

# Farm Structural Change in German Regions – An Empirical Analysis using Micro and Macro Data

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**Abstract—** General economic developments as well as recent fundamental changes in the Common Agricultural Policy will likely impact significantly on the European farm structure. Although a decline of total farm numbers continues to be the general observation, important differences occur across regions and farm types. These differentiated developments and their determinants are of high relevance for policy impact assessment at the regional level. The main objective of the analysis provided in this paper is to empirically identify whether regionally specific characteristics account for differences in regional farm structure development. This is exemplarily shown for German FADN regions. As methodological approach a combined time series, cross-sectional Markov chain analysis is applied. The non-stationary Markov model is estimated via generalised cross-entropy estimation technique with the transition probabilities being represented as multinomial logit functions of explanatory variables and their coefficients. Prior information on the transition probabilities is obtained from observed single farm movements of the FADN sample.

**Keywords—** Farm structure, Markov model, Germany.

## I. INTRODUCTION

General economic developments as well as recent fundamental changes in the Common Agricultural Policy will likely impact significantly on the European farm structure. Although a decline of total farm numbers continues to be the general observation, important differences occur across regions and farm types. This paper intends to analyse the impact of regional differences on farm structural change exemplarily for German FADN regions and three farm types for the time period 1995 to 2003. The analysis comprises all farms represented by the FADN sample farms. The farms are stratified according to their economic size into three size classes (<16, 16-<40,

=>40 ESU). As methodological approach a non-stationary Markov chain model is chosen where a generalized cross-entropy estimation is combined with a parametric setting for the transition probabilities. The annual transition probabilities are represented as multinomial logit functions of explanatory variables and coefficients and fitted with well-founded a priori information coming from observed movements of farms from the FADN sample. Firstly, the German farm structure is briefly characterised, followed by the description of the estimation approach. Then, general observations on the results and concluding remarks are presented.

## II. GERMAN FARM STRUCTURE

Due to historical reasons, Germany is one of the European countries with the sharpest regional differences concerning agricultural structure. Whereas the western part is dominated by a typical family farm structure, the eastern part is characterised by large post-socialist farm enterprises. As shown in Figure 1 the different initial farm structures led to different structural developments from 1995 to 2003. Negative growth rates in the West and zero growth or even positive growth rates in the eastern part of Germany can be observed. The western part is divided into four different zones. In the very west the sharpest decline in terms of farm numbers can be observed, whereas moderate negative growth rates can be found in the southern and northern regions of Germany. Regarding changes in the farm size distribution small farms seem to disappear totally in the time period 1995-2003 in most states except for Hesse and Bavaria. For medium farms slightly positive growth rates can be observed in all eastern states except Saxony-Anhalt. In the western part negative growth rates for medium farms of up to 5% per year have occurred.

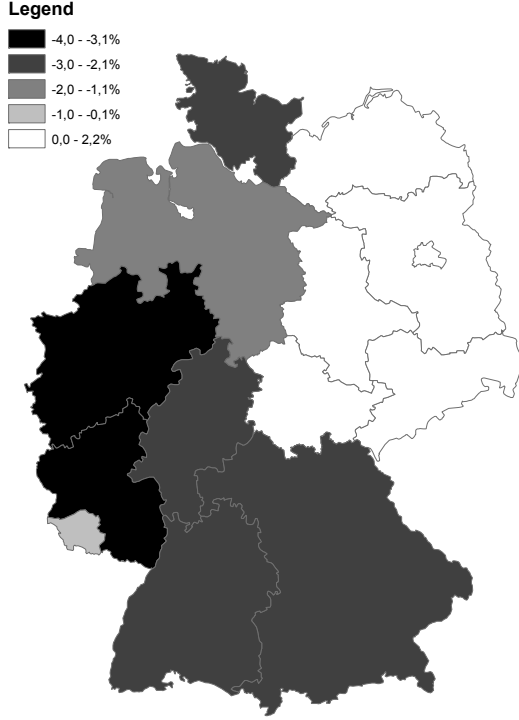


Fig. 1 Average annual entry/exit rates per region

Negative growth rates for large farms can only be observed in Schleswig-Holstein and North Rhine-Westphalia whereas annual growth rates of more than 3% occur in the states Brandenburg, Bavaria, and Baden-Wuerttemberg. In the northern and central part of Germany the number of large farms increases by up to 3% per year.

### III. ESTIMATION APPROACH

For the Markov chain estimation a generalised cross-entropy estimator (GCE) as developed by [1] and [2] and applied to agricultural structural change by [3], [4] and [5] is applied. Compared to classical Markov chain estimation (e.g. [6],[7],[8],[9],[10]), the GCE has the advantage that a priori information on the transition probabilities can easily be deployed since it minimizes the distance between prior beliefs and the information coming from the data. In GCE approaches mainly instrumental variable techniques have been applied so far where the effect of explanatory

variables can be recovered through the calculation of transition probability elasticities, but no coefficients are estimated and the resulting transition probability matrix (TPM) does not vary over time ([3], [5]).<sup>1</sup> In [4] time-varying transition probabilities are estimated in a GCE approach of which the most important ones are linearly regressed against a set of explanatory variables in a second estimation step. Here, non-stationary transition probability matrices are estimated for each region and the transition probabilities are defined as multinomial logit models according to [11], [12], [9] and [10]:

$$\begin{aligned} \min H(p_{rtij}, q_{rtij}, w_{rtmi}, u_{rtij}) \\ = \sum_r \sum_t \sum_i \sum_j p_{rtij} \ln(p_{rtij} / q_{rtij}) \\ + \sum_r \sum_t \sum_m \sum_i w_{rtmi} \ln(w_{rtmi} / u_{rtmi}) \end{aligned} \quad (1)$$

s.t.

$$y_{rtj} = \sum_i x_{rti} p_{rtij} + e_{rti} \quad (2)$$

for  $i, j = 1, \dots, S$ ; with

$$p_{rtij} = \exp(Z_{rti} \beta_{ij}) / \left( 1 + \sum_{k=1}^{s-1} \exp(Z_{rti} \beta_{ik}) \right) \quad (3)$$

and

$$p_{rtis} = 1 / \left( 1 + \sum_{k=1}^{s-1} \exp(Z_{rti} \beta_{ik}) \right) \quad (4)$$

for  $i = 1, \dots, S$  and  $j = 1, \dots, S-1$ .

Equation (1) represents the GCE function which minimizes the distance between the transition probabilities  $p_{rtij}$  and the priors  $q_{rtij}$  as well as the distance between the posterior probabilities  $w_{rtmi}$  and priors  $u_{rtmi}$  of the error term. Equation (2) represents the Markov data consistency constraint with  $y_{rtj}$  being the matrices of the shares of farms in each farm type  $j$  at time  $t+1$  in region  $r$ ,  $x_{rti}$  being the matrices of the shares in each farm type  $i$  at time  $t$  in region  $r$ ,  $p_{rtij}$  being the transition probabilities at time  $t$  in region  $r$ , and  $e_{rti}$  being the matrix of the regional

1. Although the transition probabilities do not vary over time they are called 'non-stationary', meaning that they are estimated depending on other explanatory variables.

error terms parameterized as  $e_{rti} = \sum_m v_m w_{rtmi}$ , where  $v$  is an  $m$ -dimensional vector of support points and  $w$  is an  $m$ -dimensional vector of weights. The multinomial logit formulation with explanatory variables  $Z$  and coefficients  $\beta$  of the transition probabilities ensures compliance with the probability constraints (equations (3) and (4)). The probability constraints applying to the error term are enforced by implementing further constraints ( $\sum_m w_{rtmi} = 1$  and  $w_{rtmi} \geq 0$ ). The Markov transition probabilities  $p_{rtij}$  directly enter the GCE objective function (1) without needing to be parameterized and thus permit a rather transparent use of prior information. The priors  $u$  are assumed to be uniformly distributed around zero. Probability elasticities measuring the impact of the explanatory variables on each transition probability at each point in time are calculated according to [9].<sup>2</sup>

#### IV. DATA AND RESULTS

The farm type data is drawn from the FADN sample and covers the years 1995 to 2003. Since the number of farms represented by the FADN sample is calculated according to the Farm Structure Survey and is updated only every two to three years, only data points for these Farm Structure Survey years are considered in the analysis and intermediate data is interpolated. The prior information used to estimate the model is based on observed movements of farms between the predefined farm types of the FADN sample farms. The observed transitions from the micro-data are used to calculate a stationary transition probability matrix. As the sample farms enter and exit the FADN sample more or less arbitrarily no data on market entries or exits is provided. However, for exits from each farm type the same average annual exit rate is assumed, which is obtained from the difference of the total amount of farms in the first and last observation year. For the prior information on entries an arbitrarily small number is chosen. In a first GCE estimation step the obtained stationary transition

probability matrix is used as prior information in order to estimate time-varying transition probabilities for each year without considering other explanatory variables. The time-varying transition probabilities are then used as prior information for the non-stationary Markov problem employing the multinomial logit formulation in order to capture the effect of the explanatory variables. Regarding regional differences a fixed effects model is employed where it is assumed that differences across regions can be captured through differences in the constant term (Greene 2003). The time aspect of structural change is reflected by the incorporation of a trend variable. Generally, the annual transition probability matrices do not differ much from the prior information (normalised entropy measures for all years and regions rather close to 1). Regarding the trend variable the calculated elasticities reveal nearly the same pattern for all regions with a negative impact of the time on market entries and on all transitions into the smallest size class and a positive impact on all transitions into the exit class. The impact of the trend variable generally increases over time. Over time, the impact of the regional dummies seems to be about the same magnitude in each region. However, differences regarding algebraic sign and magnitude occur between regions. Whereas positive elasticities can be found for all own-size transition probabilities in western regions, the regional elasticities are negative for the own-size transition probabilities in the smallest size class in the eastern part of Germany. The negative influence on upper and lower diagonal elements in the transition probability matrix appears to be much stronger in East than in West Germany, pushing the respective transition probabilities closer to zero and thus indicating relatively weak structural changes in this part of Germany.

#### V. CONCLUDING REMARKS

In this paper a cross-sectional Markov chain approach combining micro and macro data is presented. It is shown that, as expected, differences occur in the structural development of different German regions and that these differences can be attributed to certain regional criteria. Further research is necessary to identify the factors which lead to the

2. Probability elasticities are calculated because, as [9] remarks, the estimated coefficients cannot be interpreted as the direct effect of the explanatory variables since they enter equation (3) non-linearly.

different development patterns in the regions. The strong historical influence observed in this case would for example suggest the incorporation of the initial distribution of farm size as an explanatory variable. Also, non-sector specific factors like the opportunity for off-farm employment might contribute to regionally different developments.

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