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Andrea Zimmermann, Thomas Heckelei

Abstract

Challenges arising from the EU policy focus on rural development lead to an increased demand for farm structure analyses at a regional level. The study's aim is to show (1) which way structural change differs across EU15 regions referring to size and production orientation and (2) how far certain regional characteristics contribute to those differences. A Markov chain analysis combining sample and aggregate data is used to identify regionally different development paths. Significant regional differences are observed regarding the farm number development in general and with respect to size and specialisation classes. A cross-sectional analysis shows that region-specific structural variables partially explain those differences.

Keywords: Farm structural change, Markov chain analysis, mobility indices, cross sectional analysis.

JEL classification: C13, R11, Q12

1 Introduction

The EU policy focus on rural development leads to an increased interest in farm structural change at a regional level. General economic developments as well as recent fundamental reforms of the Common Agricultural Policy significantly impact on the European farm structure. Although a decline of total farm numbers continues to be the general observation, important differences exist across regions. Regional differences of farm structural change under similar overall conditions in Europe have long been observed and are extensively discussed in the economic history literature. Brenner (1976) describes such regional differences in Europe during the Middle Ages until 1800. Emphasizing the very similar overall conditions in Europe already at these times, he argues that most of the differences are likely to be caused by regionally specific characteristics. His article provoked a still continuing scientific discussion (e.g. Karayalcin, 2010) which was later called the “Brenner debate” (Aston et al., 1987). Though the phenomenon of regionally differing structural developments has long been described, the agricultural economics literature only very recently started to explore and to explain those differences. In comparing English and Spanish rural restructuring processes, Hoggart and Paniagua (2001a and 2001b) discover significant differences and explicitly call for analysing the cross-national dimension. Breustedt and Glauben (2007) identify determinants which cause regionally differing exit rates of farms in Western Europe.

Defining structural change as the change of the number of farms in different farm types over time, we are particularly interested in Markov chain studies which allow estimating probabilities not only for sector entries and exits but also for the movement of farms across other farm types (e.g. size increases and decreases, changes to other production specialisations). Among the Markov chain studies, Rahelizatovo and Gillespie (1999) are the first who pay attention to regional differences in farm structural change. They estimate a two-region panel data model for dairy farms in Louisiana (USA) and represent the regional characteristics by dummy variables. Gillespie and Fulton (2001) estimate a panel data model for hog farms with dummy variables representing 17 states of the USA. Zimmermann and Heckelei (2008) quantify the regional impact on structural change in the German Bundesländer by estimating a fixed effects model. Huettel and Margarian (2009) explain differences in farm structural change across West German regions with a cross-sectional[1] Markov chain approach. We explicitly aim at (1) identifying the

[1] Their focus is on the cross-sectional effects, they additionally compare two time periods (1999-2003 and 2003-2007) to each other.

differences in farm structural change across regions in Western Europe and (2) identifying key factors that likely cause these differences.

More particularly, the paper analyses differences in the farm structure development across farm types and 101 EU15 regions in the years 1990 to 2005. We apply a Markov chain approach in order to derive regional structural development patterns (which are expressed in transition probabilities and summarised in mobility indices adapted from Jongeneel and Tonini, 2008). Afterwards the regional development patterns (in form of the mobility indices) are compared to each other and cross-sectionally regressed against a set of region-specific explanatory variables.

Since Judge and Swanson (1961) used a Markov chain approach to predict the development of pig farms in Illinois, Markov chain estimations have often been applied in the farm structural change literature (recent literature reviews are provided by Piet (2008) and Zimmermann et al., 2009). By far the most Markov chain studies in agriculture focus on structural developments within one region. Often, stationary transition probabilities are estimated, i.e. the structural developments are averaged over time (recent examples are Jongeneel and Tonini, 2008 and Piet, 2008). Other studies estimate non-stationary transition probabilities which vary over time (e.g. Zepeda, 1995a and 1995b and Stokes, 2006). Stationary transition probabilities can be used to describe the general direction of structural change over a certain time period. Additionally, non-stationary probabilities can be used to describe changes in the structural change process itself. Furthermore, non-stationary transition probabilities are often regressed against other time-dependent variables which are assumed to influence structural change. Apart from the time-dependency of structural change, very few studies pay attention to differing structural developments across regions (cf. studies mentioned above: Rahelizatovo and Gillespie, 1999, Gillespie and Fulton, 2001, Zimmermann and Heckelei, 2008, Huettel and Margarian, 2009).

We conduct a cross-sectional analysis across 101 EU-15 regions. Whereas the influence of time-dependent variables on structural change has been tested in many

Markov chain studies[2], we explicitly focus on the detection of regional characteristics and their impact on the structural change process. In line with the agricultural economics literature we chose five variables representing regional characteristics: the initial farm structure is represented by the initial farm size (in the agricultural economics literature it is often tested against Gibrat's law which states the independence of farm size and its growth rate), farm size heterogeneity (Harrington and Reinsel, 1995, Huettel and Margarian, 2009) and the share of mixed farms. Additionally, the farm holders' age (Harrington and Reinsel, 1995, Pietola et al., 2003) and the regional unemployment rate (Goddard et al., 1993, Harrington and Reinsel, 1995) are considered.

According to the data type used, one distinguishes between micro and macro data Markov chain approaches. In the Markov chain terminology, micro data describe detailed information on the movement of farms across farm types (e.g. size classes) over time (Lee et al., 1977). Most of the early Markov chain approaches rely on such kind of data (e.g. Judge and Swanson, 1961, Padberg, 1962, Hallberg, 1969). Macro data, in the Markov chain terminology, describe aggregate data that comprise time series on the number of farms in different farm types (Lee et al., 1977). Since micro data are mostly not available, macro data dominate the Markov chain literature (e.g. Disney et al., 1988, Zepeda, 1995a and 1995b, Karantininis, 2002, Stokes, 2006). The Farm Accountancy Data Network (FADN) grants access to both data types, though the micro data on FADN sample farms is not sufficient for a full micro data Markov chain approach. The macro data is derived from bi- or tri-annual censuses, the Farm Structure Survey. Macro data can also be recovered by applying the weights attached to the sample farms in

[2] Variables often tested with regard to this aspect are input-output price ratios (e.g. Disney et al., 1988, Zepeda, 1995a, Karantininis, 2002), productivity measures (e.g. Zepeda, 1995b, Rahelizatovo and Gillespie, 1999), policy variables (e.g. Zepeda, 1995a, Rahelizatovo and Gillespie, 1999) and macroeconomic variables as wages (e.g. Hallberg, 1969, Ethridge et al., 1985) or interest rates (e.g. von Massow et al., 1992, Zepeda, 1995a, Rahelizatovo and Gillespie, 1999, Karantininis, 2002).

FADN.[3] Since the not fully representative micro data nonetheless provide valuable information on the magnitude of movements of farms across certain farm types, we chose to combine both data types in our estimation approach. The combination of the micro and the macro data is accomplished by using the micro data as prior information in a macro data cross-entropy estimation approach.

According to Goddard et al. (1993), the definition of structural change in the agricultural economics literature has generally narrowly focused on the number and size of farms. Almost all Markov chain applications in agriculture define structural change as the change of the number of farms in certain size classes. Additionally to the size classes mostly also sector entries and exits are considered. Given that Markov processes can generally be used to describe the movement of economic agents across a number of discrete states over time (MacRae, 1977), Ethridge et al. (1985) do not stick to the size classes but also consider activity classes in their analysis.

Considering the whole farm population represented by FADN and acknowledging potentially different underlying dynamics concerning specialisation changes, we distinguish between size and specialisation class changes. Specifically, we distinguish between an entry/exit class, three size and ten specialisation classes. Combining the size and specialisation classes, i.e. each specialisation is divided into three size classes and adding the entry/exit class, we arrive at 31 farm types to be considered in our empirical analysis. This goes far beyond the number of classes that has been considered so far in Markov chain studies. Karantininis (2002) applied a Markov chain procedure to 19 classes, the other Markov chain studies vary between three (e.g. Zepeda, 1995a) and twelve classes (Ethridge, 1985).

Summarising, our approach differs from previous Markov studies in three ways: 1) We explicitly focus on regional differences in farm structural change and

[3] Details are provided in: http://ec.europa.eu/agriculture/rica/methodology3_en.cfm, accessed at 28 February 2011.

their determinants. Considering the whole EU15, the analysis has an unprecedented cross-sectional scope (101 regions across the EU15) which significantly increases the observed variance in farm type transitions and brings new determinants into play; 2) farm type transitions observed at micro level are used as prior information in a macro data estimation approach; and 3) not only size, but also different specialisation classes are considered distinguishing 30 farm types (plus one entry/exit class) and thereby significantly exceeding the number of farm types considered up to now.

In the next chapter the data base is explained and general farm structure developments are summarized, followed by the description of the methodological approach. Thereafter the results and the analysis of the relationship between structural variables and the mobility indices are presented. The final chapter concludes.

2 European farm structure

This chapter introduces the farm typology and the data used throughout the document and gives an overview of the differences in European farm structure development from 1990 to 2005.

2.1 *Farm typology*

We use an adapted version of the multi-dimensional farm typology presented in Andersen et al. (2006) which was developed based on the FADN data. Our farm typology comprises two dimensions: a size and a specialisation dimension. According to FADN and the farm typology of Andersen et al. (2006), farm size is measured in economic terms (European Size Units). We distinguish three size categories: a small size category until 16 ESU (Small), a medium size category from 16 to 40 ESU (Medium) and a large size category greater or equal to 40 ESU (Large). The specialisation classes as defined by Andersen et al. (2006) are based on the European Community farm typology. Ten specialisation classes are considered: 1) arable systems, 2) dairy cattle, 3) beef and mixed cattle, 4) sheep, goats, and mixed grazing livestock, 5) pigs, 6) poultry and mixed pigs/poultry, 7) mixed farms, 8) mixed livestock, 9) permanent crops, 10) horticulture. As in case of the size classes, the specialisation classes are defined in economic terms, specifically by the standard gross margin shares of farming activities. The exact definition is given in the appendix (Table A 1). A farm type is defined as a combination of a certain size and a certain specialisation class. Combining our three size and ten specialisation classes, we thus arrive at 30 farm types to be considered in the empirical analysis.

2.2 *Data*

The main data used throughout the document stem from the Farm Accountancy Data Network (FADN). The FADN database uses sample farms in order to represent the European farm structure. In FADN, only 'commercial' farms, which exceed a certain country specific size threshold, are considered.[4] Weighting factors define the number of farms which is represented by each FADN sample farm. The weighting factors are calculated according to three stratification criteria: region, economic size and specialisation. A farm type is a combination of a certain economic size and a specialisation class. The weighting factors are derived from bi- to tri-annual censuses (the Farm Structure Survey). FADN has its own regional resolution such that FADN regions only roughly refer to NUTS I and II regions or their aggregates.[5] This analysis uses FADN data for the EU15 from 1990 to 2005. In 2005, about 57,000 sample farms were used to represent approximately 3

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[4] The threshold value is country-specific and defined in terms of economic size (http://ec.europa.eu/agriculture/rica/methodology1_en.cfm, accessed at 28 February 2011).

[5] Though the FADN weighting factors are derived from the Farm Structure Survey, the number of farms represented by FADN (i.e. the FADN single farms multiplied by their weighting factors) is not equal to the publicly available Farm Structure Survey farm numbers. This is due to two effects: (1) in FADN only 'commercial' farms are considered, and (2) the FADN regions differ from the NUTS II level at which the Farm Structure Survey is based.

million ‘real’ farms in the EU15. For the Markov chain estimations information of sample farm movements across different farm types (a combination of both size and specialisation classes) as well as the aggregated data on the number of farms (represented by the sample farms) in different time periods is used. The information on observed transitions of sample farms is called micro data in the Markov chain terminology (Lee et al., 1977). The aggregate data which gives the actual number of farms in the different farm types (as surveyed in the Farm Structure Survey) is named macro data.

Generally, the availability of micro data would allow for a simple calculation of transition probabilities, a so-called micro data Markov chain approach. However, the FADN micro data is not sufficient for such an approach since: (1) FADN data is based on a rotating panel. The FADN sample farms arbitrarily enter, exit and probably re-enter the sample. As a result of this policy, the data on sector entries and exits of sample farms is not meaningful at all. (2) The FADN micro data constitutes a, compared to the population, small sample with corresponding sampling noise. However, it still represents a unique and valuable source of information. Our approach combines both data types: the observed movements of sample farms across the farm types (micro data) is used as a priori information, whereas the total number of farms derived by applying the weighting factors (macro data) is used as data for the Markov chain constraint (see detailed estimation description in Chapter 3).

2.3 *Farm structure development*

This chapter provides a descriptive analysis of the differences in farm structural change across the European regions.

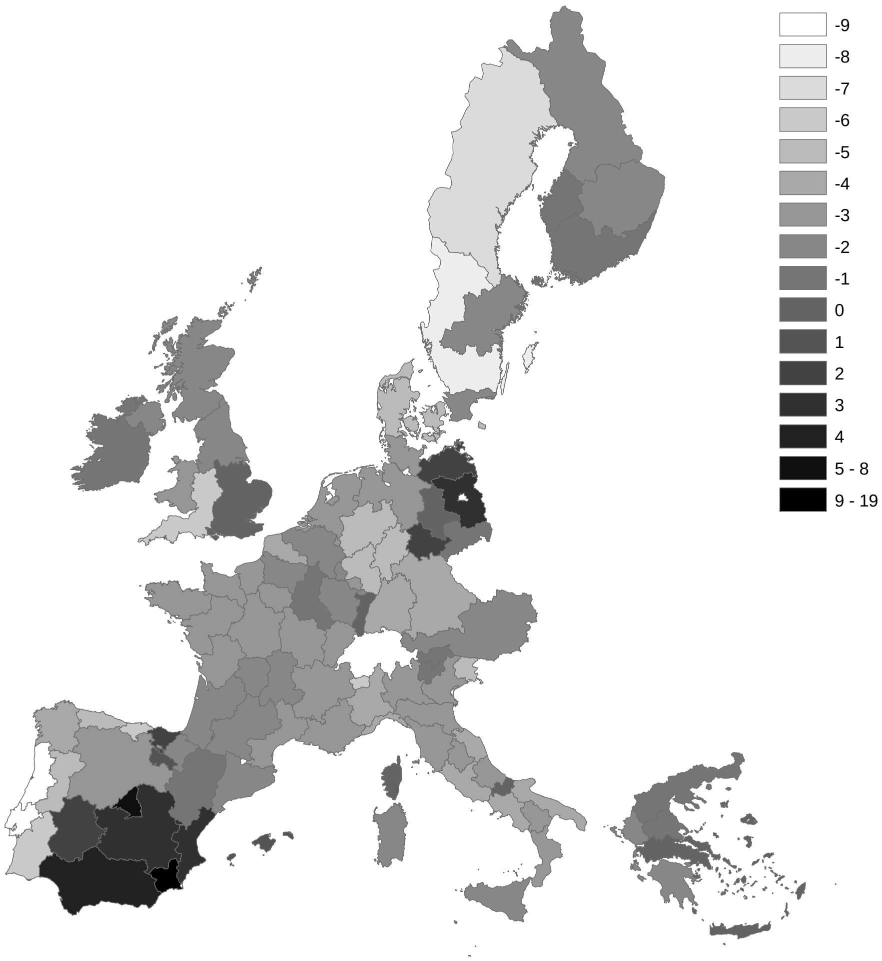
Farm number development

The number of farms in the Member States forming the EU before 1995 has decreased from more than 4 million in 1990 to less than 3 million in 2005.[6] In the countries which joined the EU in 1995 (Austria, Sweden, Finland) including East Germany, the number of farms decreased from almost 200,000 in 1995 to less than 160,000 in 2005. Figure 1 reveals the regional distribution of the average annual rates of farms leaving the sector (exit rates) for the observation period 1990 to 2005 (1995 to 2005 for East Germany, Austria, Sweden and Finland).[7]

[6] Since the analysis in this paper is based on data coming from the Farm Accountancy Data Network (FADN), here as in FADN, only so-called ‘commercial’ farms are considered.

[7] The exit rates are calculated by applying the geometric mean to the total number of farms at the beginning and at the end of the observation period.

Figure 1: Average annual rates of farm number change 1990-2005 [per cent][8]



Source: Own calculation based on FADN data.

[8] Switzerland, Andorra and the German city states Berlin, Hamburg, and Bremen are not considered.

The figure shows considerable variation in the farm number development across regions on the Iberian Peninsula, Scandinavia and Germany, whereas regional farm number change is relatively homogeneous in France and Italy. Most European regions experienced decreasing farm numbers during the time period 1990/1995 to 2005. The highest net exit rates are reported in Portugal and Sweden. The only regions where the number of farms has increased are Central and Southern Spain and, due to historical reasons, parts of East Germany.[9] Before the German reunification, farms were organised in collectives in East Germany. After the reunification, the collectives were partly split and new farms occurred which explains the raise in farm numbers in East Germany. One explanation for a growing number of farms in Spain could be that farms formerly classified as not commercial farms exceed the monetary FADN threshold value and hence newly appear in the FADN statistics.[10] This is supported by Hoggart and Paniagua (2001b) who find that in fact agriculture in rural Spain is characterised by a growth in full-time farm engagement.

Development of the size classes

In the United Kingdom, Belgium, Luxembourg, the Netherlands, Denmark and Sweden large farms already represented the majority of farms in 1990 and their share still gained importance till 2005 (Table A 2 in the appendix). In France and Germany the status of the largest size class changed from medium-sized farms in 1990 to large farms in 2005. Medium-sized farms remain the most important group in Austria and Finland, whereas the farm structure in the South European countries and Ireland was and still is dominated by small farms.

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[9] The regions with positive growth rates are: Brandenburg, Mecklenburg-Vorpommern, Thueringen in Germany, and Pais Vasco, La Rioja, Baleares, Madrid, Castilla-La Mancha, Comunidad Valenciana, Murcia, Extremadura, Andalucia, Canarias in Spain.

[10] The same holds for exits. Farms exiting the sector could also be farms that just decline in size and do not reach the threshold size anymore.

Development of the specialisation classes

In most countries either arable or dairy farms represent the largest specialisation class in terms of the proportion of farms (Table A 3). In South European countries dairy farming is less important. Instead, the share of permanent crop farms is very high. Generally, the farm structure is less diversified in the European South than in the North. In Southern Europe, the majority of farms is classified as arable or permanent crop farms. The share of the dairy farming specialisation class has significantly decreased in all European countries except Austria. Usually, the decline of the share of dairy farms coincides with an increase of the share of cattle keeping farms. In Austria, for which the persistence of small dairy farming is repeatedly reported (e.g. Kirner et al., 2009), the share of dairy farms increased from 27 per cent in 1995 to 39 per cent in 2005.[11] In Finland and in Sweden the share of arable farms increased drastically in the same time period (by 21 per cent in Finland and 17 per cent in Sweden). In Spain and in Portugal, a remarkable increase of the share of permanent crop farms took place (by 23 and 13 per cent, respectively).

Combination of size and specialisation classes

The combination of size and specialisation classes results in 30 farm types.

[11] For Austria, an increase of medium and especially large dairy farms is reported in the FADN data, whereas the number of small Austrian dairy farms decreases only slowly.

Table 1 gives an overview of the development of these farm types

Table 1. Overview of the development of the farm types

Farm type		*Share of farms in EU15 [per cent]*		*Average growth rates across regions (1990-2005) [per cent]*				
Specialisation	*Size class*	*2005*	*Δ to 1990*	*Mean*	*Standard deviation*	*Median*	*10%-Quantile*	*90%-Quantile*
Arable crops	Small	16.14	-7.62	-25.3	40.6	-5.67	-100.00	1.62
	Medium	6.48	1.20	-0.3	6.1	-1.05	-6.78	6.37
	Large	6.41	2.64	0.7	16.5	1.40	-2.18	11.15
Sheep, goats	Small	2.74	-1.76	-39.3	45.4	-9.16	-100.00	-0.94
	Medium	2.19	0.90	-13.2	35.7	0.35	-100.00	6.52
	Large	1.18	0.80	-12.6	39.6	3.30	-100.00	11.64
Permanent crops	Small	23.33	2.43	-25.1	42.2	-3.17	-100.00	5.24
	Medium	5.32	2.21	-4.5	25.2	-0.56	-8.85	10.55
	Large	3.59	2.01	2.6	15.8	2.29	-2.23	16.42
Dairy	Small	1.04	-4.19	-57.0	43.9	-100.00	-100.00	-7.43
	Medium	3.25	-1.94	-18.0	31.4	-7.46	-100.00	0.89
	Large	6.06	2.74	4.3	15.0	2.34	-2.73	18.89
Beef, mixed cattle	Small	3.71	0.06	-29.3	43.5	-6.53	-100.00	3.53
	Medium	2.17	0.58	-2.2	17.5	0.55	-8.42	10.46
	Large	1.52	0.87	2.9	15.2	4.69	-2.59	11.80
Pigs	Small	0.08	-0.07	-65.0	44.8	-100.00	-100.00	-3.41
	Medium	0.27	-0.05	-45.9	46.1	-13.96	-100.00	-1.70
	Large	1.06	0.57	-11.3	33.9	0.23	-100.00	7.02
Poultry	Small	0.07	-0.05	-62.9	44.4	-100.00	-100.00	-3.78
	Medium	0.13	0.02	-22.1	36.8	-2.65	-100.00	3.13
	Large	0.46	0.33	-0.4	22.1	2.05	-6.99	17.26
Mixed farms	Small	2.33	-2.33	-38.2	45.1	-8.71	-100.00	-0.50
	Medium	1.72	-0.45	-10.5	26.4	-4.45	-11.50	4.54
	Large	2.63	1.02	-0.3	12.7	0.44	-4.40	6.36
Mixed livestock	Small	0.94	-0.98	-46.8	45.1	-18.05	-100.00	-1.94
	Medium	0.42	-0.38	-25.1	37.8	-10.25	-100.00	4.33
	Large	0.81	0.21	-8.5	27.2	-0.59	-11.84	5.44
Horticulture	Small	1.03	0.02	-44.3	49.1	-10.29	-100.00	3.96
	Medium	1.26	0.39	-10.1	29.7	-2.98	-9.35	5.81
	Large	1.68	0.80	-0.8	20.4	1.94	-4.19	11.50
Total	Total	100.00		-1.8	4.8	-2.52	-4.83	1.61

Source: Own calculation based on FADN data.

The by far largest farm types in terms of their share of the number of farms were small permanent crop farms and small arable farms in 2005. Both farm types are mainly located in the South European countries, where the number of farms is extraordinarily high compared to the North European countries. The mean growth rates[12] and their standard deviation show that there exist significant differences in the structural development of the farm types across the regions. The average growth rates of the different farm types are evaluated in terms of the median and the 10 and 90 per cent quantiles across the regions. The differences between the quantiles indicate the very different development paths across the observed regions. The median growth rates picture a clear pattern: they are positive for the large size class apart from the mixed livestock specialisation and negative for the small and medium size classes apart from medium-sized sheep and goat farms and medium-sized beef farms which are slightly positive. The 10 per cent quantiles are negative for all farm types and indicate the total disappearance for the majority of farm types. The 90 per cent quantiles are mostly positive. They are negative for the smallest size class in all mixed and livestock breeding specialisation classes except small beef farms. In case of pig farming the 90 per cent quantile is even negative for the medium size class.

3 Methodology

A Markov chain estimation approach is chosen to analyse farm number changes in the different farm types. Beginning with Judge and Swanson (1961), the estimation of Markov chains has a long tradition in the analysis of structural change in agriculture (literature reviews are provided by Stavins and Stanton, 1980, Zepeda, 1995a, Zepeda, 1995b, Karantininis, 2002, Piet, 2008 and Zimmermann et al., 2009). The scope of our application is unique with respect to the number of regions and farm types considered. Furthermore, for the first time observed farm type

[12] The growth rates are calculated by applying the geometric mean to the number of farms in the respective farm types at the beginning and at the end of the observation period.

transitions from micro data are used as a priori information within a macro data Markov chain approach. Summarizing the estimated transition probabilities, mobility indices according to Shorrocks (1978) and as recently again suggested and adapted by Jongeneel and Tonini (2008) and Huettel and Jongeneel (2011) are calculated. They allow for better comparison across European regions and provide the statistical basis for a cross-sectional regression analysis.[13]

Chapter 3.1 describes the general concept of Markov chains, chapter 3.2 explains the estimation procedure and chapter 3.3 presents the calculation of the mobility indices.

3.1 *The Markov chain model*

A stationary first order Markov chain is described as

$$n_{jt} = \sum_{i=1}^{I} n_{it-1} p_{ij} \qquad (1)$$

where the number of farms n in farm type j at time t is the sum over the number of farms in all farm types i in the period before $(t-1)$ multiplied by their respective transition probabilities p_{ij}. Hence, a transition probability p_{ij} gives the likelihood for a farm to move from farm type i to farm type j in one time period $(i, j = 1,..., J)$.[14] It is common to collect the single transition probabilities in a transition probability matrix P $(J \times J)$:

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[13] Technically, we speak of a two-step solution. First, transition probabilities are estimated. They are summarized in mobility indices which are (after transformation to continuous intervals), in a second step, regressed against explanatory variables. Unfortunately, we are not able to exploit potential correlations between first and second step errors in the two-step approach. However, we are not aware of any methodology that is applicable in a simultaneous approach of our dimension in the literature (not even considering our objective to combine two data sources) and our own preliminary trials on a simultaneous approach failed at considerably smaller dimensions for computational reasons.

[14] In our case each farm type is a combination of a size and a specialisation class as described above.

$$P = \begin{bmatrix} p_{11} & p_{12} & \cdots & p_{1J} \\ p_{21} & p_{22} & \cdots & p_{2J} \\ \vdots & \vdots & \dots & \vdots \\ p_{I1} & p_{I2} & \cdots & p_{IJ} \end{bmatrix}.$$

Non-negativity ($p_{ij} \geq 0$) and adding-up conditions for the probabilities in each row of the matrix ($\sum_{j=1}^{J} p_{ij} = 1$) must hold. If only macro data, i.e. data where only the number of farms per farm type and year is given, is available, the Markov chain is usually estimated by replacing the number of farms n in equation (1) by farm type shares y and adding an error term e:

$$y_{jt} = \sum_{i=1}^{I} y_{it-1} p_{ij} + e_{jt} \qquad (2)$$

In the case of micro data availability, the transition probabilities can easily be derived by the following equation (Anderson and Goodman, 1957):

$$p_{ij} = \frac{m_{ij}}{\sum_{j=1}^{J} m_{ij}} \qquad (3)$$

Where the number of movements of farms m_{ij} from farm type i to farm type j is divided by the number of movements from farm type i to all farm types j .

3.2 *Estimation of the transition probabilities*

As described in Chapter 2, the FADN database mainly consists of micro data from sample farms. However, due to several reasons (cf. Chapter 2.2) the FADN micro data is not sufficient for a full micro data Markov chain approach. The weighting factors attached to the FADN data allow reproducing the farm type distribution (the weighting factors are derived from the Farm Structure Survey, a bi- to tri-annual census). Given this ‘real’ distribution (the macro data) and the valuable information on transitions of the sample farms (the micro data), we present an estimation approach to efficiently combine both data types. The main idea behind our approach is to use the micro data as prior information to the macro data Markov chain estimation. Note that this approach is consistent in the sense that if the size of the micro sample approaches the population, then the estimated transition probabilities will converge to the a priori transition probabilities as the underlying observed transitions generate the macro data.

The only approach available allowing to incorporate a priori information in estimating transition probabilities for a large number of farm types is a cross-entropy estimator (Golan et al., 1996, Karantininis, 2002, Stokes, 2006) which we also use here.[15] The same estimation procedure is applied to each of the 101 regions. Transition probabilities are calculated for 30 farm types plus an artificial entry/exit class, i.e. we arrive at 31 x 31 transition probabilities for each of the 101 regions. For each region data from 1990 to 2005, that means 15 transitions are available.[16,17] 465 data points (15 transitions times 31 farm types) are available to estimate 930 transition probabilities (31 x 30 observing adding-up conditions), a lack of 465 degrees of freedom.[18] However, since we set transition probabilities for which not a single transition in the micro data was observed to zero, the number of

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[15] Alternative Bayesian estimators are not fully developed at this point. Building on the work of Martin (1967), Lee et al. (1977) are the first to derive a Bayesian estimator for micro and macro data based stationary Markov chain approaches. MacRae (1977), however, shows that their statistical assumptions do not correspond to the true nature of the data generation process. She derives the correct specification of the likelihood function and shows that the vector of state proportions is distributed as a sum of multinomials rather than a multinomial. Taking this into account, Storm and Heckelei, (2011) developed a Bayesian estimator, but it is not applicable to a problem of our size at this point.

[16] For East Germany, Austria, Sweden and Finland only time series from 1995 to 2005 are available.

[17] Since the Farm Structure Survey and its weights are updated only every two to three years, the farm numbers between these years are interpolated.

[18] For East Germany, Austria, Sweden and Finland with a limited number of only 10 transitions (data from 1995 to 2005), the lack of degrees of freedom is 620 (31 x 30 transition probabilities to be estimated minus 31 farm types x 10 transitions).

transition probabilities to be estimated decreases significantly in most regions which automatically leads to an increase in the degrees of freedom. On average across the regions, 280 degrees of freedom are available with a maximum of 407 and a minimum of 38 degrees of freedom.

$$\min\left[\sum_{i=1}^{I}\sum_{j=1}^{J} p_{ij}\ln\left(p_{ij}/q_{ij}\right)+\sum_{m=1}^{M}\sum_{j=1}^{J}\sum_{t=1}^{T} w_{mjt}\ln\left(w_{mjt}/u_{mjt}\right)\right] \tag{4}$$

s.t.

$$y_{jt}=\sum_{i=1}^{I} y_{it-1}p_{ij}+\sum_{m=1}^{M} v_m w_{mjt} \tag{5}$$

The objective function (4) minimises the distance between the estimated transition probabilities p_{ij} and the a priori information on the transition probabilities q_{ij} and the distance between the error weights w_{mjt} and the a priori information on the error weights u_{mjt}. The Markov constraint (5) relates the farm type shares y at time t to the farm type shares at time $t-1$ multiplied by the respective transition probabilities. The error term is constructed as the product of the m-dimensional vector of supports v and the error weights for each farm type and time period w. Additional constraints establish non-negativity ($p_{ij}, w_{mjt} \geq 0$) and ensure adding-up to unity of the estimated probabilities ($\sum_{j=1}^{J} p_{ij}=1,\ \sum_{m=1}^{M} w_{mjt}=1$).

We use the micro data to construct the prior transition probability matrix (TPM). Our a priori information is composed by applying equation (3) to the micro data of each region and averaging across years ($q_{ij}=\sum_{t=1}^{T} m_{ijt}\Big/\sum_{t=1}^{T}\sum_{j=1}^{J} m_{ijt}$ with m_{ijt} being the movement of a sample farm from farm type i to farm type j in one time period). Hence, the movements of the sample farms across the farm types are used to determine the prior transition probabilities. In case that not a single transition is observed, the associated transition probability is set to zero. Since the micro data does not provide information on sector entries or exits cruder assumptions had to be made with regard to the entry/exit prior information. Regarding sector exits an average annual exit rate was calculated depending on the total number of farms at the beginning and at the end of the observation period. This exit rate was applied to all farm types in a region and transformed into an exit probability (such that the prior transition probabilities add up to one in each row). The prior probability for sector entries was set to a value close to zero (1E-10). Empirical evidence from the literature shows that entry probabilities are usually not zero for all size classes even though they are generally small. Karantininis (2002) for example detects positive entry probabilities for the smallest as well as for medium and large size classes for Danish pork farms. Huettel and Jongeneel (2011) detect positive entry probabilities for Dutch and West German dairy farms to the medium and large size classes.[19] Our results show that the estimation procedure could deal well with the prior entry/exit information in that the final estimates regarding entry and exit probabilities vary significantly across farm types.

Using a priori information coming from observed transitions of sample farms we go far beyond other Markov chain studies. Karantininis (2002) starts by constructing a prior transition probability matrix of uniform probabilities and further develops the matrix by setting certain off-diagonal elements to zero (entry and exit probabilities are kept at the initial uniform value) and increasing the diagonal prior probabilities accordingly. Stokes (2006) uses a uniform prior TPM in order to estimate stationary transition probabilities. The estimated stationary TPM is then used as a priori information for a non-stationary Markov chain approach. Admitting weaknesses in comparability, Tonini and Jongeneel (2009) derive their a priori information for dairy farm size development in Poland from other Markov chain analyses. Earlier Markov chain studies which use frequentist

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[19] Additionally, one should keep in mind that entry in case of the FADN data does not necessarily mean that new farms are set up. More likely is a growth process of smaller, formerly 'not commercial' farms which then exceed the FADN threshold and thus newly appear in the FADN farm population.

estimation methods and therefore do not rely on a priori information restrict the probabilities to certain ranges as well. In fact, those constraints are much more restrictive as they are fixed and cannot be adjusted in the estimation process as it is possible in the cross-entropy formalism. Zepeda (1995b) for example assumes that farms can change by only one size class within one period.

The prior information on the error weights, u_{mjt}, is uniformly distributed with m=3, i.e. $u_{mjt} = 1/3$. Following Tonini and Jongeneel (2009) and Golan et al. (1996, p. 88), the vector of supports is set according to the 3-sigma-rule of Pukelsheim (1994). This means defining v as $v = -3\sigma, 0, 3\sigma$ with σ being the standard deviation of y_j. By applying the 3-sigma-rule, we acknowledge that each farm type share can be characterized by a different variance over time. The specification of common support bounds for each farm type would lead to very large bounds even for farm types with small variances. As a result, the estimates of the transition probabilities for those farm types would converge closely to the respective a priori information and underutilize the information from the macro-data in the Markov chain constraint (Tonini and Jongeneel, 2009).[20] A bootstrap procedure according to Mittelhammer et al. (2000, p. 728) is applied in order to derive standard errors for the estimated transition probabilities.

3.3 *Mobility indices*

The movements across entry, exit, size and specialisation classes are estimated simultaneously. Combining the 10 specialisation classes with the three size classes introduced above results in a total of 30 farm types to which an artificial entry/exit class is added. Due to their dimension, the resulting 31×31 transition probability

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[20] For some regions the support bounds had to be widened in order to (numerically) solve the problem. For 63 regions the three-sigma rule was applied ($v = -3\sigma, 0, 3\sigma$). For 15 regions v was multiplied by 1.1, in 4 cases by 1.2 and in 19 cases by 1.3.

matrices are difficult to meaningfully compare between the 101 regions. Hence, mobility indices according to Shorrocks (1978) are calculated to provide summary type information suitable for the subsequent cross-sectional analysis. Denoting the matrix of estimated transition probabilities as $\hat{P}$, the overall mobility index is defined as

$$M^{ov} = \left[J - tr(\hat{P}) \right] \big/ (J - 1) \tag{6}$$

If farms do not change the farm type at all, the overall mobility M^{ov} is equal to zero and we speak of immobility. Perfect overall mobility with a value of one occurs if the average probability of remaining in the same category is not larger than the one of moving to any category ($1/J$).

The overall mobility can be decomposed into partial mobility indices according to Jongeneel and Tonini (2008) and Huettel and Jongeneel (2011):

$$M^{exit} + M^{entry} + M^{s+} + M^{s-} + M^{spec} = M^{ov} \tag{7}$$

M^{exit} is defined as the part of overall mobility associated with going out of business, M^{entry} with new or re-entry to the market, M^{s+} with increase in size, M^{s-} with decrease in size, and M^{spec} with the move to another specialisation class. The size mobilities refer to size class changes within each specialisation class. The mobility index for specialisation class changes denotes changes from one specialisation to another. It does not specifically reflect size class changes taking place simultaneously.

The partial mobility indices (M^{part}) are calculated according to formula:

$$M^{part} = \sum_i \sum_k \hat{p}_{ik} \big/ (J - 1) \tag{8}$$

with $\hat{p}_{ik}$ being the respective probabilities in the exit or entry class, for size increases or declines or specialisation changes. Let the set Z contain the ordered size classes $z = 1,...,3$ and the set C specialisations $c = 1,...,10$. Consequently, each farm type i, k corresponds to a unique pair (z^i, c^i) and (z^k, c^k), respectively, or is equal to the entry/exit category $J = 31$. Denoting the correspondence as $i \sim (z^i,\ c^i)$ and $k \sim (z^k,\ c^k)$ allows characterising partial mobility indices by the different definitions of i and k:

M^{exit}: $i = 1,...,30$; $k = 31$

M^{entry}: $i = 31$; $k = 1,...,30$

M^{s+}: $i \sim (z^i, c^i)$ with $z^i = 1,2$ and $c^i = 1,...,10$; $k \sim (z^k, c^k)$ with $z^k > z^i$ and $c^k = c^i$

M^{s-}: $i \sim (z^i, c^i)$ with $z^i = 2,3$ and $c^i = 1,...,10$; $k \sim (z^k, c^k)$ with $z^k < z^i$ and $c^k = c^i$

M^{spec}: $i \sim (z^i, c^i)$ with $z^i = 1,...,3$ and $c^i = 1,...,10$;

$k \sim (z^k, c^k)$ with $z^k = 1,...,3$ and $c^k \neq c^i$

4 Results on the regional farm type mobility

In describing the results of the outcome of the estimation of the transition probabilities and the resulting mobility indices this chapter contributes to the identification of differences in farm structural developments across the European regions. In order to focus on those differences, generally moments or quantiles of the distribution of transition probabilities and mobility indices across the regions are given.

4.1 *Transition probabilities*

Table 2 shows the average transition probability matrix in which the transition probabilities are averaged across the 101 regions. The first row of small, italic numbers below the mean transition probabilities give the standard deviation of the transition probabilities across the regions. As typical for transition probability matrices, the elements on the diagonal are relatively high reflecting the high probability to remain in the same farm type as in the year before. High probabilities can also be found for changes to other size classes within the same specialisation class. These probabilities are arranged in blocks around the main diagonal (for better visibility the diagonal is shaded). Mostly, non-zero probabilities exist also for changes between the mixed farms and mixed livestock farms and the other farm types. Changes are rare between livestock producing specialisations (especially pig and poultry farming) and other farm types and between horticulture and other farm types. The probabilities to move into the exit class are generally relatively high, whereas the probabilities for entering the sector are typically close to zero.

Stokes (2006) tested against the hypothesis that the probabilities are zero. In our case, it is not tested against the hypothesis that the probabilities are zero because from the a priori information we already know that those actually estimated are not zero.[21] A bootstrap procedure (Mittelhammer et al., 2000, p. 728) with 250 repetitions is used to approximate the standard errors for the estimated transition probabilities. The mean standard errors averaged across the regions are given in each second row of small, italic numbers in Table 2. The mean standard error across all regions for all elements on the diagonal is 0.0254, for the off-diagonal elements it is 0.0013, for entry 0.0006 and for exit it is 0.0048.

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[21] As said above, only transition probabilities for which transitions are actually observed in the period of analysis are estimated. Probabilities for which the prior information from the FADN sample farms is zero are eliminated from the estimation.

Table 2. Average transition probabilities, standard deviation and mean standard errors across regions

Farm type		Variable[a]	Arable			Sheep and goats			Permanent crops			Dairy			Beef		
			Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Arable	Small	Mean probability	0.74837	0.09510	0.01157	0.00018	0.00016	0.00000	0.03101	0.00478	0.00036	0.00120	0.00008	0.00036	0.00042	0.00001	0.00000
		Standard deviation	*0.27041*	*0.20488*	*0.09678*	*0.00066*	*0.00139*	*0.00000*	*0.07112*	*0.02578*	*0.00304*	*0.00792*	*0.00039*	*0.00264*	*0.00258*	*0.00014*	*0.00000*
		Mean standard error	*0.02381*	*0.01168*	*0.00097*	*0.00026*	*0.00014*	*0.00001*	*0.00665*	*0.00142*	*0.00027*	*0.00019*	*0.00005*	*0.00012*	*0.00029*	*0.00002*	*0.00000*
	Medium	Mean probability	0.06515	0.76902	0.05340	0.00053	0.00004	0.00003	0.00835	0.01737	0.00154	0.00002	0.00004	0.00016	0.00073	0.00017	0.00004
		Standard deviation	*0.06049*	*0.13671*	*0.03831*	*0.00281*	*0.00029*	*0.00026*	*0.02346*	*0.03098*	*0.00438*	*0.00017*	*0.00028*	*0.00074*	*0.00472*	*0.00141*	*0.00030*
		Mean standard error	*0.01413*	*0.02599*	*0.01247*	*0.00016*	*0.00006*	*0.00002*	*0.00203*	*0.00415*	*0.00060*	*0.00003*	*0.00004*	*0.00006*	*0.00018*	*0.00010*	*0.00005*
	Large	Mean probability	0.01213	0.07376	0.80857	0.00192	0.00065	0.00037	0.00101	0.00555	0.02670	0.00000	0.00036	0.00005	0.00150	0.00019	0.00034
		Standard deviation	*0.08697*	*0.07216*	*0.16227*	*0.01711*	*0.00356*	*0.00309*	*0.00931*	*0.01785*	*0.10278*	*0.00000*	*0.00322*	*0.00027*	*0.01311*	*0.00112*	*0.00201*
		Mean standard error	*0.00081*	*0.01194*	*0.02241*	*0.00040*	*0.00014*	*0.00018*	*0.00008*	*0.00087*	*0.00441*	*0.00000*	*0.00003*	*0.00003*	*0.00018*	*0.00004*	*0.00012*
Sheep and goats	Small	Mean probability	0.00553	0.00048	0.00007	0.75911	0.05812	0.00091	0.00135	0.00003	0.00002	0.01236	0.00455	0.00004	0.02298	0.00365	0.00000
		Standard deviation	*0.01598*	*0.00225*	*0.00047*	*0.25181*	*0.14091*	*0.00685*	*0.00695*	*0.00023*	*0.00019*	*0.06500*	*0.02511*	*0.00041*	*0.05804*	*0.03041*	*0.00000*
		Mean standard error	*0.00128*	*0.00023*	*0.00014*	*0.02798*	*0.01169*	*0.00072*	*0.00020*	*0.00003*	*0.00003*	*0.00230*	*0.00075*	*0.00000*	*0.00475*	*0.00107*	*0.00000*
	Medium	Mean probability	0.00580	0.00223	0.00028	0.06728	0.69046	0.02637	0.00052	0.00004	0.00019	0.01447	0.02790	0.00718	0.00640	0.02997	0.00493
		Standard deviation	*0.04744*	*0.01674*	*0.00127*	*0.10905*	*0.26557*	*0.05287*	*0.00524*	*0.00039*	*0.00147*	*0.05652*	*0.13847*	*0.05275*	*0.02320*	*0.08312*	*0.03172*
		Mean standard error	*0.00075*	*0.00024*	*0.00009*	*0.01303*	*0.03320*	*0.00959*	*0.00012*	*0.00001*	*0.00002*	*0.00125*	*0.00226*	*0.00028*	*0.00110*	*0.00505*	*0.00098*
	Large	Mean probability	0.00100	0.00006	0.00010	0.00019	0.07362	0.70613	0.00000	0.00000	0.00005	0.00000	0.00463	0.04092	0.00022	0.01102	0.02700
		Standard deviation	*0.00915*	*0.00059*	*0.00100*	*0.00106*	*0.12717*	*0.31182*	*0.00000*	*0.00000*	*0.00046*	*0.00000*	*0.03362*	*0.15442*	*0.00219*	*0.06303*	*0.07556*
		Mean standard error	*0.00006*	*0.00001*	*0.00003*	*0.00004*	*0.01077*	*0.02547*	*0.00000*	*0.00000*	*0.00001*	*0.00000*	*0.00054*	*0.00251*	*0.00006*	*0.00101*	*0.00353*
Permanent crops	Small	Mean probability	0.02439	0.00451	0.00055	0.00031	0.00000	0.00000	0.84724	0.05888	0.01424	0.00005	0.00003	0.00000	0.00000	0.00003	0.00000
		Standard deviation	*0.04176*	*0.01895*	*0.00413*	*0.00176*	*0.00000*	*0.00000*	*0.21561*	*0.15569*	*0.07601*	*0.00037*	*0.00030*	*0.00002*	*0.00000*	*0.00034*	*0.00000*
		Mean standard error	*0.00541*	*0.00146*	*0.00018*	*0.00015*	*0.00001*	*0.00000*	*0.02150*	*0.00943*	*0.00233*	*0.00003*	*0.00001*	*0.00001*	*0.00004*	*0.00002*	*0.00001*
	Medium	Mean probability	0.00739	0.01642	0.01462	0.00002	0.00003	0.00000	0.04906	0.81090	0.06232	0.00002	0.00000	0.00000	0.00004	0.00000	0.00000
		Standard deviation	*0.01997*	*0.02465*	*0.10145*	*0.00019*	*0.00018*	*0.00000*	*0.12324*	*0.20897*	*0.11748*	*0.00019*	*0.00000*	*0.00000*	*0.00044*	*0.00000*	*0.00000*
		Mean standard error	*0.00176*	*0.00376*	*0.00131*	*0.00000*	*0.00004*	*0.00000*	*0.00782*	*0.02314*	*0.01091*	*0.00002*	*0.00000*	*0.00000*	*0.00002*	*0.00000*	*0.00000*
	Large	Mean probability	0.00201	0.00482	0.02328	0.00014	0.00005	0.00001	0.00714	0.05203	0.88462	0.00001	0.00000	0.00000	0.00057	0.00010	0.00009
		Standard deviation	*0.00967*	*0.01235*	*0.09933*	*0.00101*	*0.00045*	*0.00015*	*0.02450*	*0.06723*	*0.13408*	*0.00007*	*0.00000*	*0.00000*	*0.00571*	*0.00105*	*0.00088*
		Mean standard error	*0.00036*	*0.00079*	*0.00346*	*0.00013*	*0.00001*	*0.00002*	*0.00083*	*0.00867*	*0.01561*	*0.00001*	*0.00000*	*0.00000*	*0.00022*	*0.00001*	*0.00001*
Dairy	Small	Mean probability	0.01415	0.00054	0.00001	0.01452	0.00029	0.00000	0.00002	0.00002	0.00000	0.73161	0.10252	0.00017	0.03435	0.00271	0.00000
		Standard deviation	*0.04414*	*0.00317*	*0.00014*	*0.06874*	*0.00152*	*0.00000*	*0.00016*	*0.00021*	*0.00000*	*0.23466*	*0.17679*	*0.00090*	*0.06387*	*0.01266*	*0.00000*
		Mean standard error	*0.00157*	*0.00016*	*0.00001*	*0.00273*	*0.00014*	*0.00000*	*0.00000*	*0.00006*	*0.00000*	*0.02065*	*0.01235*	*0.00021*	*0.00742*	*0.00123*	*0.00000*
	Medium	Mean probability	0.00432	0.00243	0.00044	0.00134	0.00717	0.00011	0.00003	0.00001	0.00000	0.04061	0.76627	0.06724	0.01465	0.02419	0.00300
		Standard deviation	*0.01317*	*0.01395*	*0.00361*	*0.00558*	*0.03109*	*0.00065*	*0.00028*	*0.00012*	*0.00000*	*0.10580*	*0.15300*	*0.06976*	*0.04193*	*0.03234*	*0.00726*
		Mean standard error	*0.00104*	*0.00063*	*0.00009*	*0.00022*	*0.00182*	*0.00011*	*0.00000*	*0.00001*	*0.00000*	*0.00742*	*0.02661*	*0.01550*	*0.00377*	*0.00704*	*0.00191*
	Large	Mean probability	0.00076	0.00100	0.00079	0.00001	0.00148	0.00428	0.00597	0.00000	0.00034	0.00096	0.04558	0.86302	0.00012	0.00444	0.01760
		Standard deviation	*0.00453*	*0.00394*	*0.00289*	*0.00011*	*0.01113*	*0.02290*	*0.05862*	*0.00000*	*0.00339*	*0.00611*	*0.06520*	*0.11136*	*0.00046*	*0.01086*	*0.03116*
		Mean standard error	*0.00008*	*0.00046*	*0.00036*	*0.00001*	*0.00020*	*0.00135*	*0.00048*	*0.00000*	*0.00012*	*0.00012*	*0.00951*	*0.02100*	*0.00021*	*0.00140*	*0.00688*
Beef	Small	Mean probability	0.02644	0.00038	0.00019	0.03902	0.00392	0.00024	0.00028	0.00000	0.00000	0.05152	0.00560	0.00054	0.70930	0.06005	0.00041
		Standard deviation	*0.08335*	*0.00269*	*0.00195*	*0.09612*	*0.03303*	*0.00243*	*0.00227*	*0.00000*	*0.00000*	*0.11605*	*0.01414*	*0.00514*	*0.24281*	*0.12516*	*0.00326*
		Mean standard error	*0.00289*	*0.00009*	*0.00005*	*0.00746*	*0.00071*	*0.00030*	*0.00003*	*0.00000*	*0.00000*	*0.00583*	*0.00145*	*0.00019*	*0.03014*	*0.01089*	*0.00022*
	Medium	Mean probability	0.00449	0.00277	0.00055	0.00298	0.01687	0.00085	0.00134	0.00000	0.00008	0.00762	0.07926	0.00693	0.05392	0.67989	0.03912
		Standard deviation	*0.02349*	*0.01157*	*0.00316*	*0.01173*	*0.03465*	*0.00347*	*0.01344*	*0.00000*	*0.00078*	*0.02815*	*0.11320*	*0.01382*	*0.05931*	*0.19867*	*0.04728*
		Mean standard error	*0.00033*	*0.00057*	*0.00008*	*0.00039*	*0.00375*	*0.00028*	*0.00006*	*0.00000*	*0.00002*	*0.00061*	*0.00942*	*0.00114*	*0.01050*	*0.02949*	*0.00870*
	Large	Mean probability	0.00104	0.00324	0.00044	0.00000	0.00562	0.01047	0.00000	0.00000	0.00000	0.00000	0.03608	0.10440	0.00310	0.07996	0.64312
		Standard deviation	*0.01042*	*0.02346*	*0.00220*	*0.00000*	*0.02952*	*0.03031*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.14722*	*0.14471*	*0.02505*	*0.16799*	*0.28929*
		Mean standard error	*0.00002*	*0.00025*	*0.00016*	*0.00000*	*0.00064*	*0.00280*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00221*	*0.01158*	*0.00024*	*0.00761*	*0.02819*
Pigs	Small	Mean probability	0.00387	0.00014	0.00000	0.00382	0.00000	0.00000	0.00433	0.00000	0.00947	0.00010	0.00000	0.00000	0.00000	0.00000	0.00000
		Standard deviation	*0.02839*	*0.00102*	*0.00000*	*0.03081*	*0.00000*	*0.00000*	*0.04354*	*0.00000*	*0.09515*	*0.00101*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
		Mean standard error	*0.00054*	*0.00002*	*0.00000*	*0.00039*	*0.00000*	*0.00000*	*0.00036*	*0.00000*	*0.00002*	*0.00002*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
	Medium	Mean probability	0.01195	0.00032	0.00023	0.00244	0.00000	0.00030	0.00062	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		Standard deviation	*0.09984*	*0.00321*	*0.00199*	*0.01922*	*0.00000*	*0.00301*	*0.00509*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
		Mean standard error	*0.00026*	*0.00006*	*0.00008*	*0.00041*	*0.00000*	*0.00007*	*0.00012*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
	Large	Mean probability	0.00217	0.00121	0.00083	0.00000	0.00020	0.00000	0.00044	0.00030	0.00036	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		Standard deviation	*0.01812*	*0.00516*	*0.00463*	*0.00000*	*0.00198*	*0.00000*	*0.00331*	*0.00301*	*0.00268*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
		Mean standard error	*0.00038*	*0.00040*	*0.00017*	*0.00000*	*0.00004*	*0.00000*	*0.00009*	*0.00005*	*0.00007*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
Poultry	Small	Mean probability	0.00357	0.00097	0.00000	0.00000	0.00000	0.00000	0.00265	0.00108	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		Standard deviation	*0.02756*	*0.00726*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.01879*	*0.01081*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
		Mean standard error	*0.00054*	*0.00019*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00031*	*0.00021*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
	Medium	Mean probability	0.00529	0.00000	0.00000	0.00000	0.00000	0.00000	0.00138	0.00000	0.00000	0.00117	0.00000	0.00000	0.00000	0.00000	0.00000
		Standard deviation	*0.03250*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.01144*	*0.00000*	*0.00000*	*0.01176*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
		Mean standard error	*0.00070*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00023*	*0.00000*	*0.00000*	*0.00022*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
	Large	Mean probability	0.00960	0.00566	0.00168	0.00000	0.00000	0.00000	0.00000	0.00284	0.00052	0.00000	0.00000	0.00130	0.00000	0.00005	0.00966
		Standard deviation	*0.03912*	*0.02646*	*0.01379*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.01559*	*0.00523*	*0.00000*	*0.00000*	*0.01231*	*0.00000*	*0.00053*	*0.09711*
		Mean standard error	*0.00179*	*0.00076*	*0.00025*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00043*	*0.00008*	*0.00000*	*0.00000*	*0.00012*	*0.00000*	*0.00001*	*0.00000*
Mixed farms	Small	Mean probability	0.12202	0.02319	0.00033	0.02293	0.00345	0.00000	0.01380	0.00197	0.00000	0.00828	0.00174	0.00000	0.04921	0.00159	0.00006
		Standard deviation	*0.12567*	*0.10136*	*0.00162*	*0.05054*	*0.01508*	*0.00000*	*0.03694*	*0.01183*	*0.00000*	*0.02362*	*0.00864*	*0.00000*	*0.12523*	*0.00618*	*0.00062*
		Mean standard error	*0.01623*	*0.00326*	*0.00014*	*0.00493*	*0.00107*	*0.00000*	*0.00198*	*0.00056*	*0.00000*	*0.00180*	*0.00061*	*0.00000*	*0.00890*	*0.00102*	*0.00006*
	Medium	Mean probability	0.01839	0.05962	0.00844	0.00663	0.01863	0.00143	0.00109	0.00923	0.00125	0.01125	0.01844	0.00272	0.00949	0.02225	0.00238
		Standard deviation	*0.03173*	*0.05606*	*0.01324*	*0.01616*	*0.02826*	*0.00513*	*0.00346*	*0.04484*	*0.00526*	*0.07075*	*0.03684*	*0.00805*	*0.04485*	*0.02805*	*0.00812*
		Mean standard error	*0.00333*	*0.01050*	*0.00213*	*0.00108*	*0.00464*	*0.00068*	*0.00011*	*0.00178*	*0.00034*	*0.00164*	*0.00274*	*0.00075*	*0.00192*	*0.00583*	*0.00110*
	Large	Mean probability	0.00142	0.01889	0.05587	0.00000	0.01152	0.01680	0.00006	0.00824	0.01655	0.00003	0.00490	0.02447	0.00003	0.00237	0.01552
		Standard deviation	*0.00732*	*0.05446*	*0.05450*	*0.00000*	*0.04062*	*0.03193*	*0.00059*	*0.05144*	*0.08623*	*0.00026*	*0.02766*	*0.03930*	*0.00032*	*0.00836*	*0.03290*
		Mean standard error	*0.00014*	*0.00304*	*0.00905*	*0.00000*	*0.00171*	*0.00327*	*0.00000*	*0.00092*	*0.00227*	*0.00001*	*0.00099*	*0.00425*	*0.00002*	*0.00065*	*0.00488*
Mixed livestock	Small	Mean probability	0.03966	0.00524	0.00000	0.03393	0.00309	0.00000	0.00066	0.00018	0.00039	0.02318	0.01057	0.00000	0.03660	0.00132	0.00000
		Standard deviation	*0.10263*	*0.03873*	*0.00000*	*0.07996*	*0.01537*	*0.00000*	*0.00448*	*0.00135*	*0.00387*	*0.10405*	*0.09574*	*0.00000*	*0.12196*	*0.00487*	*0.00000*
		Mean standard error	*0.00340*	*0.00066*	*0.00000*	*0.00510*	*0.00078*	*0.00000*	*0.00012*	*0.00006*	*0.00006*	*0.00173*	*0.00040*	*0.00000*	*0.00497*	*0.00056*	*0.00000*
	Medium	Mean probability	0.00686	0.02550	0.00323	0.00843	0.02591	0.00120	0.00083	0.00000	0.00025	0.00174	0.03660	0.00358	0.00328	0.05538	0.00062
		Standard deviation	*0.02051*	*0.10876*	*0.01610*	*0.02242*	*0.04924*	*0.00425*	*0.00633*	*0.00000*	*0.00254*	*0.00583*	*0.08523*	*0.01249*	*0.01323*	*0.15711*	*0.00356*
		Mean standard error	*0.00063*	*0.00154*	*0.00051*	*0.00120*	*0.00347*	*0.00032*	*0.00006*	*0.00000*	*0.00004*	*0.00016*	*0.00366*	*0.00045*	*0.00041*	*0.00539*	*0.00013*
	Large	Mean probability	0.00000	0.00583	0.01207	0.00000	0.00332	0.02106	0.00000	0.00000	0.00008	0.00000	0.00158	0.03835	0.00000	0.00738	0.03386
		Standard deviation	*0.00000*	*0.02471*	*0.04035*	*0.00000*	*0.01906*	*0.06948*	*0.00000*	*0.00000*	*0.00083*	*0.00000*	*0.00659*	*0.07481*	*0.00000*	*0.04143*	*0.09193*
		Mean standard error	*0.00000*	*0.00087*	*0.00130*	*0.00000*	*0.00019*	*0.00368*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00021*	*0.00559*	*0.00000*	*0.00062*	*0.00445*
Horticulture	Small	Mean probability	0.06812	0.00331	0.00154	0.00027	0.00000	0.00001	0.00300	0.00170	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		Standard deviation	*0.14689*	*0.01555*	*0.01547*	*0.00276*	*0.00000*	*0.00005*	*0.01576*	*0.01629*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00002*	*0.00000*	*0.00000*
		Mean standard error	*0.00989*	*0.00057*	*0.00037*	*0.00006*	*0.00000*	*0.00005*	*0.00058*	*0.00059*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00003*	*0.00000*	*0.00000*
	Medium	Mean probability	0.05274	0.03275	0.00288	0.00051	0.00000	0.00000	0.00785	0.00033	0.00014	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
		Standard deviation	*0.14588*	*0.08108*	*0.01471*	*0.00490*	*0.00000*	*0.00000*	*0.03529*	*0.00241*	*0.00099*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
		Mean standard error	*0.00574*	*0.00510*	*0.00062*	*0.00009*	*0.00000*	*0.00000*	*0.00190*	*0.00021*	*0.00008*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
	Large	Mean probability	0.01017	0.04321	0.05253	0.00000	0.00000	0.00000	0.00420	0.00714	0.00205	0.00000	0.00004	0.00024	0.00000	0.00050	0.00000
		Standard deviation	*0.03160*	*0.13220*	*0.15597*	*0.00000*	*0.00000*	*0.00000*	*0.01768*	*0.06131*	*0.01810*	*0.00000*	*0.00027*	*0.00202*	*0.00000*	*0.00492*	*0.00000*
		Mean standard error	*0.00184*	*0.00457*	*0.00556*	*0.00000*	*0.00000*	*0.00000*	*0.00078*	*0.00043*	*0.00049*	*0.00000*	*0.00002*	*0.00004*	*0.00000*	*0.00010*	*0.00000*
Entry		Mean probability	0.00052	0.00071	0.00040	0.00060	0.00133	0.00076	0.00049	0.00049	0.00077	0.00038	0.00046	0.00021	0.00074	0.00092	0.00059
		Standard deviation	*0.00245*	*0.00180*	*0.00124*	*0.00163*	*0.00311*	*0.00178*	*0.00234*	*0.00130*	*0.00217*	*0.00209*	*0.00182*	*0.00055*	*0.00240*	*0.00218*	*0.00129*
		Mean standard error	*0.00044*	*0.00043*	*0.00037*	*0.00066*	*0.00086*	*0.00064*	*0.00043*	*0.00043*	*0.00049*	*0.00028*	*0.00032*	*0.00020*	*0.00050*	*0.00055*	*0.00038*

Farm type		Variable[a]	Pigs			Poultry			Mixed farms			Mixed livestock			Horticulture			Exit
			Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	
Arable	Small	Mean probability	0.00003	0.00017	0.00002	0.00001	0.00017	0.00068	0.02901	0.02176	0.00042	0.00373	0.00001	0.00000	0.00618	0.00395	0.00218	0.03810
		Standard deviation	0.00021	0.00158	0.00011	0.00012	0.00149	0.00669	0.10062	0.12245	0.00413	0.02335	0.00012	0.00000	0.02055	0.02400	0.01117	0.05677
		Mean standard error	0.00007	0.00009	0.00006	0.00002	0.00021	0.00026	0.00517	0.00228	0.00008	0.00163	0.00004	0.00001	0.00197	0.00149	0.00110	0.00829
	Medium	Mean probability	0.00002	0.00002	0.00009	0.00000	0.00008	0.00010	0.00375	0.02872	0.00376	0.00052	0.00062	0.00020	0.00098	0.00472	0.00802	0.03179
		Standard deviation	0.00022	0.00017	0.00041	0.00000	0.00083	0.00079	0.01145	0.07685	0.00722	0.00240	0.00200	0.00092	0.00424	0.01312	0.04004	0.07307
		Mean standard error	0.00014	0.00001	0.00014	0.00000	0.00002	0.00013	0.00112	0.00575	0.00140	0.00025	0.00040	0.00012	0.00028	0.00174	0.00192	0.00574
	Large	Mean probability	0.00000	0.00009	0.00045	0.00000	0.00000	0.00014	0.00019	0.00353	0.02386	0.00004	0.00047	0.00099	0.00000	0.00265	0.01022	0.02427
		Standard deviation	0.00000	0.00095	0.00381	0.00000	0.00000	0.00101	0.00106	0.00791	0.03621	0.00044	0.00403	0.00281	0.00000	0.01386	0.03856	0.04950
		Mean standard error	0.00002	0.00003	0.00016	0.00000	0.00000	0.00011	0.00010	0.00121	0.00617	0.00001	0.00009	0.00074	0.00001	0.00074	0.00316	0.00458
Sheep and goats	Small	Mean probability	0.00001	0.00000	0.00001	0.00008	0.00000	0.00000	0.06075	0.01291	0.00000	0.01637	0.00158	0.00000	0.00042	0.00069	0.00020	0.03781
		Standard deviation	0.00005	0.00000	0.00008	0.00077	0.00000	0.00000	0.13487	0.06161	0.00000	0.04141	0.00630	0.00000	0.00417	0.00498	0.00194	0.06570
		Mean standard error	0.00009	0.00000	0.00001	0.00005	0.00000	0.00000	0.00851	0.00185	0.00001	0.00458	0.00071	0.00000	0.00007	0.00048	0.00007	0.00707
	Medium	Mean probability	0.00000	0.00000	0.00003	0.00000	0.00000	0.00000	0.00680	0.05624	0.00801	0.00231	0.01140	0.00114	0.00000	0.00000	0.00000	0.03005
		Standard deviation	0.00000	0.00000	0.00031	0.00000	0.00000	0.00000	0.02618	0.15546	0.02605	0.01109	0.03096	0.00707	0.00000	0.00000	0.00000	0.03784
		Mean standard error	0.00000	0.00000	0.00001	0.00000	0.00000	0.00000	0.00093	0.00561	0.00250	0.00036	0.00253	0.00047	0.00000	0.00000	0.00000	0.00462
	Large	Mean probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00460	0.07709	0.00000	0.00089	0.02486	0.00000	0.00000	0.00000	0.02762
		Standard deviation	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.02541	0.20280	0.00000	0.00673	0.08669	0.00000	0.00000	0.00000	0.06860
		Mean standard error	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00078	0.00534	0.00000	0.00030	0.00447	0.00000	0.00000	0.00000	0.00372
Permanent crops	Small	Mean probability	0.00000	0.00001	0.00004	0.00002	0.00000	0.00000	0.00182	0.00009	0.00000	0.00003	0.00000	0.00000	0.00849	0.00025	0.00151	0.03752
		Standard deviation	0.00000	0.00009	0.00034	0.00019	0.00000	0.00000	0.00516	0.00042	0.00001	0.00029	0.00000	0.00000	0.07785	0.00116	0.01448	0.08231
		Mean standard error	0.00000	0.00009	0.00005	0.00002	0.00000	0.00000	0.00080	0.00018	0.00000	0.00006	0.00000	0.00000	0.00149	0.00020	0.00038	0.00806
	Medium	Mean probability	0.00000	0.00000	0.00003	0.00000	0.00000	0.00003	0.00106	0.00720	0.00016	0.00009	0.00005	0.00000	0.00004	0.00133	0.00363	0.02554
		Standard deviation	0.00000	0.00000	0.00033	0.00000	0.00000	0.00024	0.00430	0.06062	0.00058	0.00058	0.00040	0.00000	0.00033	0.01325	0.02524	0.05320
		Mean standard error	0.00000	0.00000	0.00003	0.00000	0.00000	0.00008	0.00023	0.00177	0.00027	0.00007	0.00002	0.00003	0.00010	0.00058	0.00053	0.00463
	Large	Mean probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00021	0.00000	0.00046	0.00185	0.00000	0.00000	0.00001	0.00000	0.00053	0.00057	0.02149
		Standard deviation	0.00000	0.00000	0.00000	0.00000	0.00000	0.00151	0.00000	0.00293	0.00936	0.00000	0.00000	0.00010	0.00000	0.00332	0.00255	0.02406
		Mean standard error	0.00000	0.00000	0.00000	0.00000	0.00000	0.00012	0.00000	0.00014	0.00078	0.00000	0.00000	0.00001	0.00000	0.00027	0.00036	0.00437
Dairy	Small	Mean probability	0.00004	0.00000	0.00000	0.00000	0.00000	0.00000	0.03987	0.01287	0.00000	0.01307	0.00243	0.00000	0.00000	0.00000	0.00000	0.03081
		Standard deviation	0.00035	0.00000	0.00000	0.00000	0.00000	0.00000	0.06954	0.05698	0.00000	0.02918	0.01267	0.00000	0.00000	0.00000	0.00000	0.04232
		Mean standard error	0.00009	0.00000	0.00000	0.00000	0.00000	0.00000	0.00501	0.00236	0.00000	0.00243	0.00048	0.00000	0.00000	0.00000	0.00000	0.00472
	Medium	Mean probability	0.00013	0.00003	0.00004	0.00000	0.00000	0.00000	0.00575	0.01706	0.00291	0.00107	0.00555	0.00222	0.00067	0.00000	0.00000	0.03277
		Standard deviation	0.00132	0.00028	0.00042	0.00000	0.00000	0.00000	0.01784	0.03045	0.00773	0.00367	0.01123	0.00871	0.00674	0.00000	0.00000	0.05024
		Mean standard error	0.00004	0.00001	0.00002	0.00000	0.00000	0.00001	0.00140	0.00344	0.00115	0.00052	0.00157	0.00100	0.00007	0.00000	0.00000	0.00602
	Large	Mean probability	0.00000	0.00000	0.00018	0.00000	0.00000	0.00004	0.00006	0.00318	0.02141	0.00000	0.00099	0.00570	0.00000	0.00012	0.00000	0.02197
		Standard deviation	0.00000	0.00000	0.00128	0.00000	0.00000	0.00028	0.00037	0.01094	0.04194	0.00000	0.00940	0.02153	0.00000	0.00119	0.00002	0.01910
		Mean standard error	0.00000	0.00000	0.00010	0.00000	0.00000	0.00005	0.00004	0.00089	0.00549	0.00000	0.00028	0.00268	0.00000	0.00002	0.00003	0.00490
Beef	Small	Mean probability	0.00009	0.00000	0.00000	0.00001	0.00000	0.00000	0.05004	0.00805	0.00009	0.01676	0.00062	0.00000	0.00122	0.00000	0.00020	0.02501
		Standard deviation	0.00094	0.00000	0.00000	0.00015	0.00000	0.00000	0.07496	0.02374	0.00091	0.04090	0.00293	0.00000	0.01223	0.00000	0.00200	0.02239
		Mean standard error	0.00001	0.00000	0.00000	0.00003	0.00000	0.00000	0.00770	0.00205	0.00002	0.00343	0.00026	0.00000	0.00070	0.00000	0.00002	0.00423
	Medium	Mean probability	0.00000	0.00005	0.00000	0.00000	0.00000	0.00002	0.00815	0.04587	0.00560	0.00201	0.01752	0.00114	0.00000	0.00000	0.00000	0.02297
		Standard deviation	0.00000	0.00053	0.00000	0.00000	0.00000	0.00017	0.02041	0.06309	0.01941	0.00957	0.04598	0.00394	0.00000	0.00000	0.00000	0.02056
		Mean standard error	0.00000	0.00001	0.00000	0.00000	0.00000	0.00004	0.00151	0.00759	0.00113	0.00022	0.00343	0.00031	0.00000	0.00000	0.00000	0.00288
	Large	Mean probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00482	0.07341	0.00000	0.00176	0.01160	0.00000	0.00000	0.00001	0.02094
		Standard deviation	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.01875	0.13750	0.00000	0.01085	0.02781	0.00000	0.00000	0.00006	0.01961
		Mean standard error	0.00000	0.00000	0.00000	0.00000	0.00000	0.00001	0.00000	0.00058	0.01035	0.00000	0.00036	0.00253	0.00000	0.00000	0.00003	0.00228
Pigs	Small	Mean probability	0.77668	0.07565	0.01431	0.00016	0.00000	0.00000	0.04374	0.00690	0.00000	0.03296	0.00400	0.00000	0.00000	0.00000	0.00250	0.02138
		Standard deviation	0.32612	0.20860	0.09911	0.00141	0.00000	0.00000	0.14852	0.03817	0.00000	0.13079	0.02283	0.00000	0.00000	0.00000	0.02512	0.06383
		Mean standard error	0.01946	0.00928	0.00158	0.00016	0.00000	0.00000	0.00335	0.00080	0.00000	0.00224	0.00077	0.00000	0.00000	0.00000	0.00026	0.00360
	Medium	Mean probability	0.04688	0.72055	0.08267	0.00000	0.00050	0.00030	0.01601	0.03685	0.00331	0.00169	0.02587	0.01116	0.00000	0.00000	0.00000	0.03835
		Standard deviation	0.14195	0.28549	0.12958	0.00000	0.00329	0.00283	0.07322	0.09377	0.01144	0.00852	0.09910	0.09768	0.00000	0.00000	0.00000	0.10426
		Mean standard error	0.01023	0.02800	0.01502	0.00000	0.00037	0.00010	0.00126	0.00437	0.00052	0.00040	0.00264	0.00023	0.00000	0.00000	0.00000	0.00489
	Large	Mean probability	0.00028	0.05782	0.78756	0.00000	0.00000	0.00087	0.00355	0.00783	0.05976	0.00000	0.00205	0.04407	0.00000	0.00000	0.00001	0.03069
		Standard deviation	0.00193	0.16074	0.27597	0.00000	0.00000	0.00538	0.03572	0.02444	0.16456	0.00000	0.01185	0.14577	0.00000	0.00000	0.00007	0.08916
		Mean standard error	0.00017	0.01035	0.02371	0.00000	0.00000	0.00037	0.00039	0.00166	0.00668	0.00000	0.00066	0.00564	0.00000	0.00000	0.00000	0.00507
Poultry	Small	Mean probability	0.00204	0.00000	0.00000	0.73881	0.10334	0.03470	0.03253	0.01045	0.00000	0.01806	0.00124	0.00000	0.00000	0.00193	0.00135	0.04728
		Standard deviation	0.02049	0.00000	0.00000	0.34792	0.23229	0.13698	0.15418	0.09960	0.00000	0.08502	0.01242	0.00000	0.00000	0.01938	0.01360	0.12865
		Mean standard error	0.00042	0.00000	0.00000	0.02347	0.01304	0.00521	0.00271	0.00010	0.00000	0.00245	0.00026	0.00000	0.00000	0.00040	0.00027	0.00761
	Medium	Mean probability	0.00000	0.00030	0.00174	0.04774	0.72272	0.09112	0.01458	0.04108	0.00373	0.01903	0.00529	0.00636	0.00000	0.00000	0.00000	0.03848
		Standard deviation	0.00000	0.00260	0.01001	0.13222	0.32126	0.19287	0.08707	0.13720	0.03190	0.09124	0.02763	0.06391	0.00000	0.00000	0.00000	0.08257
		Mean standard error	0.00000	0.00012	0.00031	0.01153	0.03073	0.01311	0.00176	0.00509	0.00030	0.00270	0.00105	0.00101	0.00000	0.00000	0.00000	0.00726
	Large	Mean probability	0.00000	0.00000	0.00474	0.00392	0.02579	0.82370	0.00418	0.00889	0.04294	0.00031	0.00473	0.02944	0.00000	0.00036	0.00000	0.01970
		Standard deviation	0.00000	0.00000	0.02114	0.02023	0.07025	0.24017	0.02785	0.03283	0.13492	0.00314	0.01763	0.11633	0.00000	0.00357	0.00000	0.03403
		Mean standard error	0.00000	0.00000	0.00068	0.00236	0.00773	0.02108	0.00084	0.00219	0.00411	0.00005	0.00123	0.00407	0.00000	0.00009	0.00000	0.00343
Mixed farms	Small	Mean probability	0.00280	0.00099	0.00006	0.00091	0.00157	0.00046	0.62464	0.06415	0.00016	0.01735	0.00294	0.00000	0.00050	0.00018	0.00005	0.03467
		Standard deviation	0.01335	0.00454	0.00060	0.00512	0.00710	0.00335	0.24241	0.12781	0.00113	0.03168	0.00701	0.00000	0.00272	0.00119	0.00053	0.10097
		Mean standard error	0.00143	0.00054	0.00001	0.00059	0.00084	0.00026	0.02794	0.00950	0.00007	0.00489	0.00098	0.00000	0.00014	0.00014	0.00001	0.00308
	Medium	Mean probability	0.00002	0.00544	0.00373	0.00133	0.00246	0.00126	0.03033	0.65745	0.05178	0.00299	0.02011	0.00200	0.00117	0.00298	0.00035	0.02537
		Standard deviation	0.00017	0.01543	0.00972	0.00829	0.00918	0.00640	0.03248	0.14048	0.06757	0.00964	0.02853	0.00447	0.00950	0.02789	0.00213	0.02562
		Mean standard error	0.00006	0.00201	0.00155	0.00089	0.00179	0.00102	0.00587	0.02995	0.01110	0.00064	0.00559	0.00112	0.00019	0.00084	0.00028	0.00284
	Large	Mean probability	0.00047	0.00048	0.01422	0.00000	0.00064	0.00264	0.00088	0.04667	0.71621	0.00000	0.00212	0.01803	0.00000	0.00066	0.00039	0.01991
		Standard deviation	0.00475	0.00410	0.03548	0.00000	0.00545	0.00772	0.00882	0.10768	0.17894	0.00000	0.00755	0.02706	0.00000	0.00523	0.00273	0.01807
		Mean standard error	0.00005	0.00012	0.00408	0.00000	0.00058	0.00125	0.00009	0.00577	0.02778	0.00000	0.00065	0.00620	0.00000	0.00020	0.00015	0.00265
Mixed livestock	Small	Mean probability	0.00496	0.00563	0.00000	0.00360	0.00062	0.00040	0.12119	0.00502	0.00032	0.64949	0.03038	0.00000	0.00004	0.00000	0.00000	0.02352
		Standard deviation	0.01933	0.02656	0.00000	0.02323	0.00435	0.00347	0.17770	0.01627	0.00318	0.31477	0.10596	0.00000	0.00042	0.00000	0.00000	0.03882
		Mean standard error	0.00198	0.00102	0.00000	0.00127	0.00068	0.00018	0.01100	0.00142	0.00004	0.02512	0.00419	0.00000	0.00002	0.00000	0.00000	0.00343
	Medium	Mean probability	0.00074	0.01312	0.00925	0.00013	0.00329	0.00624	0.01597	0.11133	0.00772	0.02521	0.57442	0.03683	0.00000	0.00000	0.00005	0.02228
		Standard deviation	0.00681	0.03025	0.05391	0.00116	0.01793	0.03748	0.05616	0.16404	0.01916	0.06417	0.27820	0.06466	0.00000	0.00000	0.00051	0.02211
		Mean standard error	0.00006	0.00386	0.00173	0.00020	0.00152	0.00220	0.00143	0.01142	0.00141	0.00363	0.02983	0.00733	0.00000	0.00000	0.00002	0.00212
	Large	Mean probability	0.00000	0.00124	0.03380	0.00000	0.00002	0.00245	0.00000	0.02339	0.09275	0.00000	0.02983	0.66097	0.00000	0.00000	0.00397	0.02804
		Standard deviation	0.00000	0.00919	0.08619	0.00000	0.00017	0.00752	0.00000	0.10693	0.12455	0.00000	0.09118	0.25647	0.00000	0.00000	0.03974	0.05003
		Mean standard error	0.00000	0.00017	0.00563	0.00000	0.00001	0.00108	0.00000	0.00147	0.01190	0.00000	0.00460	0.03282	0.00000	0.00000	0.00013	0.00413
Horticulture	Small	Mean probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00552	0.00000	0.00000	0.00036	0.00000	0.00000	0.78399	0.08726	0.02576	0.01917
		Standard deviation	0.00000	0.00000	0.00000	0.00000	0.00002	0.00000	0.04163	0.00000	0.00000	0.00338	0.00000	0.00000	0.25379	0.17208	0.10954	0.02628
		Mean standard error	0.00000	0.00000	0.00000	0.00000	0.00005	0.00001	0.00160	0.00000	0.00000	0.00007	0.00000	0.00000	0.02886	0.01446	0.00358	0.00395
	Medium	Mean probability	0.00008	0.00000	0.00000	0.00000	0.00000	0.00000	0.00032	0.00010	0.00026	0.00000	0.00000	0.00000	0.03395	0.75966	0.07424	0.03419
		Standard deviation	0.00076	0.00000	0.00000	0.00000	0.00000	0.00000	0.00256	0.00105	0.00260	0.00000	0.00000	0.00000	0.07206	0.22920	0.09388	0.08137
		Mean standard error	0.00014	0.00000	0.00000	0.00000	0.00000	0.00000	0.00006	0.00004	0.00007	0.00000	0.00000	0.00000	0.01019	0.03261	0.01869	0.00561
	Large	Mean probability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00045	0.00073	0.00215	0.00000	0.00000	0.00000	0.00839	0.05330	0.78281	0.03209
		Standard deviation	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00387	0.00552	0.01198	0.00000	0.00000	0.00000	0.05278	0.07813	0.24699	0.06559
		Mean standard error	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00006	0.00010	0.00068	0.00000	0.00000	0.00000	0.00148	0.01385	0.02675	0.00622
Entry		Mean probability	0.00015	0.00062	0.00073	0.00051	0.00057	0.00050	0.00032	0.00063	0.00057	0.00073	0.00042	0.00043	0.00075	0.00109	0.00082	0.98178
		Standard deviation	0.00049	0.00236	0.00165	0.00149	0.00123	0.00089	0.00149	0.00157	0.00183	0.00378	0.00105	0.00135	0.00248	0.00317	0.00202	0.01534
		Mean standard error	0.00026	0.00039	0.00063	0.00041	0.00046	0.00042	0.00036	0.00045	0.00037	0.00068	0.00037	0.00039	0.00071	0.00098	0.00067	0.00527

Source: Own calculation based on FADN data 1990-2005, a: all measures calculated across regions.

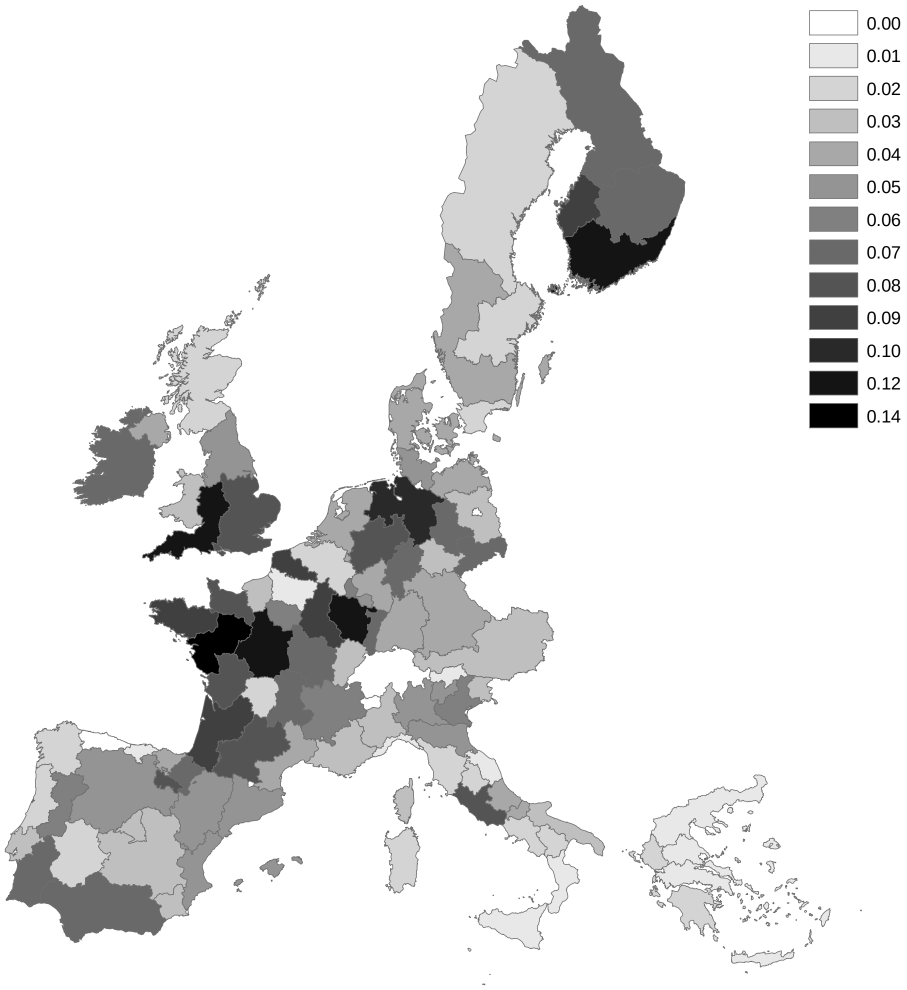
4.2 *Mobility indices*

In the following, we present a descriptive analysis of the mobility indices, restricting the attention to size and specialisation class changes as market entry and exit are already sufficiently considered in chapter 2.3 on the farm number development.

The overall mobility comprises all off-diagonal transition probabilities in the transition probability matrix, i.e. the likelihood for all possible farm type changes. It is the sum of the partial mobility indices. Overall mobility is very high (above the 90 per cent quantile of 0.3810) in many parts of Italy, especially in the North and in Portugal. It is high in Scandinavia, in West and North Spain, in West France, South England, and West Germany. In East Germany, the Netherlands, and partly in the North of France and of Spain farms are relatively unlikely to change their actual farm type (mobility index below the 10 per cent quantile of 0.1389). The median of the overall mobility index across regions is 0.2578. As the overall mobility gives a general indication of the structural volatility in a region but does not provide insight into the direction of structural change, it is neither shown nor further analysed in the paper.

The analysis of farm size changes distinguishes between size increases and size decline. Figure 2 shows the mobility to change to a larger size class per region.

Figure 2: Mobility for size increases 1990-2005 [index]



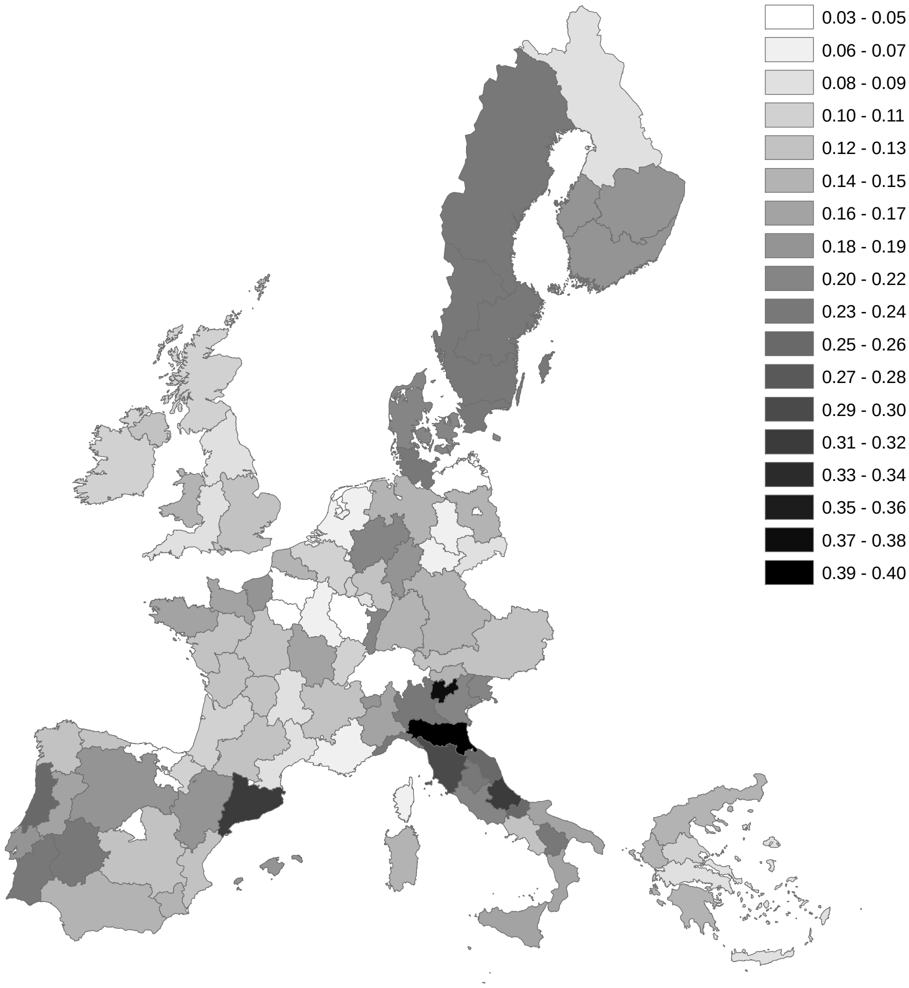
Source: Own calculation based on FADN data.

Increasing farm sizes are found in all European regions, though the mobility values for farm size increases are generally higher in the central part of the EU15. The median of the mobility to increase in size across regions is 0.0425. The probability to increase in size is very high (above the 90 per cent quantile of 0.0875) in Finland, Northwest Germany, Southern England and in large parts of France. In Southern Europe, especially Greece and South Italy, the mobility index is below the 10 per cent quantile of 0.0132 indicating that farms are less likely to increase in size in these regions.

Generally, the mobility values for a decline in farm size are much lower than the values for size increases. The median across the regions is 0.0301. Compared to farm size increases which take mainly place in the central part, declining farm sizes can be found at the border zones of the EU15. The countries with the highest mobility indices (above the 90 per cent quantile of 0.0659) for farm size decline are Portugal, Italy, Greece, and Finland. In Finland already high values of the mobility for size increases could be found. In the central part of the EU15, and here especially in Northern France and East Germany, farms are very unlikely to change to lower size classes (mobility index below the 10 per cent quantile of 0.0071). Surprisingly, farm size decline seems to take place mainly in regions which are already dominated by small scale farming. This effect might at least partly be due to the fact that many small farms are kept as hobby or part-time businesses in the Mediterranean countries (Lianos and Parliarou, 1986, Hoggart and Paniagua, 2001). In Portugal, Spain, Italy, Greece and Sweden, the mobility to decrease in size usually is higher than the mobility for size growth. In Finland, the mobility of size increases is higher.

Figure 3 shows the mobility index for specialisation class changes. Due to the high amount of specialisation classes, the share of specialisation class changes on the overall mobility is rather high in most regions. The median of the mobility index for specialisation changes across the regions is 0.1474.

Figure 3: Mobility to change the specialisation class 1990-2005 [index]



Source: Own calculation based on FADN data.

Farms are most likely to change their specialisation class in Italy, Portugal and West and North Spain (mobility index above the 90 per cent quantile of 0.2295). The share of the mobility for specialisation class changes of the overall mobility is highest in Italian regions (65 per cent compared to the European average share of specialisation class changes of 56 per cent). In order to answer the question to which farm types the farms change to, the transition probability matrices and regional farm type shares are analysed. Generally, specialisation changes are likely to happen between dairy and beef farming and various specialisation classes and the mixed and mixed livestock specialisations. Farms are less likely to change their specialisation class in East Germany, Northern France, the Netherlands and Northern Spain (mobility index below the 10 per cent quantile of 0.0621).

5 Relationship between structural variables and mobility indices

It has been shown above that there exist considerable differences in structural change across the European regions. Given that the overall political conditions are rather similar for all of these regions under the Common Agricultural Policy, other – regionally specific – reasons must be responsible for this result. Based on explicitly formulated hypotheses, the relationship between structural variables and the mobility indices is investigated by means of a multiple regression. The mobility indices derived above are transformed from the zero-one to a continuous interval and serve as dependent variable. The structural variables discussed below are used as explanatory variables in OLS (Ordinary Least Squares) regressions. The regressions are accomplished at EU15 level and also for Member States with a reasonably large number of regions to conduct cross-sectional analyses. These Member States are Germany (13 regions), France (22 regions), Spain (17 regions) and Italy (21 regions). For each of the mobility indices a separate regression is set up. All mobility indices (for exits, for changes to larger size classes, changes to smaller size classes, specialization class changes) are regressed against a constant, the initial farm size, farm size heterogeneity and farmers' age. The mobility for sector exits (M^{exit}) is additionally regressed against the unemployment rate and the mobility for specialization class changes is additionally regressed against the share of mixed farms in a region. The mobility to enter the sector is not considered because it is almost zero in most regions.

5.1 *Hypotheses*

From a vast amount of factors which potentially might lead to the regional differences in structural change, we have chosen five variables for a closer examination in this respect. Acknowledging that structural change is path dependent (Balmann, 1995) we assume that the initial farm structure significantly determines structural developments in a region. We characterise the initial farm structure by the initial farm size, farm size heterogeneity and the share of mixed farms in a region. Among others, Harrington and Reinsel (1995) point to the relevance of the farmers' age to structural change. Finally, the unemployment rate as proxy for off-farm employment opportunities is assumed to affect sector exits (e.g. Goddard et al., 1993). Hypotheses are made concerning the relationship between the aforementioned structural variables and the mobility indices. They are described in the following and an overview of the expected signs is given in the third column of Table 4. A descriptive analysis of the explanatory variables is given in Table 3 and in Chapter 5.2.

Farm size

Conflicting theories exist on the relationship between farm size and structural change. Gibrat's law states that the size of a firm and its growth rate are independent, whereas other authors stipulate the existence of scale economies (e.g. Hallam, 1991, Boehlje, 1992, Goddard et al., 1993, Harrington and Reinsel, 1995) and path dependency in agriculture (Balmann, 1995). Empirical evidence is found for and against Gibrat's law. Shapiro et al. (1987) and Weiss (1999) reject Gibrat's law for Canada and Upper Austria, whereas it is, with limitations, supported by Kostov et al. (2006) and Piet (2008) for Northern Ireland and France, respectively. Melhim et al. (2009) detect a correlation between farm size and production diversification. We formulate the following hypotheses with regard to the relationship between farm size and regional differences in structural change:

1. We suppose that a more consolidated farm structure at the beginning of the period (expressed in a higher average farm size) would lead to less

sector exits (M^{exit}) compared to regions where small-scale farming still dominates the agricultural sector.

2. Concerning the relationship between initial size and the mobility for changes into higher size classes (M^{s+}) a positive sign is expectable. This could be explained with an ongoing growth process steered by technical change and scale economies (e.g. Hallam, 1991, Boehlje, 1992, Goddard et al., 1993, Harrington and Reinsel, 1995), which led to larger farm sizes in the past, but still has potential for more growth based on a favourable distribution of shrinking and growing farms in the regions. The farm size heterogeneity is therefore used as another explanatory variable. The respective hypotheses are formulated in the following section on the farm size heterogeneity.4.b.

3. Complementary to hypothesis 1. and 2., we expect that the larger the initial size, the lower is the mobility for changes into smaller size classes (M^{s-}).

4. For the relationship between the initial size and the mobility for specialisation changes (M^{spec}) two alternatives can be thought of:

   a. On the one hand one could imagine that the higher the initial size, the more has been invested in the past in certain production technologies and the lower is the probability to change the specialisation class due to path dependency.

   b. On the other hand it could be assumed that holders of large farms who generally contribute a larger share to the corresponding farm household income act 'more economically' than small scale farmers, i.e. might be willing to alter specialisation more rapidly if suggested by changed product and factor market conditions in order to improve returns to primary factors. This would lead to a positive relationship between farm size and specialisation class changes.

Farm size heterogeneity

Besides the correlation between initial farm size and structural change, we assume a relationship between the heterogeneity of farm size and structural change. Up to now, this aspect has seldom been analysed in the literature, though for example Harrington and Reinsel (1995) discuss different potential implications of sectoral heterogeneity. Huettel and Margarian (2009) find a relationship between both variables. Based on Harrington and Reinsel (1995) we assume that a higher regional heterogeneity in farm size mirrors differences in the production efficiency. The existence of large differences in the production efficiency would allow more efficient farms to acquire resources of less efficient farms. This process would generally lead to accelerated structural adjustments. Following, our hypotheses are formulated:

5. The more heterogeneously farm size is distributed in a region, the easier resources of shrinking or exiting farms are taken over by larger farms. If less efficient farms go out of business, the mobility of sector exits (M^{exit}) will be rather high.

6. The higher the heterogeneity, the more likely are takeovers of resources from smaller farms leading to higher mobility values for farm size growth (M^{s+}).

7. If heterogeneity is high and large farms take over resources of smaller farms, the smaller farms may either go out of business as argued in hypothesis 5. or decline. If we assume that at least a part of the smaller farms just declines (instead of leaving the sector altogether), this would lead to high mobility values for changes into smaller size classes (M^{s-}) as well.

8. Regarding the connection between farm size heterogeneity and the mobility of specialisation changes (M^{spec}), we expect that the process of structural change where relatively large farms take over the resources of smaller farms leads to generally higher mobility values for specialisation

class changes. Large farms probably specialise during the growth process and small farms change their specialisation while changing to part-time farming or moving to some niche production.

Farmers' age

Since farmers usually do not quit and change to another business during their active working age, the farmers' age is widely conceived as one of the main drivers of structural change (e.g. Harrington and Reinsel, 1995, Weiss, 1999, Pietola et al., 2003). Farms are much more likely to lower farming activities or go out of business as soon as the farmer retires or dies and there is no successor willing to continue farming. This effect is also exploited in age cohort analyses in order to identify farm structural change in terms of the total number of farms (e.g. De Haen and Von Braun, 1977). Our hypotheses regarding the relationship between farmers' age and regional differences in farm structural change are:

9. The higher the share of farmers being older than 55 years in a region, the higher will be the mobility value for sector exits (M^{exit}),
10. the lower should be the mobility values for changes into higher size classes (M^{s+}),
11. and the higher are the mobility values for changes to smaller size classes (M^{s-}),
12. Regarding the relationship between farmers' age and specialisation class changes, again two contradictory hypotheses can be developed:
    a. On the one hand, one could argue that the higher the share of farmers being older than 55 years is in a region, the less specialisation changes take place (M^{spec}). This is due to the fact that older farmers are probably less flexible in changing the type of business.
    b. On the other hand, retired farmers might continue a less intensive farming activity. This would lead to more specialisation changes.

Share of mixed farms

The relationship between the degree of specialisation and structural change has rarely been analysed in the literature.

13. Based on the descriptive analysis, we assume that the higher the share of mixed farms is in a region, the higher will be the mobility for specialisation class changes (M^{spec}). This is due to the fact that mixed farms can easier focus on one of their activities (which would lead to a reclassification of the specialisation type) than more specialised farms are able to switch their specialisation (due to sunk costs and path dependency).

Unemployment rate

14. In the theoretical and empirical literature, the opportunity for off-farm employment in a region has proven to be an important driver for structural change in that better off-farm employment opportunity raises the probability of farm sector exits (e.g. Harrington and Reinsel, 1995, Weiss, 1999). A higher unemployment rate in a region implies less opportunity for off-farm employment which in turn leads to small exit rates and lower mobility values for sector exits (M^{exit}).

5.2 *Results*

This chapter aims at identifying the impact of assumed key factors on regionally different structural developments across Europe. It provides results of the regression of the mobility indices against the explanatory variables discussed above. The regression analyses are accomplished at EU15 and at Member State level for countries with a reasonably large number of regions (Germany, France, Spain, and Italy). The cross-regional mobility indices are regressed against the explanatory factors discussed above. Table 3 displays averages and standard deviations (small values below the averages) for every structural variable used in the regression at EU15 level and for the four Member States considered.

Table 3: Averages and standard deviations of the structural variables

Variable	Definition of the variable	Measure	EU	DE	FR	ES	IT
Initial farm size	Average ESU/Farm 1990[a] [per cent]	Mean	37.7	117.3	41.2	11.5	13.4
		Standard deviation	52.8	111.1	14.0	8.2	5.3
Hetero-geneity	Gini coefficient 1990[b] [index]	Mean	0.374	0.409	0.296	0.356	0.475
		Standard deviation	0.1	0.1	0.0	0.1	0.1
Age	Share of farmers > 55 years (average 1990/1991)[b] [per cent]	Mean	26.2	27.9	17.2	29.3	34.3
		Standard deviation	11.9	5.9	4.9	11.3	12.4
Mixed farms	Share of mixed farms 1990[b] [per cent]	Mean	12.5	25.5	14.2	4.9	9.2
		Standard deviation	9.3	7.8	8.4	6.5	4.9
Unemploy ment	Unemployment rate[c] [per cent]	Mean	8.6	10.5	9.0	11.9	7.3
		Standard deviation	4.1	5.6	2.4	3.8	4.8

Source: Own calculation, a: data from the public FADN database, b: based on FADN data, c: EUROSTAT[22].

Concerning the categories initial farm size and farm size heterogeneity, different measures are suitable a-priori. To represent the initial farm size we considered the average economic size per farm and the average Utilized Agricultural Area (UAA) per farm, both in the beginning of the observation period. We chose the definition

[22] Averages from 1990 to 2005. Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/region_cities/regional_statistics/data/database, tables reg_lfh3unrt and reg_lfu3rt, downloaded in November 2009

based on economic size units given the differences in relevance of land resources between the specialisations. For the measure on farm size heterogeneity we picked a Gini coefficient weighted by specialisation shares (motivated further below). The farmers' age is expressed by the regional share of farmers being older than 55 years as those are the ones considered to leave the sector within the following 10 to 15 years. The opportunity for off-farm employment is represented by the regional unemployment rate. The share of mixed farms is used as a measure of production diversification in a region.

The mobility indices representing the dependent variable in the regressions are transformed from the zero-one interval to a continuous interval by the inverse of the standard normal distribution. An ordinary least squares (OLS) estimator is applied to regress the transformed mobility indices against the structural variables. In case of the EU15, we have 101 observations (from the 101 regions). For Germany 13 regions, for France 22 regions, for Spain 17 regions and for Italy 21 regions are considered. Depending on the type of mobility, four to five explanatory variables (including the constant) are used in the regressions (four in case of the size mobilities and five in case of the exit and specialisation change mobilities). Accordingly, the degrees of freedom vary from eight (country: Germany, mobility: M^{exit} or M^{spec}) to 97 (country: EU15, mobility: M^{s+} or M^{s-}).

Table 4 shows the results of the regression of the mobility indices against the structural variables. The R^2 measures are generally surprisingly high for a cross-sectional analysis, though they just give an impression how well the variance in the transformed mobility indices is explained by the structural variables. For a better overview, the discussion of the results is divided into subsections.

Table 4: Estimated coefficients

Mobility	Variable	Expected sign	EU (101 regions)	DE (13 regions)	FR (22 regions)	ES (17 regions)	IT (21 regions)
M^{exit}	Constant		7.490 **	19.127 **	-1.192 **	-19.293	-2.618 ***
	Average ESU/Farm 1990	-	-0.041 **	-0.098 ***	0.015 **	0.668	-0.026 *
	Gini coefficient	+	11.078	116.513 ***	0.796	53.347	2.811 **
	Share of farmers > 55 years	+	-0.182 **	-0.976 ***	-0.067 ***	-0.225	-0.001
	Unemployment rate	-	-1.464 ***	-3.888 ***	-0.059 **	-1.990 *	-0.023 *
	R^2		0.319	0.959	0.540	0.204	0.334
M^{s+}	Constant		-1.631 ***	-1.572 ***	-1.901 ***	-2.495 ***	-3.342 ***
	Average ESU/Farm 1990	+	0.001 *	-0.002 **	0.001	0.013	0.015
	Gini coefficient	+	-0.055	1.395 **	1.383	1.624 *	2.786 **
	Share of farmers > 55 years	-	-0.006 **	-0.013	-0.005	-0.002	-0.005
	R^2		0.065	0.413	0.046	0.214	0.386
M^{s-}	Constant		-1.038	-5.400	-1.892 ***	-2.428 ***	-2.077 ***
	Average ESU/Farm 1990	-	-0.027 ***	-0.019	-0.020 ***	-0.001	-0.021 **
	Gini coefficient	+	-0.917	-6.921	1.437	1.405 ***	1.194 *
	Share of farmers > 55 years	+	0.005	0.197	0.004	0.004	0.001
	R^2		0.172	0.116	0.563	0.612	0.318
M^{spec}	Constant		-1.671 ***	-1.365 ***	-1.564 ***	-2.690 ***	-1.155 ***
	Average ESU/Farm 1990	- / (+)	-0.004 ***	-0.001	-0.013 ***	0.008	0.019 **
	Gini coefficient	+	1.410 ***	-0.780	1.247	2.898 ***	-0.021
	Share of farmers > 55 years	-	0.000	0.013	0.014	0.008	0.002
	Share of mixed farms	+	0.015 ***	0.009	0.017 **	0.021 **	0.004
	R^2		0.432	0.621	0.430	0.697	0.216

*Source: Own calculation based on FADN data. Significance levels: ***: 1 per cent, **: 5 per cent, *: 10 per cent.*

Initial farm size

The average economic size per farm (in ESU) in the initial observation year was highest in Germany, close to the European average in France and far below the European average in Italy and in Spain (Table 2). In the case of the EU15, Germany and Italy, the initial farm size has, as expected, a significantly negative impact on the mobility of sector exits: the higher the farm size was at the beginning of the observation period, the lower is the probability to exit the sector due to a more consolidated farm structure. For France and Spain a positive relationship between the initial farm size and mobility of sector exits is found, though the coefficient is not significant in the Spanish case. Huettel and Margarian (2009) find in an analysis on structural change of West German farms that the higher the inital share of small farms was in a region, the lower are the exit probabilities for small farms and the higher are the exit probabilities for larger farms. Foltz (2004) finds for dairy farms in Connecticut that a small farm size is per se not significant for sector exits. While testing Gibrat’s Law for Upper Austrian farms, Weiss (1999) observes a highly significant impact of the initial farm size on both farm survival (i.e. exit) and farm growth. Supporting our results, he finds that an increase in the initial farm size leads to higher survival probabilities.

Concerning the relationship between initial farm size and the mobility for changes to larger size classes, a positive coefficient was expected. The regression results show that at EU15 level the relationship is significantly positive, whereas in Germany a significantly negative relationship is found. This might be caused by the fact that in regions where the average farm size was already very large at the beginning of the observation period (as for example in East Germany), further farm size increases might just not be detected because there are only three size classes with the largest size class having no upper bound. Our assumption of a negative sign for the connection between the initial farm size and the mobility for changes to smaller size classes is confirmed by the data. Contrary to our results, Huettel and Margarian (2009) find in their analysis on West German farms that the mobility to change to larger size classes is highest in regions which are characterised by a small average farm size. A high initial share of small farms corresponds to higher probabilities for farm size growth in their analysis. Weiss (1999) reports two turning points: the impact of the initial farm size is negative for farms below and above the turning points, whereas it is positive for medium-sized farms. The different dynamics observed by Weiss (1999) are moreover correlated to the farmers' off-farm employment status.

As argued in the hypotheses, the initial farm size is positively as well as negatively connected with the mobility for specialisation class changes.

Farm size heterogeneity

We use a weighted Gini coefficient to represent farm size heterogeneity. The weighted Gini coefficient takes into account the relative importance of a farm type in a region. It is constructed by calculating Gini coefficients based on the economic farm size distribution for each specialisation class individually and weighting the specialisation class Gini coefficients by the share of farms falling into the respective specialisation classes. Afterwards, it is averaged across the specialisation classes in order to derive a singular heterogeneity measure per region. Gini coefficients are generally defined between 0 and 1. The higher the Gini coefficient, the more heterogeneously is farm size distributed in a region.

The weighted Gini coefficients for Italy and Germany are above and the coefficients for Spain and France are below the European average (Table 2).

As expected, farm size heterogeneity has a positive impact on the mobility for sector exits. Concerning the relationship between the farm size heterogeneity and the mobility for changes to larger size classes, the coefficients are, as expected, positive for Germany, France, Spain, and Italy. They are negative at EU15 level, though not significantly. As expected, the Gini coefficient has a positive impact (where significant) on the mobility for changes to smaller size classes and on the mobility for specialisation class changes. Huettel and Margarian (2009) distinguish between Gini coefficients at two different points in time. They generally found a higher mobility with increasing Gini coefficients which is in line with our results.

Farmers' age

The share of farmers being older than 55 years in the FADN sample at the beginning of the observation period is used as explanatory variable. Clear differences across the regions are detected. On European average, 26.2 per cent of the farmers in FADN are older than 55 in the beginning of the observation period. This value is only slightly higher in Germany and about 3 per cent and 8 per cent in Spain and Italy, respectively. In France only 17.2 per cent of the farm holders are older than 55 years.

We assumed that the higher the share of farmers being older than 55 years is in the beginning of the observation period, the higher would be the mobility for sector exits. Surprisingly, the data exhibit that this share has a negative impact on the mobility for sector exits. It was further assumed that the share of farmers older than 55 years would negatively affect the mobility of changes to larger size classes. This is verified by the data, though the coefficient is significant only at EU15 level. For the mobility to smaller size classes and the mobility for specialisation class changes, the share of farmers being older than 55 is not significant. Unfortunately, we do not have any information on farm succession. While simultaneously controlling for the existence of a successor, Weiss (1999) finds a positive effect of age on the probability of survival for young farmers in Upper Austria and a negative effect once it exceeds 51 years. He observes a similar pattern regarding farm growth rates: a younger age promotes farm growth (up to 34 years), whereas a negative relationship exists for older farmers and farm growth. Bremmer et al. (2004) cannot find an influence of neither the farmers' age nor the existence of a successor on growth of Dutch arable and horticulture farms.

Share of mixed farms

The share of mixed farms is especially high in Germany, close to the European average of 12.5 per cent in France, and relatively small in Spain and Italy.

We assumed that the higher the share of mixed farm is in a region, the higher would be the mobility for specialisation class changes. This relationship is generally confirmed by the data.

Unemployment

In Italy, the average of the official unemployment rate is lowest, followed by France. In Germany the unemployment rate is a little and in Spain it is well above the European average of 8.6 per cent (Table 2). It was expected that good off-farm employment opportunities let farmers give up the farming business more easily, whereas a high unemployment rate leads them to stay in farming as long as possible. This effect can be shown in all considered cases (EU15, Germany, France, Spain, and Italy). Our results are supported by Weiss (1999) who observes a significantly lower probability of survival for part-time compared to full-time farms.

6 Conclusions

The purpose of the paper was 1) to identify differences in farm structural change across EU15 regions and 2) to identify the impact of key factors on those differences.

In a first part, the differences of farm structural change across 101 EU15 regions are described for the years 1990 to 2005.

A generalized cross-entropy Markov chain estimation is conducted in order to derive transition probabilities which indicate the likelihood for a farm to change from one farm type to another in a certain period. The cross-entropy technique is employed in order to combine micro data representing movements of sample farms across the farm types and macro data which correctly mirror the distribution of farms across the farm types and which is derived from census data.

Transition probabilities are estimated for size and specialisation class changes. The information contained in the transition probabilities is summarized in mobility indices. Distributional measures of both the transition probabilities and the mobility indices are used to demonstrate the regionally different structural development paths. The analysis confirms the often stated observation of decreasing farm numbers for most regions of the EU15. Large differences are however found in pace and scope of the farm number decline and referring to the mobility of farms across size and specialisation classes.

In order to understand what determines the cross-sectional variation in farm structural change, the mobility indices representing general directions of structural change (amount of sector exits, size class changes and specialisation class changes) are cross-sectionally regressed against a number of structural variables.

It could be shown that the considered regional characteristics significantly contribute to explaining regional differences, even though some impacts vary when looking at some Member States separately. Initial average farm size levels are negatively related to farm exit mobility but their marginal impact on upward size mobility is mixed and depends on the initial level itself. Exit and size mobility generally increase with initial farm size heterogeneity in the regions. The share of farmers above the age of 55 has surprisingly little, and if significant, negative impacts on exit mobility, but dampens specialisation changes. Regional unemployment rates show the strong and expected negative impact on exits. Specialisation changes are more likely to happen with an increasing initial share of mixed farms.

Overall we find that farm structural variables caused by structural change processes antedating our time period of analysis contribute substantially to explaining current regional variations in farm sector adjustments. This generally confirms strong path dependency of the structural change process. The current analysis is constrained by limited socio-demographic information on the farm household such as on the existence of successors. Indicators on institutional differences in regional succession laws and land transfer could further explain observed processes. A more explicit model of farm structural change, however, would very quickly force the analyst to reduce the scope with respect to included regions and farm types thereby also changing the observed variance to be explained.

The contributions of the paper to the existing literature on structural change in agriculture lie in: (1) the focus on regional differences in farm structural change and their determinants, (2) the combination of micro and macro data in estimating the transition probabilities and (3) the multidimensionality of the farm typology.

The significant contribution of regional characteristics in explaining regional differences of farm structural change stresses the importance of considering regional aspects in the policy making process. This would support decentralized policies as they are intended in the EU rural development program.

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Appendix

Table A 1. Types in the specialisation dimension with definitions and reference to codes in the Community typology

Specialisation type	EU-Code	Definition
Arable systems	1 + 6	>2/3 of Standard Gross Margin (SGM) from arable or (>1/3 of SGM from arable and/or permanent crops and/or horticulture)
Dairy cattle	4.1	>2/3 of SGM from dairy cattle
Beef and mixed cattle	4.2 + 4.3	>2/3 of SGM from cattle and <2/3 of SGM from dairy cattle
Sheep, goats and mixed grazing livestock	4.4	>2/3 of SGM from grazing livestock and <2/3 of SGM from cattle
Pigs	5.01	>2/3 of SGM from pigs
Poultry and mixed pigs/poultry	5.02 + 5.03	>2/3 of SGM from pigs and poultry and <2/3 of SGM from pigs
Mixed farms	8	All other farms
Mixed livestock	7	>1/3 and <2/3 of SGM from pigs and poultry and/or >1/3 and <2/3 of SGM from cattle
Permanent crops	3	>2/3 of SGM from permanent crops
Horticulture	2	>2/3 of SGM form horticultural crops

Source: Andersen et al. 2006.

Table A 2. Shares of farms in the size classes per Member State [per cent]

Country	Year	Small	Medium	Large
UK	1990	18.4	32.7	49.0
	2005	2.3	33.9	63.7
FR	1990	19.3	49.4	31.2
	2005	6.7	28.4	64.9
DE	1990	27.1	46.0	26.9
	2005	0.0	37.1	62.9
IT	1990	79.8	13.7	6.6
	2005	63.6	23.2	13.2
BL	1990	0.0	44.2	55.8
	2005	0.0	23.3	76.7
LU	1990	7.1	44.7	48.2
	2005	11.7	22.2	66.1
NL	1990	0.0	27.6	72.4
	2005	0.0	21.7	78.3
DK	1990	33.6	28.8	37.5
	2005	23.2	27.0	49.7
IR	1990	64.6	25.0	10.4
	2005	64.1	21.5	14.4
EL	1990	90.9	8.6	0.5
	2005	84.6	13.4	1.9
ES	1990	85.2	12.1	2.7
	2005	65.8	21.3	12.9
PT	1990	94.7	3.9	1.4
	2005	81.4	11.3	7.3
AT	1995	45.2	45.3	9.5
	2005	33.7	46.0	20.2
FI	1995	41.0	50.4	8.7
	2005	25.3	41.2	33.6
SE	1995	27.9	36.0	36.1
	2005	31.7	32.1	36.1

Source: Own calculation based on FADN data.

Table A 3. Shares of farms in the specialisation classes per Member State [per cent]

Country	Year	Arable	Sheep and goats	Permanent crops	Dairy	Beef	Pigs	Poultry	Mixed farms	Mixed livestock	Horticulture
UK	1990	24	23	1	26	11	2	1	9	1	3
	2005	31	18	1	21	14	2	2	8	1	3
FR	1990	27	5	14	21	13	1	0	11	4	3
	2005	29	6	17	16	13	1	1	11	3	3
DE	1990	17	0	7	42	4	1	0	18	8	2
	2005	23	1	7	33	8	3	0	17	5	4
IT	1990	40	3	39	5	2	0	0	6	2	2
	2005	36	4	44	4	3	1	0	4	1	4
BL	1990	11	0	3	31	14	6	1	14	9	10
	2005	15	0	5	19	20	10	0	13	7	11
LU	1990	1	0	11	67	7	0	0	9	4	0
	2005	4	3	12	40	25	1	0	9	4	0
NL	1990	14	2	5	39	5	8	3	4	4	16
	2005	15	11	6	32	3	6	3	5	3	15
DK	1990	48	0	1	21	1	5	0	19	4	2
	2005	58	1	1	14	1	4	1	16	1	2
IR	1990	3	24	0	31	38	0	0	3	0	0
	2005	3	23	0	18	51	0	0	4	0	0
EL	1990	39	7	45	0	1	0	0	5	1	1
	2005	39	7	43	0	1	0	0	5	2	2
ES	1990	34	9	25	14	6	1	1	5	2	3
	2005	24	5	48	3	6	1	1	5	2	5
PT	1990	38	6	21	5	4	1	0	15	8	3
	2005	27	7	34	7	6	1	0	8	5	6
AT	1995	17	1	8	27	22	4	0	13	7	0
	2005	18	2	9	39	13	6	0	9	3	0
FI	1995	22	1	0	53	3	7	0	10	3	0
	2005	43	1	1	33	4	2	0	10	0	4
SE	1995	33	3	0	37	6	1	0	19	0	0
	2005	50	0	0	27	6	2	0	12	1	1