to derive regional transition probabilities for two periods (1999-2003; 2003-2007). The long-term time dependency is approximated by the use of the initial regional structure as explanatory variable. The multinomial logit formulation allows to express the log of a ratio of probabilities as a linear function of the explanatory variables. The Markov chain model has *J* sets of probabilities, one for each row of the transition probability matrix (MacRae, 1977). Thus, there are *J* sets of ratios whereby the transition probability from the last column of **P** is used as the denominator. Thus, the large category is chosen as the respective base category. Additionally, we add an error term $u_{itj'}$ with zero mean and finite variance to account for disturbances that are not observable.

$$\log\left(\frac{p_{ijj'}}{p_{ijJ}}\right)_t = Z_{it}\beta_{jj'} + u_{itjj'} \tag{3}$$

where Z_{it} denotes a *k* by *T*N matrix of explanatory variables, $j = 0,1,....,J-1$, $j' = 0,1,....,J-1$, $i = 0,1,....,\mathrm{N}$ and $t = 1,2$.

The use of the log odds ratio maps the range of the endogenous probability from a zero-one interval to the range of minus infinity to plus infinity for the log odds ratio. The equations expressed in (3) are then estimated using equation by equation OLS.[3] The estimated parameters in the *k* by *J*-1 vector $\beta_{jj'}$ denote the impact of the respective explanatory variables on the log odds that the transition probability in region *i* from category *j* to *j'* relative to the move from *j* to *J*.

3.2 Mobility Measures

The TPMs reflect a certain degree of farm mobility over the size classes (Jongeneel and Tonini, 2008). However, to compare the results we use mobility indices, which map the mobility information inherent in the TPM into a scalar metric. Referring to Shorrocks (1978) an overall mobility index M_{it}^{OV} is defined as

$$M_{it}^{OV} = \left[J - tr\{\mathbf{P}(t)\}\right]\cdot\left[(J-1)\right]^{-1} \tag{4}$$

where $tr\{\mathbf{P}(t)\}$ denotes the trace of the transition probability matrix. If there is no mobility the TPM would be an identity matrix and the trace of the TPM would be equal to *J*. In this case, M_{it}^{OV} would be equal to zero. In case of perfect mobility, M_{it}^{OV} is equal to one.

In order to be more precise with respect to the direction of mobility changes, we refer to Huettel and Jongeneel (2008), and use three further mobility indicators that allow decomposing the mobility into upward, downward and exit mobility. These can be interpreted as shares of the overall mobility and sum up to one. Probabilities in the lower (off-diagonal) triangle part of the TPM indicate downward mobility. In contrast, the upper

[3] We refer to SAS Proc Syslin.

triangle represents upward mobility. The aggregation of the diagonal mobility elements gives a sum, which is exactly equal to the aggregated value of all off-diagonal terms. This sum of the mobility part of the diagonal is used as a 'deflator' in the upward and downward mobility indices (Huettel und Jongeneel, 2008).

The upward mobility index M_{it}^{U} is defined as

$$M_{it}^{U} = \left[\sum_{j} \sum_{j'>j} p_{itjj'} \right] \cdot \left[\sum_{j} (1 - p_{itjj'}) \right]^{-1} \tag{5}$$

If there is full upward mobility and no downward mobility the index would be equal to one, since the sum of the upward triangle probabilities of the TPM would than exactly equal the sum of the mobility part of the diagonal elements. If there is no upward mobility the index would be zero since then the sum of the probabilities of the upper triangle of the TPM would be equal to zero.

Likewise, the downward mobility, M_{it}^{D} is defined as

$$M_{it}^{D} = \left[\sum_{j} \sum_{j'<j, j'\neq 0} p_{itjj'} \right] \cdot \left[\sum_{j'} (1 - p_{itjj'}) \right]^{-1} \tag{6}$$

If only downward mobility exists this index would be one and vice versa. With regard to exits we define the following mobility index:

$$M_{it}^{E} = \left[\sum_{j} p_{itj0} \right] \cdot \left[\sum_{j'} (1 - p_{itjj'}) \right]^{-1}. \tag{7}$$

3.3 Technical Hypotheses

We aim to explore the differences between the transitions for two periods within eight years. The first period refers to 1999-2003; the second period refers to 2003-2007. The following hypotheses related to regional and time differences in the mobility indicators were aimed to be tested.

- Less overall mobility is expected in regions with an equal distribution of land among farms compared to regions with a more concentrated land distribution. Regions showing equally distributed land imply less competitive behaviour on the land market.
- Higher downward and exit mobility is expected in regions with higher competition, i.e., in regions that show a rather unequal land distribution among farms.
- For regions characterised by farm size structures that allow farms with a high growth potential to crowd out competitors on the land market, we expect the most pronounced differences in the overall mobility between years of good and years of bad economic conditions.

Further, we consider several exogenous factors that we expect to have a significant impact on the transition probabilities. Based on the log-linear model as shown in (3) it is possible to quantify the impact of those on the log odds ratio of the transition probabilities. The technical hypotheses are as follows.

- *Gini coefficient 1979*: This coefficient represents the inequality of the distribution of land among farms within a region in the year 1979. It accounts for a possible dependence of the transition probability, and thereby the decision to grow, decline or exit, on the initial farm size distribution. Thus, a significant Gini coefficient for 1979 indicates the presence of path dependency.
- *Share of medium farms 1979*: This measure gives the percentage share of the number of medium farms in 1979. A high share of medium farms implies an initially high stability of farms, which coexist with a lower number of small farms. This causes a reduced potential for growth. Medium farms therefore behave as quantity followers. In good years those medium farms with a higher potential for growth suppress the other medium farms on the land market. This increases the differentiation of farms by size. As a consequence, in the course of differentiation overall mobility rises, accompanied by a decline of its dependence on the present economic environment.
- *Gini coefficient 1999*: This Gini coefficient for the year 1999 accounts for a dependence on the current farm size structure. The higher the inequality of the land distribution the higher is the expected mobility in these regions. The simultaneous significance of the Gini coefficients of 1979 and 1999 confirm the existence of path dependencies.
- *Share of area used by large farms with >50 hectares 1999*: This share is an additional indicator for market power and the presence of quantity leaders. The higher this share is, the higher is the chance that small farms cannot grow under such conditions. Thus, we expect in terms of the log odds ratio that the chance to persist in the respective class increases with market power, in particular for small farms.
- *Gross value added 1999*: This measure reflects the regions' potential of the primary sector in 1999. The higher the potential of primary production, the higher are the potential status quo rents. Further, high capital intensity and sunk investment costs are more likely compared to regions with a low gross value added. Both aspects are expected to reduce overall-mobility further in regions, which are dominated by quantity-followers.
- *Years/Time*: We expect the difference between the periods to be more pronounced for regions with many potential quantity leaders. In the appendix, there is a figure showing German farmers' assessment of their economic situation and future prospects. It clarifies that while period one is characterised by negative economic expectations, the contrary is true for period two.

4 APPLICATION: STRUCTURAL CHANGE IN THE WEST GERMAN AGRICULTURAL SECTOR

The aforementioned and theoretically derived hypotheses are tested empirically. The West German agricultural sector shows a strong decline in the number farms over the last decades. The number of farms decreased from 827,200 farms in 1979 to 374,500 farms in 2007, whereas the average farm size increased from 14.4 hectares (ha) to 46 ha in 2007. Further, the West German agricultural sector is characterized by a strong north-south divide with respect farm size. In northern Germany, mainly large farms dominate (e.g. Schleswig Holstein with 80.8 ha on average in 2005), whereas in southern Germany mainly small scaled farms with a high share of off-farm workers predominates (e.g. Bavaria with 39.2 ha on average in 2005). Overall, the West German agricultural sector offers many regionally differentiated farm distributions by land, by size and by specialisation.[4] In order to explore further these differences we start with the descriptive analysis of the data set, followed by the results of the Markov model.

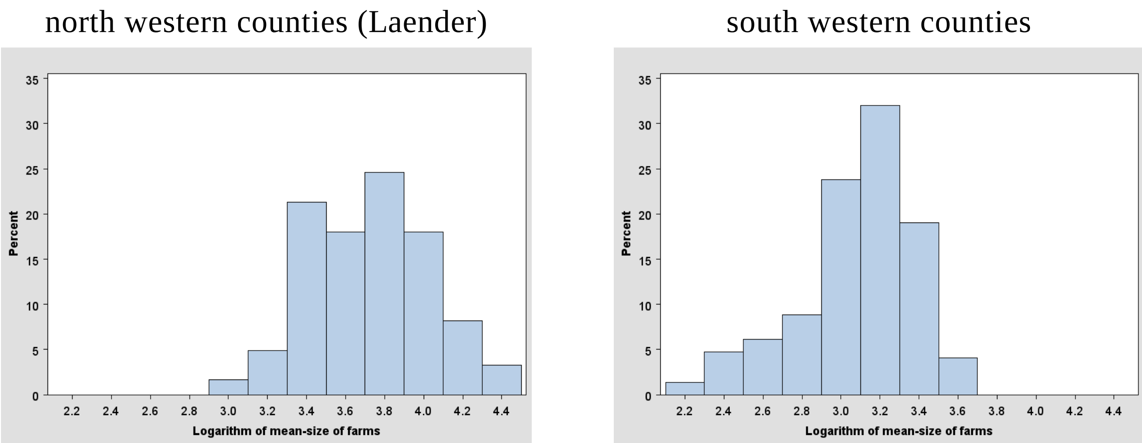
4.1 Data and Descriptive Analysis

We used the data provided by the Research Data Centre of the Federal Statistical Office and the statistical offices of the German Laender (FDZ). These data refer to the Agricultural Census including 441 485 active farms in the Western Federal States in 1999. The years 1999, 2003 and 2007 are available and used for the subsequent analysis. The resulting transition probabilities are aggregated at the NUTS III level. These TPMs for 327 regions are subject to further analysis. We define three size classes, namely, small (1-30 hectares), medium (30-50 hectares) and large (>50 hectares); we use the same size class classification for all regions to ensure the comparability between the regions.

The distribution of the logarithm of the mean farm size between the German districts (NUTS III) confirms the different farm size between northern and southern Germany (Figure 1). Further, the development of number of farms as illustrated in Figure 2 shows that the number of farms in northern Germany is less stable than the number in southern Germany even though the average farm size is larger. The summary statistics can be found in the annex, Table A.1.

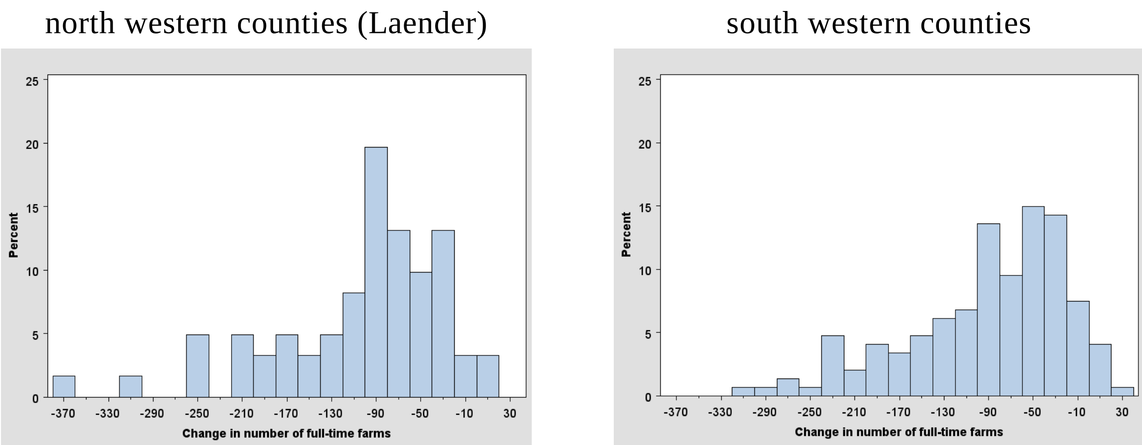
[4] We abstract from analysing the East German sector. The East German agricultural sector shows a number of peculiarities that we could not account for.

Figure 1: Log farm size distribution in the districts in West Germany



Source: Own calculation based on FDZ, 1999.

Figure 2: Development of the number of full-time farms in West Germany



Source: Own calculation based on FDZ, 1999, 2003.

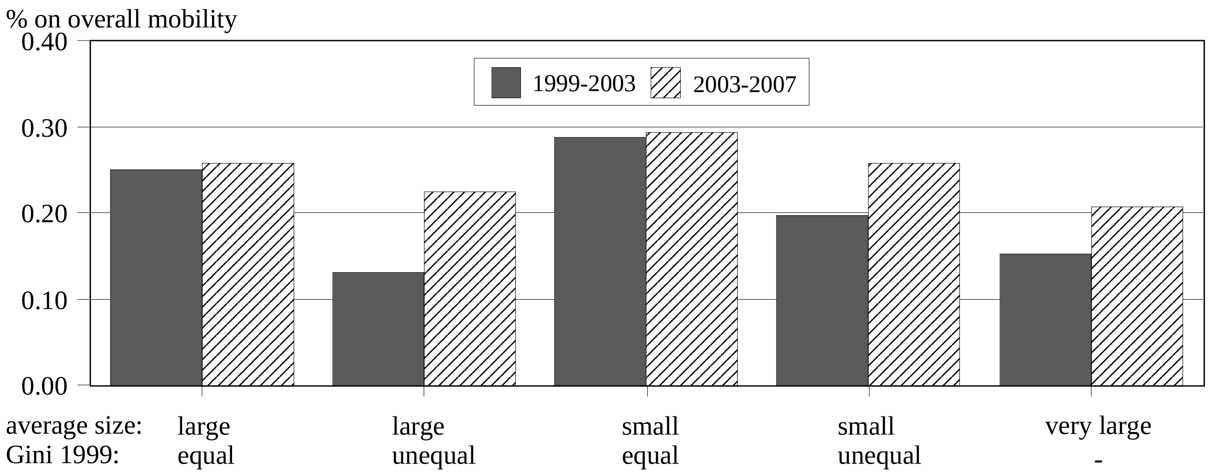
4.2 Results

The derived transition probabilities are difficult to present. For the comparison between the periods and regions we rely on the mobility indicators and use regional clusters describing the farm structure. In what follows we explore the variation over the regions with respect to regional clusters of representative farm structures. These clusters were created using the following variables: The Gini coefficient, the average regional farm size, the share of small farms, the share of farms in a region with more than 100 hectares and the share of part time farms. According to the cluster analysis, we differentiate between five different types of regions according to the structure. ‘Small and equal’ represents cluster regions with a rather low average farm size of 23 ha in the mean and a more or less equal distribution of land among farms. ‘Small and unequal’ describes the cluster regions with 20 ha farm size on average and a rather unequal land distribution according to the Gini coefficient. ‘Large and equal’ describes the cluster regions with a comparably large average farm size (mean of 32 ha) and equal land distribution (Gini 0.51). ‘Large and unequal’ refers to a large average farm size in combination with a high Gini coefficient (0.58). Further, we use ‘very large’ as cluster regions with an average farm size of 53 ha in the mean, further details can be found in Table A.2 in the annex.

In a similar manner regional clusters with respect to regionally dominant types of production and the economic environment are derived. These clusters serve to control for further exogenous influences, which might be correlated with defined farm structure. The detailed characteristics of the clusters are summarised in the annex in Table A.3 and A.4. The variance of the mobility indices then has been partitioned among clusters with the help of a variance analysis (MANOVA), the results are shown in the annex (Table A.5). The respective mobility indicators for the farm structure clusters have been derived as conditional means by controlling for the impact of economic and production type clusters in the variance analysis. These are visualized in Figures 4-6.

The *upward mobility* (Figure 4) is highest in regions characterized by a small average farm size and an equal distribution of land among farms. Since only upward mobility of small and medium size farms is observed, the observation supports the hypothesis that in such regions many farms grow, but rather slow. The differences between the years are negligible for those regions that show an equal distribution of land among farms. For the ‘unequal’ regions and those characterized by very large farms, the upward mobility is higher in the second period (2003-2007). The second period is characterised by favourable economic conditions (Figure A.1). Therefore, simultaneous growth of farms with high potential for growth occurs.

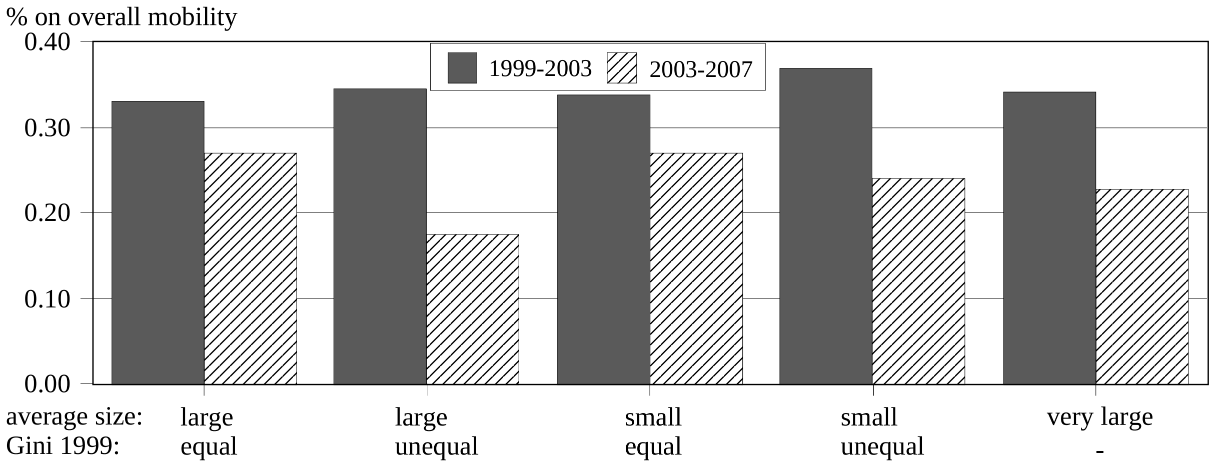
Figure 4: Upward Mobility



Source: Own calculations based on FDZ 1999-2007.

Correspondingly, for the *downward mobility* (Figure 5) the highest difference is observed in the large-unequal cluster. The simultaneous growth of farms with a high potential to grow ousts less competitive farms out of the land market in years characterized by economic booms. The stabilising strategy of shrinking in period two is mainly realised within regions characterised by an equal distribution of land.

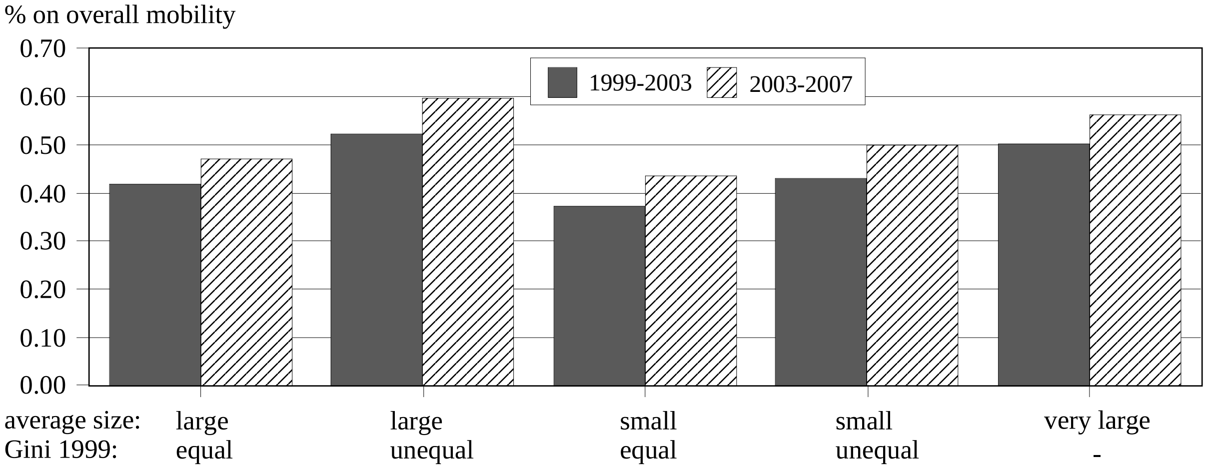
Figure 5: Downward Mobility



Source: Own calculations based on FDZ 1999-2007.

This is confirmed by the increase in the exit mobility in contrast to the decrease of downward mobility in the second period. Farms with low competitiveness on the land market in years of economic booms prefer exiting towards shrinking as a strategic option due to rising demand for land of competitive farms. As expected the *exit mobility* (Figure 6) shows the highest shares for regions characterized by a large average farm size and even more so in combination with an unequal land distribution. This indicates a higher competition in such regions and the pressure on small farms to exit the sector.

Figure 6: Exit Mobility



Source: Own calculations based on FDZ 1999-2007.

In a further step, the derived transition probabilities are analysed using the log-linearized model as given in (3). The resulting parameter estimates are presented in Table 1. Coefficients express the covariates' influence on the relation between the transition probabilities and the probability to move to (remain in) the class of large farms (the odds). The odds to exit for small farms in relation to grow into the large class is positive if all explanatory variables are zero as expressed by the constant. This odds increases even further if the share of large farms becomes larger. This could be due to an increase in the probability of small farms to exit as well as to a reduction in the probability of growing into the large class. In addition, the results of this log-odds ratio show that the higher the share of the middle class the lower the odd of exiting of small farms but the higher their odd of growth.

However, these coefficients are difficult to interpret. A direct interpretation of the coefficients in the light of the hypotheses is not possible. In order to relate the results directly to our hypotheses, a direct dependency of each probability to the respective covariates is derived. Transforming the log-odds ratio equation (3) and using the row sum condition (2a) it is possible to derive the effects of the covariates on the probabilities. Due to the multiplicative relationship of the coefficients we present the effects of a specific covariate with low, medium and high values and thereby hold all other covariates fixed; the results are visualized in Figure 7.

Table 1: Results of the log-linearized estimation

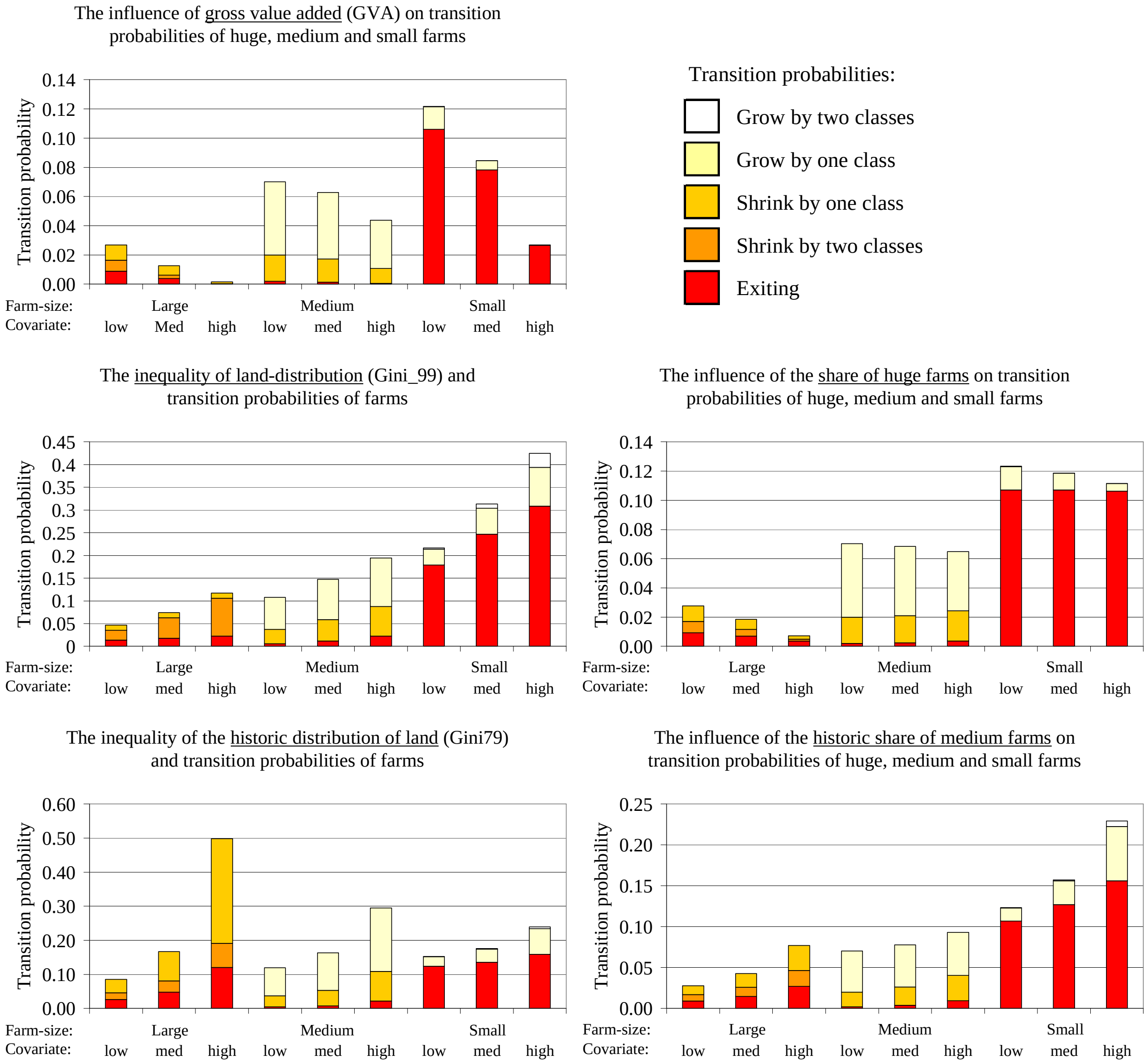
Dependent Variable	Intercept	Year	Gini 1999	% land by large farms 1999	% medium 1979	Gini 1979	Gross value added 1999	R-squared
$\log(p_{10}/p_{13})$	6.251 (0.633)***	-0.402 (0.129)***	-4.768 (1.180)***	1.832 (0.552)***	-4.311 (0.611)***	-2.982 (0.827)***	0.026 (0.002)***	0.354
$\log(p_{11}/p_{13})$	8.429 (0.836)***	-0.478 (0.171)**	-6.762 (1.558)***	1.862 (0.728)***	-5.113 (0.806)***	-3.652 (1.092)***	0.032 (0.002)***	0.342
$\log(p_{12}/p_{13})$	4.165 (0.354)***	-0.223 (0.072)***	-3.928 (0.660)***	0.245 (0.309)	-2.653 (0.342)***	-1.527 (0.463)***	0.014 (0.001)***	0.391
$\log(p_{20}/p_{23})$	-3.333 (0.243)***	0.071 (0.050)*	2.306 (0.453)***	1.252 (0.212)***	2.444 (0.235)***	1.392 (0.318)***	-0.005 (0.001)***	0.422
$\log(p_{21}/p_{23})$	-1.031 (0.190)***	0.003 (0.039)	0.714 (0.354)**	0.490 (0.166)***	0.773 (0.183)***	0.336 (0.248)	-0.001 (0.001)	0.102
$\log(p_{22}/p_{23})$	2.793 (0.218)***	0.121 (0.044)***	-1.207 (0.406)***	0.317 (0.190)**	-0.112 (0.210)	-1.979 (0.284)***	0.002 (0.001)***	0.199
$\log(p_{30}/p_{33})$	-4.630 (0.484)***	-0.027 (0.099)	1.329 (0.902)*	-1.341 (0.422)***	1.792 (0.467)***	4.038 (0.633)***	-0.017 (0.001)***	0.312
$\log(p_{31}/p_{33})$	-4.822 (0.647)***	-0.013 (0.132)	3.336 (1.205)***	-2.585 (0.563)***	1.512 (0.624)**	3.587 (0.845)***	-0.024 (0.002)***	0.311
$\log(p_{32}/p_{33})$	-4.509 (0.401)***	-0.005 (0.082)	0.218 (0.748)	-2.258 (0.350)***	1.773 (0.387)***	5.032 (0.524)***	-0.010 (0.001)***	0.303

The higher the gross value added is the lower the overall mobility. This has been expected due to possibly higher capital intensity and rents of the status-quo. Further, the higher the inequality of the land distribution (the Gini coefficient) in 1999, the higher the overall mobility for all size classes. Thereby all mobility indicators increase. This shows that regional concentration tendencies lead to growth on the one hand and farm closure and possible part-time farming on the other hand.

If the share of large farms is high, the large farms' downward mobility is low. In accordance with our hypotheses, this seems to be due to the high growth potential and dominance of these farms on the land market. At the same time, upward mobility of the small and medium farms is lower. Contrarily, the higher the downward mobility of large farms, where only few large farms exist, might be due to the high stability of small and medium farms and the resulting generally reduced growth potential.

The initial farm size structure measured by the Gini coefficient in 1979, significantly affects the mobility in more recent years (1999-2007). The higher the former inequality is, the higher is the mobility today. This indicates that farm level decisions depend on expectations, which concern the decisions of others and have been coined in the past. Such an interdependence could explain regional path dependency. Similar tendencies are shown by the impact of the share of medium farms in 1979. A high initial share of medium farms corresponds to a small growth potential and a predominant strategy of quantity adoption on the land market. Accordingly, the upward mobility of small farms is relatively high in such regions. Additionally, the exit mobility of large, medium and small farms in these regions is higher, too. A possible reason might be the higher pressure on these farms on the land market.

Figure 7: Partial Effects of the Covariates on the Transition Probabilities



Source: Own calculations based on FDZ 1999-2007.

5 SUMMARY, CONCLUSIONS AND OUTLOOK

The objective of this paper is to explain regionally differentiated patterns of structural change based on a theoretical framework. The crucial hypothesis that these patterns rely on strategic interaction of farms on the market for land is aimed to be tested empirically. Relying on a Markov chain model, we aim to explain individual farm moves between predefined size classes. We make use of now available panel data from the agricultural census including all farms in the West German agricultural sector for the years 1999-2007. The use of mobility indicators allows comparing regions and periods. By means of the multinomial logit specification of the transition probabilities explaining farm growth, decline or exit, it was possible to quantify the impact of the current and former farm size structure in the respective region. Further, the impact of variables describing the regional farm structure, thereby indicating market power of the large, the potential of high competition for land within a region and possibly high rents of the status quo in combination with sunk costs, could be quantified. The results confirm the relevance of strategic interaction as a crucial determinant of regionally different structural change and persistent regional differences in the farm size structure over time. Thus, we conclude that the classical view of path dependency caused by farm individual restrictions does not suffice and should be expanded by the implications of strategic interaction among farms. Nevertheless, the derivation of the results and in particular the estimation method could be improved. In future work, we aim to consider also market entries as an issue that should be tested, even though entries are expected to be negligible. Further, the estimation method could be improved. A first step would be to use system estimators as these are more efficient. In a second step, we plan to apply mixed models to account for unobserved time and heterogeneity effects.

Besides the academic exercise, our results have policy implications such that earlier findings about regionally different patterns of structural change should be corrected in the light of our results. First, the effect of structural policies might have been *overestimated* in earlier studies without consideration of the strategic interaction among farms. Our estimation results show that farmers' decisions to exit, decline or grow are affected by the farm size structure in the respective region. Further, we can demonstrate that the competitiveness of farms on the land market has a considerable impact on structural decisions. This indicates that structural policies might have supported existing paths and fostered already existing path dependency. Second, many policy interventions exist in agriculture that do not directly aim at influencing structural change. The non-intended impacts of such policies might have been *underestimated* in the past. In general, subsidies create rents of the sector that might further induce rising status quo rents at the farm level. Our results show that the impact of status quo rents on the regional structural development is not negligible. Due to the repeated interaction of farms on the land market, farmers' reaction towards increasing rents is strategic. From the society's perspective, this might lead to unfavourable inefficiencies of policy funding. Future structural policies should take these findings into account to reduce social costs of structural policies.

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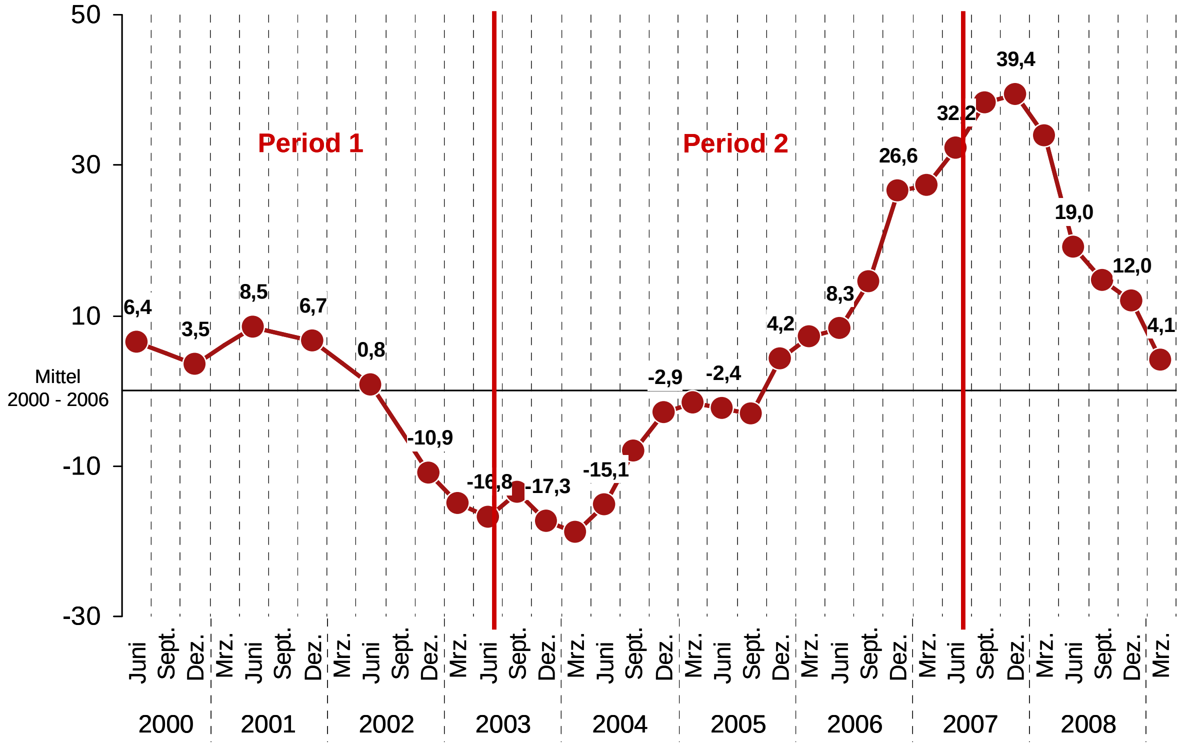
ANNEX

Figure A.1: Assessment of economic situation and future prospects of German farms



Source: Konjunktur- und Investitionsbarometer Agrar, März/April 09.
http://www.bauernverband.de/?redid=301312

Table A.1: Summary Statistics

Variable	Mean	Standard deviation	Minimum	Maximum	N*T
Gini 1999	0.541	0.080	0.315	0.742	654
Gini 1979	0.446	0.100	0.275	1.053	646
% land by large farms 1999	0.205	0.156	0.000	0.700	654
% medium 1979	0.263	0.119	0.000	0.632	646
Gross value added 1999 per ha	51.948	38.948	1.739	217.437	649

Source: FDZ, Agricultural Census 1979, Arbeitskreis Volkswirtschaftliche Gesamtrechnung
Note: The different observation numbers are due to missing values in the data set.

Table A.2: Characteristics of structural clusters

Cluster	N	Average farm size	Gini coefficient	Share of farms <30 ha	Share of farms >100 ha	Share of part time farms
Small - equal	79	22.64	0.46	0.74	0.01	0.5
		(3.25)	(0.05)	(0.06)	(0.01)	(0.09)
Small - unequal	134	20.12	0.59	0.8	0.03	0.59
		(6.09)	(0.07)	(0.08)	(0.02)	(0.15)
Large - equal	49	31.85	0.51	0.59	0.04	0.36
		(4.21)	(0.05)	(0.06)	(0.02)	(0.10)
Large - unequal	26	36.03	0.58	0.62	0.09	0.58
		(4.22)	(0.03)	(0.04)	(0.03)	(0.06)
Very large	39	53.23	0.54	0.45	0.15	0.36
		(10.24)	(0.07)	(0.10)	(0.05)	(0.09)
All regions	327	27.7	0.54	0.7	0.05	0.51
		(12.24)	(0.08)	(0.14)	(0.05)	(0.15)

Note: Standard deviation in brackets.
Source: Own calculations based on FDZ 1999-2007.

Table A.3: Characteristics of production-type-clusters

Cluster	N	Share of dairy farms	Share of pig and poultry farms	Share of horticulture farms	Share of arable farms	Cows per hectar	Pigs (animal-units) per hectar
Horticulture	38	0.09	0.01	0.63	0.47	0.09	0.11
		(0.06)	(0.01)	(0.16)	(0.21)	(0.08)	(0.10)
Dairy	122	0.64	0.02	0.06	0.16	0.47	0.18
		(0.14)	(0.02)	(0.09)	(0.11)	(0.20)	(0.13)
Mixed	84	0.33	0.03	0.11	0.53	0.20	0.29
		(0.09)	(0.02)	(0.09)	(0.12)	(0.08)	(0.18)
Pig and poultry	35	0.39	0.13	0.07	0.31	0.29	1.03
		(0.11)	(0.04)	(0.07)	(0.10)	(0.11)	(0.41)
Arable farms	37	0.13	0.02	0.19	0.82	0.06	0.16
		(0.07)	(0.01)	(0.13)	(0.10)	(0.06)	(0.12)
Intensive Pig-prod.	11	0.36	0.29	0.02	0.18	0.27	2.32
		(0.09)	(0.07)	(0.00)	(0.08)	(0.11)	(0.83)
All regions	327	0.40	0.04	0.15	0.38	0.28	0.36
		(0.23)	(0.06)	(0.20)	(0.25)	(0.21)	(0.51)

Note: Standard deviation in brackets.
Source: Own calculation based on FDZ 1999 – 2007.

Table A.4: Characteristics of economic clusters

Cluster, characterised by: Population-density	econ. development	N	Share of area covered by buildungs	Share of agricultural GVA 1992	Relative change in number of emplyees	1992: non-agricultural Employees per inhabitant	GDP per inhabitant 1992	relative change of GDP	2006: non-agricultural Employees per inhabitant	GDP per inhabitant 2006
rural	positive	105	0.17	0.02	0.10	0.39	18429	0.41	0.40	24199
			(0.08)	(0.01)	(0.07)	(0.06)	(3445)	(0.15)	(0.06)	(5040)
purely rural		71	0.11	0.05	0.12	0.35	16122	0.52	0.38	22134
			(0.02)	(0.01)	(0.08)	(0.06)	(2615)	(0.17)	(0.06)	(4392)
rural	negative	51	0.10	0.03	-0.05	0.42	18657	0.27	0.40	23253
			(0.03)	(0.01)	(0.06)	(0.06)	(2632)	(0.12)	(0.05)	(3427)
urban	positive	45	0.50	0.00	0.06	0.74	36145	0.39	0.76	48947
			(0.28)	(0.00)	(0.11)	(0.12)	(6656)	(0.24)	(0.12)	(12489)
urban	negative	53	0.72	0.00	-0.02	0.54	25695	0.24	0.53	32023
			(0.41)	(0.00)	(0.06)	(0.09)	(5073)	(0.12)	(0.09)	(6077)
All regions		325	0.28	0.02	0.06	0.46	21599	0.38	0.47	28302
			(0.30)	(0.02)	(0.10)	(0.15)	(7735)	(0.19)	(0.15)	(10978)

Note: Standard deviation in brackets.
Source: Own calculation based on Arbeitskreis Volkswirtschaftliche Gesamtrechnung and INKAR (Bundesamt für Bauwesen und Raumordnung).

Table A.5: Description of variance analysis (MANOVA)

		Upward mobility		Downward mobility		Exit mobility	
Source	Degrees of freedom	Typ3 III sum of squares	Pr > F	Typ3 III sum of squares	Pr > F	Typ3 III sum of squares	Pr > F
economic cluster	4	0.11	0.024	0.12	0.074	0.07	0.342
production-type-cluster	5	0.04	0.548	0.07	0.396	0.10	0.241
structural cluster	4	0.70	<.0001	0.06	0.339	0.60	<.0001
year	1	0.00	0.640	0.10	0.008	0.07	0.029
year*economic cluster	4	0.08	0.084	0.08	0.225	0.02	0.792
year*production-type-cluster	5	0.04	0.553	0.04	0.649	0.05	0.610
year*structural cluster	4	0.11	0.019	0.16	0.019	0.01	0.982
R-square		0.18		0.08		0.20	
Pr>F		<.0001		0.002		<.0001	

Note: 642 observations (321 districts for two time-periods)
Source: Own calculation based on FDZ 1999 - 2007, Arbeitskreis Volkswirtschaftliche Gesamtrechnung; SAS Proc GLM.