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## Farm size and growth in field crop and dairy farms in France, Hungary and Slovenia

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### Abstract

The aim of this article is to investigate the relationship between size and farm growth. The existing theories of the association between size and farm growth give mixed results by countries and over time. This paper pursues a twofold objective: on one hand, to test the validity of Gibrat's Law for French, Hungarian and Slovenian specialized dairy and crop farms during the pre- and post-accession period to the European Union membership. Dairy and crops farms are prevailing in the farming structure of these countries. Using Farm Accountancy Data Network datasets makes it necessary to avoid biases due to heterogeneous structures across the farming systems. Thus we use quantile regressions to control for farm size related heterogeneity in the samples. On the other hand, the main novelty of this paper is the comparative analysis of the relationship between farm size and farm growth between transition Hungarian and Slovenian and non-transition French farming sectors, characterized by rather different farm structures. The results reject the validity of Gibrat's Law for crop farms in Hungary and to a lesser extent in France, and for French and Slovenian dairy farms. We provide evidence that smaller farms grew faster than larger ones over the studied period 2001-2007 for France, 2001-2008 for Hungary, and 2004-2008 for Slovenia. Conversely, the results for Slovenia suggest that the rate of growth of crop farms in terms of its land is independent from its size.

**Additional key words:** farm size; farm growth; Gibrat's Law; quantile regression.

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### Introduction

Comparative analysis of farm size and its dynamics is of high importance for research and farm policy because the farm size growth is one of the key research issues with implications for rural factor markets and farm competitiveness. This has motivated our research to provide comparative empirical evidence and better understanding on the investigation of the relationship between farm size and farm growth employing the Law of Proportionate Growth, also called Gibrat's (1931) Law. The Law states that the rate of growth of a firm/farm is independent from its size and thus

determined by random factors. From an economic perspective the violation of Gibrat's Law would mean that either smaller farms are growing faster than larger ones, implying convergence, or that larger farms are growing faster than smaller ones thus suggesting divergence in the farm growth. Not being able to reject Gibrat's Law would mean no significant difference in size dependent farm growth. It is important to characterize the relationship between the validity of Gibrat's Law and the economic driving forces that shape industry structure in the short-run (economies of size) and in the long-run (scale and scope economies). In other words, it is important to understand whether other

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Abbreviations used: AWU (Annual Working Unit); CAP (Common Agricultural Policy); EU (European Union); ESU (European Size Unit); FADN (Farm Accountancy Data Network); LSU (livestock unit); NMS (New Member States); OLS (ordinary least square); SFP (Single Farm Payment); TF (type of farming); UAA (utilized agricultural area).

economic factors that determine the long-run distribution of farm size have reached equilibrium or the steadiness of this equilibrium.

In this paper the comparative analyses of the validity of Gibrat's Law for individual farms is conducted for three different European Union (EU) countries (France, Hungary and Slovenia) and for two commodity sectors (crops and dairy) using multi-year farm level data within a quantile regression framework. A body of literature has been developed on different approaches on pros-cons to estimate and model structural change and structural adjustment on farms and on farm typology (Zimmermann *et al.*, 2006, 2009; Bernués & Herrero, 2008; Moreno-Pérez & Ortiz-Miranda, 2008; Pardos *et al.*, 2008; Zimmermann & Heckelei, 2012). The choice of quantile regression is common in such kind of analysis, where the impact of explanatory variables upon the left hand side variable depends on the location of observation within the distribution. These three countries are chosen for the empirical analysis due to the different size distribution of field crop and dairy farms in comparable periods before and after the accession to the EU: Hungary and Slovenia are transition Central European Countries that entered the EU on 1<sup>st</sup> May 2004. France has been one of the founding members of the EU. The historical development and the evolution of farms in the EU vary by countries, not only between Eastern and Western Europe, but also within both regions (Swinnen *et al.*, 1997; Csaki & Lerman, 2000; Swinnen & Vranken, 2009). Within Eastern Europe difference in farm structures' development are caused by the initial conditions that are linked to the agricultural history during the previous communist system and later to institutional and policy reforms during transition. In Western Europe they are caused by the long-term institutional and policy evolutionary factors and market conditions (Serra *et al.*, 2005; Choisis *et al.*, 2012). During the communist system Hungarian agriculture was collectivized and the average farm size has been amongst the largest in Europe. In Slovenia the communist collectivization failed and small-scale farm structure survived, yet remained amongst the smallest in Europe. In France farm structure has developed under market conditions and policy support, in particular the Common Agricultural Policies (CAP) measures introduced after the Second World War (Piet *et al.*, 2012). While its farms are among the largest in Western Europe, they are smaller than in Hungary. Transition from centrally-planned to market economy

in Slovenia has strengthened further development of small-scale family farms, while in Hungary a bi-modal farm structure has emerged, with a large number of small-scale family farms and a small number of large-scale corporate farms. The proportion of small farms in Slovenian agriculture is much higher than in Hungary. Therefore, our comparative analysis includes three countries with different historical-institutional developments and different farm structures: small-scale farms in Slovenia, medium-sized farms in France, and bi-modal (or bipolar) farm size distribution in Hungary. For example, Wolf & Sumner (2001) discussed and analysed bi-modal farm size distribution between small-scale and large-scale farms as one of the stylized facts in size distribution differences according to farm characteristics such as farm age and region. In the case of Hungary, the bi-modal farm structure, *i.e.* large number of small-scale and small number of large scale farms is generally attributed to the land ownership changes of the post-socialist transition period. Thus, in the rest of this paper the growth of field crop and dairy farms in three rather different countries is empirically assessed, and discussed in the light of the key contributions and an outline of opportunities for further research.

## Material and methods

### Literature review

Researchers have long been interested in the evolution of structures within an economic sector—industry or the farming sector—with the objective of forecasting future structures and assessing optimal policies to attain a specific industry structure. During the communist system social planners were seeking to achieve the increase of farms in the socialist agriculture by government supports and soft budget constraints, while in market-oriented economies this is a result of farm evolution and market competition. During the 1990s, the post-socialist countries (*e.g.* Hungary and Slovenia) with agricultural and land reforms shifted from the communist economic system to market-oriented economies. On the other hand, farms in France have been determined by market rules.

There are several studies that have investigated the validity of Gibrat's Law. For example, Piergiovanni

(2010) investigated the validity of Gibrat's Law for a sample of firms active in the Veneto region of Italy for the years 1995-2005 and rejected its validity in the early stages of a firm's life cycle suggesting that younger firms growing faster than established ones up to a given minimum age threshold. Gardebroek *et al.* (2010) investigated factors of dairy processing firms' growth using a 10-year panel data set for six European countries. They found that firm size growth measured in total assets was determined by firm size, firm age, and financial variables, while firm size growth measured in number of employees was determined by firm age and lagged labour productivity.

In the farming sector, the evolution of farming structures and farm restructuring have been determined by different socio-economic, technological, institutional and policy changes (Swinnen *et al.*, 1997). Several studies aim to explain the evolution and restructuring of farming structures, farm diversity and farm performance (*e.g.* Lambarra *et al.*, 2007; Latruffe *et al.*, 2012; Bojnec & Latruffe, 2013). Most of these studies, however, are restricted to a single country case, and when papers focusing on Gibrat's Law are considered, to non-transition economies. A rare example of transition economy focused paper is Bakucs & Fertő (2009). Authors test Gibrat's Law for Hungarian family farms, concluding that smaller farms tend to grow faster than larger ones. Aubert & Perrier-Cornet (2009) analyzed the survival and growth of small farms using the French Farm Structure Survey for the period 2000-2007. They found that the trajectory of small farms is marked by farm exit as the result of farmers retiring. Zimmermann *et al.* (2009) provide a literature review of factors contributing to structural change in agriculture, methods and determinants relevant for modelling farm growth and farm structural change within integrated multi-agent management systems. They found that agricultural and agri-environmental policies' impacts at individual farm level depend on farm types' characteristics like farm size, specialization, and production intensity.

The main weakness of Gibrat's Law is that the effects of systematic factors such as policy or off-farm employment that are of primary interest from a social science perspective are subsumed within the random process (Zimmermann *et al.*, 2006). Off-farm employment and off-farm incomes are

particularly important for the size distribution of farms and farm dynamics for Slovenia. Due to this shortcoming some of the models tested the effects of other explanatory variables, not just farm growth. Weiss (1999) investigated farm entry and exit (farm survival) based on Gibrat's Law as determinants contributing significantly to structural change in the farm sector.

As stressed by Wagner (1992), from a policy point of view testing whether Gibrat's Law holds can provide valuable insights for tuning industry or regional policy measures, in particular whether they need to be size-specific. This issue is particularly important in agriculture, which has always been highly protected in industrialized countries, where farm size distribution has substantially evolved during the past decades. Hallam (1993) provides an overview of previous studies on empirical tests of Gibrat's Law for the United States and Canadian agriculture. His results underline the importance of economies of size to explain the variety of structures in livestock production. Duffy (2009) describes economies of size in association with an L-shaped average cost curve<sup>1</sup>, *i.e.* the limits of farms' ability to lower average costs by increasing production. Major differences between animal and crop production relate to economies of size due to the differences in the vertical integration of the industry.

Weiss (1998) investigated the evolution of the size distribution, growth and survival in the Upper Austrian farm sector using Gibrat's Law over the period 1980-1990. He found the emergence of a bimodal structure of farm sizes (*e.g.* Wolf & Sumner, 2001), with faster growth for smaller farms —towards some minimum efficient scale of production— than for farms at or above this threshold size, and the deterioration of middle size farms. The process of farm polarization is argued to be associated with the off-farm employment (Weiss, 1999). On the other hand, Rizov & Mathijs (2003) for the period 1994-1997 for a sample of individual farms surveyed in Hungary found that older and larger individual farms are more likely to survive. They reject Gibrat's Law as the growth of smaller and newer farms is found to be faster than larger and older ones. Similar as Weiss (1998, 1999) for Upper Austria, Rizov & Mathijs (2003) for Hungary found non-linearity's in the farm size – farm growth relationship

<sup>1</sup> Duffy (2009, p. 382) explains the L-shaped average cost curve as 'there are initial economies of size but these size advantages dissipate, and then costs remain relatively flat over a range of sizes'.

with a polarization of growth rates diminishing for middle farms in the agricultural structure in Hungary.

Different approaches have been developed in firm/farm level analyses to test whether Gibrat's Law holds (Goddard *et al.*, 2002; Harris & Trainor, 2005; Goddard *et al.*, 2006; Bakucs & Fertő, 2009). Most often cross-section tests, panel tests, and alternative panel unit root tests have been applied to test the relationship between firm/farm growth and the measures of firm/farm size. The empirical research yielded rather contradictory results. Some studies (Shapiro *et al.*, 1987; Weiss, 1998; Rizov & Mathijs, 2003) rejected Gibrat's Law for farm growth, finding that small farms tend to grow faster than large ones. Other studies (Upton & Haworth, 1987; Kostov *et al.*, 2005) found no evidence (except for the small farms in the case of Kostov *et al.*, 2005) to reject Gibrat's Law.

The issue of farm growth is also linked to farm survival. Previous research on Hungarian agriculture shows that older and larger farms are more likely to survive (Rizov & Mathijs, 2003) and that the growth trajectory of family and corporate farms is similar (Fertő & Bakucs, 2009).

## Methodology

Equation [1] represents the stochastic process underlying Gibrat's Law:

$$\frac{S_{i,t}}{S_{i,t-1}} = \alpha S_{i,t-1}^{\beta_1 - 1} \varepsilon_{i,t} \quad [1]$$

where  $S_{i,t}$  and  $S_{i,t-1}$  are the size of the  $i^{\text{th}}$  farm in the period  $t$  and in the previous period  $t-1$ , respectively;  $\varepsilon_{i,t}$  is the disturbance in period  $t$ , independent from  $S_{i,t-1}$ ;  $\alpha$  is the common growth rate of all farms; whilst  $\beta_1$  measures the effect of the initial size upon the given farm's growth rate.

If  $\beta_1 = 1$ , then growth rate and initial size are independently distributed, indicating that Gibrat's Law holds. If  $\beta_1 < 1$ , it follows that small farms tend to grow faster than large farms, while the opposite is the case if  $\beta_1 > 1$ . Rewriting Eq. [1] into the form represented by Eq. [2], allows testing for the significance of the coefficient  $\beta_1$ :

$$\log S_{i,t} = \beta_0 + \beta_1 \log S_{i,t-1} + \mu_{i,t} \quad [2]$$

where  $\beta_0 = \log \alpha$  and  $\mu_{i,t} = \log \varepsilon_{i,t}$ .

Following Ward & McKillop (2005), if  $\beta_1 = 1$ , *i.e.* Gibrat's Law holds, then positive (negative) values of  $\beta_0$  indicate a growth (decrease) in the average farm size. If however  $\beta_1 < 1$ , *i.e.* smaller farms tend to grow faster than larger ones.

The empirical analysis of Gibrat's Law faces several econometric issues. The first concern is the heteroskedasticity issue which may occur when Gibrat's Law is not confirmed: if small farms grow faster than their larger counterparts, the variance of growth should tend to decrease with size (see Lotti *et al.*, 2013 for more details). The second traditional problem is when there is serial correlation in growth rates, and the Best Linear Unbiased Estimator (BLUE) properties of Ordinary Least Square (OLS) estimators stated in the Gauss-Markov theorem are lost. A third important issue in the empirical analysis is the sample selection problem. Since growth rate can only be measured for surviving farms (*i.e.* farms still operating in period  $t$ ), and since slow growing farms are most likely to exit the farming sector between period  $t$  and period  $t-1$ , small, fast growing farms may easily be overrepresented in the sample, thus introducing biases in the results. This problem is of particular importance in the present paper, since the proportion of small farms in transition economies in general, and in Slovenia in particular, is much higher than in developed economies. Heckman (1979) introduced a two-step procedure to control for the selection bias problem. In step one, a farm survival model for the full sample (both surviving and exiting farms) is estimated, using a probit regression. This model is used to obtain the inverse of Mill's Ratio for each observation; it is given by Eq. [3]:

$$P(f_i = 1) = F(\delta + \gamma \log S_{i,t-1}) + \mu \quad [3]$$

where  $P$  is the probability,  $f_i = 1$  denotes a surviving farm (while  $f_i = 0$  would indicate a farm in exiting),  $\delta$ ,  $\gamma$  are parameters to be estimated, and  $\mu$  is the disturbance.

The inverse Mill's Ratio derived from Eq. [3] is then introduced in Eq. [2]. A significant coefficient for the inverse Mill's Ratio would then indicate that the sample selection problem is present.

In the OLS regression estimation, error terms are assumed to follow the same distribution irrespectively of the value taken by the explanatory variables. Since we can only analyze surviving farms, estimations are conditional on survival (*conditional objects*, see Lotti



*et al.*, 2003). Therefore, in this paper we use the quantile regression estimation technique. Following Lotti *et al.* (2003), the  $\theta^{\text{th}}$  sample quantile, where  $0 < \theta < 1$ , can be defined as:

$$\min_{b \in R} \left[ \sum_{i \in \{i: y_i \geq b\}} \theta |y_i - b| + \sum_{i \in \{i: y_i < b\}} (1 - \theta) |y_i - b| \right] \quad [4]$$

For a linear model such as, the  $y_i = \beta'x_i + \varepsilon_i$ , the  $\theta^{\text{th}}$  regression quantile is the solution of the minimization problem, similar to Eq. [4]:

$$\min_{b \in R^k} \left[ \sum_{i \in \{i: y_i \geq x_i b\}} \theta |y_i - x_i b| + \sum_{i \in \{i: y_i < x_i b\}} (1 - \theta) |y_i - x_i b| \right] \quad [5]$$

Solving Eq. [5] for  $b$  provides a robust estimate of  $\beta$ . To obtain unbiased error terms, we use a bootstrap methodology to estimate the variance-covariance matrix<sup>2</sup>.

## Data

The analysis is based on farm-level data from the Hungarian, Slovenian and French Farm Accountancy Data Network (FADN) datasets. FADN data are collected in each EU member state for a sample of professional farms exceeding the specific minimum threshold in terms of size greater than two Economic Size Units (ESUs)<sup>3</sup>. The analysis is performed for two farm production types: farms specialized in dairy and farms specialized in field crop farming. Farms are selected using their European type of farming (TF) standard classification (see [http://ec.europa.eu/agriculture/rica/diffusion\\_en.cfm](http://ec.europa.eu/agriculture/rica/diffusion_en.cfm)). Within the FADN datasets, the European classification into a specific TF requires a farm to obtain at least 66% of its gross margin from the specific production. Dairy farms are classified as TF41 and field crop farms as TF1. The time span used for analysis is 2001-2008 for Hungarian farms, 2001-2007 for French farms, and 2004-2008 for Slovenian farms; the time spans are based on national FADN data availability at the farm level: earlier years than 2001 for Hungary and 2004 for Slovenia are not available, as FADN was created at the beginning of the 2000's in the EU new member states;

most recent years of FADN data in France were not yet available at the time of analysis.

There is no single measure of farm size in agriculture, and research findings may differ according to the proxy used (*e.g.* Garcia *et al.*, 1987; Sumner & Wolf, 2002; Rizov & Mathijs, 2003). The proxy mainly depends on farms' production specialization and technology. Although statistics on farm size generally refer to land in terms of utilized agricultural area (UAA), this indicator is often irrelevant for livestock farms. Therefore, in this paper UAA (which consists of owned and leased-in land) is used as a farm size proxy for crop farms, while livestock units (LSUs), that is to say the total number of livestock heads on the farm aggregated with European standard weighting coefficients within the FADN datasets) are employed for dairy farms' size. More, within a specific farm specialization, technology (such as capital or land intensity) may be different and may thus render the comparison between crop farm size (in terms of UAA) and livestock farm size (in terms of livestock units) difficult. For this reason, in this paper, farm size is also measured with the amount of labour used: the number of full-time equivalent workers per year on the farm (in Annual Working Units, AWUs), including both family and hired workers, is used for both dairy and crop farms. Thus, two size variables are used for each of the two farm specialization samples: hectares of UAA and number of AWU per crop farm, and number of livestock units and number of AWU per dairy farm.

## Results

### Descriptive statistics

Table 1 presents some descriptive statistics of the data used for averages of size variables over time.

These summary statistics clearly indicate the size differences of dairy and crop farms between Hungary, France and Slovenia. The Hungarian samples present the largest farms on average, while the Slovenian samples the smallest farms. This is due to the different historical trajectories of both countries: while the

<sup>2</sup> STATA 11.0 is used for all econometric estimations. Qreg command family is used for quantile regression, and bsqreg for bootstrapped variance-covariance matrix estimations.

<sup>3</sup> One ESU is equivalent to €1,200 of gross margin.

**Table 1.** Descriptive statistics for the whole period studied

Country <sup>1</sup>		Dairy farms		Crop farms	
		Livestock units	Labour in AWU <sup>2</sup>	Land (UAA) in hectares	Labour in AWU <sup>2</sup>
Hungary	Number of obs.	719	719	6,154	6,154
	Mean	243.5	12.32	236.5	3.66
	St. Dev.	389.5	22.27	426.7	8.52
	Min	2.9	0.10	6.0	0.004
	Median	76	2.81	100	1.18
	Max	2,842.5	199.49	3,836.9	103.18
France	Number of obs.	7,598	7,598	13,403	13,403
	Mean	89.0	1.80	133.8	1.85
	St. Dev.	51.5	0.84	82.4	1.47
	Min	12.3	0.80	2.0	0.75
	Median	75.8	1.76	118.0	1.44
	Max	658.6	8.19	774.4	41
Slovenia	Number of obs.	1,221	1,221	327	327
	Mean	39.5	2.41	19.6	2.13
	St. Dev.	31.9	0.84	32.8	2.85
	Min	3.1	0.38	1.9	0.21
	Median	30.4	2.36	9.46	1.65
	Max	236.0	6.75	325.6	46.08

<sup>1</sup>2001-2008 for Hungary; 2001-2007 for France; 2004-2008 for Slovenia. <sup>2</sup>One AWU is equivalent to 2,200 hours of full time labour in France's and Hungary's FADN datasets, and 1,800 hours in Slovenia's FADN dataset.

Hungarian farming sector had been almost fully collectivized during the communist time, this was not the case for the former Yugoslavia, including Slovenia, where small family farms prevailed. The Slovenian farms use more labour on average than French farms, despite their UAA (for crop farms) or number of LSUs (for dairy farms) being much lower than those of French farms.

In Slovenia the maximum size in terms of LSUs within the dairy farms is 12 times lower than in Hungary (236.0 vs. 2842.5 LSUs). The average Hungarian dairy farm is approximately 2.7 times larger than the one in France or 6.2 times larger than the one in Slovenia (average LSUs of 243.5 LSUs in Hungary, vs. 88.9 and 39.5 LSUs in France and Slovenia respectively). Such large differences for dairy farms between the analyzed countries are also seen in terms of labour in AWU: the average Hungarian dairy farm has 12.32 workers, which is approximately 6.8 times greater than in France or 5.1 times greater than in Slovenia. This implies that in Hungary the ratio between the number of LSUs and the number of AWU

is on average 19.8, while it is 49.4 for France and 16.4 for Slovenia. It is however worth mentioning at this point that within the national FADN datasets one AWU is equal to 1,800 hours annual full time employment in Slovenia and to 2,200 hours in France and Hungary. Farm size differentials between the analyzed countries are also present within the crop specialization. The average crop farm size in Hungary is 236.5 ha, which is around 1.8 times greater than in France and around 12 times greater than in Slovenia. The Hungarian crop farms use on average 3.66 workers, which is around twice as much than in France and 1.7 times more than in Slovenia. On average, one AWU on a Hungarian crop farm cultivates 64.6 ha of land, against 72.3 ha in France and 9.2 ha in Slovenia. These statistics show that using a single farm size measure for Gibrat Law's analysis may present some limits, giving support to our methodology to use different farm size measures in this analysis. In addition, the bi-modal structure of Hungarian (and to some extent Slovenian) farms with respect to the more uniform farms size distribution experienced in France is clearly visible. Therefore, one

should compute the coefficient of variation of size variables<sup>4</sup>.

The agricultural sector in the three countries had to face changes in their economic and policy environment during the period studied. Most notably, Hungary and Slovenia have entered the EU in 2004. For this reason, in addition to analyzing Gibrat's Law over the full period, two sub-periods are used for Hungary, 2001-2003 and 2004-2008, to test for the influence of EU accession. Unfortunately, the time span for Slovenian data (2004-2008) is not long enough to analyze the pre-accession 2001-2003 effect. Regarding France, the agricultural sector has experienced the 2003 Luxembourg reform of the CAP, which introduced the new decoupled instrument of Single Farm Payments (SFPs), that is to say payments given to farms on a per hectare basis regardless of their production level or type. The reform of the CAP was implemented in France in 2006. Therefore, the two sub-periods used for this country are 2001-2005 and 2006-2007.

## Econometric results

We present our econometric results separately by farm specialization type (crop and dairy farms) and sub-periods. The empirical models for the three countries are estimated separately in order to compare the results and findings.

Preliminary estimations showed that the inverse Mill's ratio is not significant, suggesting that a two-step model is not necessary. In other words, the FADN database used successfully avoids the presence of sample selection issue. Thus, we present calculations based on quantile models. Crop farm estimation results for  $q0.50$  are shown in Table 2 and dairy farm results for  $q0.50$  in Table 3. In Table 4 results for both crop and dairy farms are presented for five different quantiles:  $q0.10$ ,  $q0.25$ ,  $q0.50$ ,  $q0.75$  and  $q0.90$ .

Regarding crop farms for  $q0.50$  (Table 2), our estimations suggest that we can reject Gibrat's Law for such specialization in Hungary since the coefficient for size ( $\beta_1$ ) is consistently significantly different from one across the periods and irrespective of the size variable used. The coefficient is always less than one implying the farm size-farm growth convergence that

small farms grew faster than large farms during the periods studied. In France, all coefficients for size (irrespective of the period and of the size variable used) are equal to or very close to 0.99, suggesting strong evidence in favour of Gibrat's Law (farm growth is independent of its initial size). In Slovenia the results are mixed depending on the size proxy employed. Gibrat's Law is rejected whatever the size variable, but we find that coefficients are larger than one when using land in hectares (UAA) as the measure of farm size, providing evidence for the farm size-farm growth divergence by faster growth of larger crop farms, while the opposite is true when using labour as the farm size.

The estimation results for dairy farms at  $q0.50$  (Table 3) are similar to the ones found for crop farms. We can reject Gibrat's Law for Hungarian dairy farms, suggesting the farm size-farm growth convergence with smaller farms growing faster than larger farms. For French dairy farms all coefficients are very close to one, suggesting the validity of Gibrat's Law. In Slovenia Gibrat's Law is not valid, suggesting the farm size-farm growth divergence by larger farms (in terms of livestock units) growing faster than smaller farms, while suggesting the farm size-farm growth convergence by larger farms in terms of labour growing less fast than smaller farms.

The estimation results for crop and dairy farms by five different quantiles (Table 4) reinforce previous findings for  $q0.50$ , but add some variations between other analyzed quantiles.

For French crop farms, the coefficients for the land size variable indicate slight variations by the quantiles, which are consistent by the periods. For the lowest quantile  $q0.10$ , the coefficient greater than one suggests the farm size-farm growth divergence that larger farms in this quantile grew faster than smaller ones, and vice versa the farm size-farm growth convergence for the largest quantile  $q0.90$ , where the coefficient smaller than one suggests that smaller farms in this quantile grew faster than larger ones. Yet, for French crop farms, the coefficients for the labour size variable indicate greater variations by the quantiles and by the periods. For the lowest quantile  $q0.10$  the coefficient smaller than one suggests the farm size-farm growth conference that smaller farms in this quantile grew faster than larger ones. For the largest quantile  $q0.90$ , the coefficients for

<sup>4</sup> The coefficient of variation (CV) of a variable is the standard deviation normalized by the mean. The CV for farm size defined in livestock units are: 1.6, 0.57, and 0.8 for Hungary, France and Slovenia, respectively; for size defined in hectares are: 1.8, 0.61, and 1.67 for Hungary, France and Slovenia, respectively.



**Table 2.** Quantile regression ( $q0.50$ ) estimates for crop farms

	France		Hungary		Slovenia	
	Land <sup>a</sup>	Labour <sup>b</sup>	Land	Labour	Land	Labour
<i>Full period<sup>c</sup></i>						
Size <sup>d</sup>	0.997***	1.000***	0.896***	0.822***	1.040***	0.978***
Constant	0.023*	0.000	0.603***	0.157***	-0.044	-0.054
Wald test <sup>e</sup>	0.010	0.000	0.021	0.139	0.512	0.618
Wald test <sup>f</sup>	0.009	0.000	0.000	0.007	0.988	0.243
Pseudo R <sup>2</sup>	0.805	0.528	0.591	0.454	0.816	0.374
N total <sup>g</sup>	2,061	2,061	691	691	48	48
N censored	1,086	1,086	456	456	14	14
N uncensored	975	975	235	235	34	34
<i>First period<sup>c</sup></i>						
Size <sup>d</sup>	0.998***	1.000***	0.949***	0.843***		
Constant	0.011*	0.000	0.314**	0.137***		
Wald test <sup>e</sup>	0.003	0.000	0.001	0.292		
Wald test <sup>f</sup>	0.001	0.000	0.000	0.011		
Pseudo R <sup>2</sup>	0.855	0.574	0.667	0.437		
N total <sup>g</sup>	2,061	2,061	691	691		
N censored	784	784	395	395		
N uncensored	1,277	1,277	296	296		
<i>Second period<sup>c</sup></i>						
Size <sup>d</sup>	1.000***	1.000***	0.990***	0.920***		
Constant	-0.000	-0.000*	0.078**	0.091***		
Wald test <sup>e</sup>	0.000	0.000	0.242	0.822		
Wald test <sup>f</sup>	0.000	0.000	0.415	0.000		
Pseudo R <sup>2</sup>	0.943	0.863	0.812	0.631		
N total <sup>g</sup>	1,838	1,838	851	851		
N censored	267	267	280	280		
N uncensored	1,571	1,571	571	571		

<sup>a</sup> Land is UAA in ha. <sup>b</sup> Labour is in AWU. <sup>c</sup> Full period is 2001-2008 for Hungary, 2001-2007 for France, and 2004-2008 for Slovenia. First period is 2001-2003 for Hungary and 2001-2005 for France. Second period is 2004-2008 for Hungary and 2006-2007 for France. <sup>d</sup> Size is either in terms of land or in terms of labour. <sup>e</sup> Wald: shows the probability of the test of the following  $H_0$ : size at the beginning of each period (2001, 2004 or 2006) = 1. <sup>f</sup> Wald: shows the probability of the test of the following  $H_0$ : equality of the coefficients from quantile regression when  $q = 0.10$ ,  $q = 0.25$ ,  $q = 0.50$ ,  $q = 0.75$ , and  $q = 0.90$ . <sup>g</sup> N: number of observations. \*\*\*, \*\*, \* significant at 10%, 5%, and 1% respectively

the labour size variable are mixed. Except for the period 2006-2007, they are less than one suggesting the farm size-farm growth convergence that smaller farms in this quantile grew faster than larger ones. The smallest French crop farms ( $q0.10$ ) grew in terms of land, while the largest ones ( $q0.90$ ) expand in terms of labour. For French dairy farms the land size coefficients are close to one, suggesting the validity of Gibrat's Law. However, the main exceptions are the smallest  $q0.10$  and the largest  $q0.90$  quantiles in the period 2006-2007. For the smallest quantile  $q0.10$ , the coefficient less than one suggests the farm size-farm growth convergence that smaller farms in this quantile grew faster than larger one, and vice versa for the largest size quantile,  $q0.90$ .

Our estimations by five different quantiles suggest that Gibrat's Law can be rejected for Hungarian crop farms. The coefficients pertaining to the size variable for both the land and labour sizes are significantly different from one by the quantiles across the periods. The size coefficient is always less than one implying the farm size-farm growth convergence that small crop farms grew faster than large ones in each of the quantiles during the periods studied. For most quantiles, the validity of Gibrat's Law can also be rejected for Hungarian dairy farms. Indeed, the coefficients pertaining to the size variable are less than one suggesting the farm size-farm growth convergence that smaller farms grew faster than larger ones. There are

**Table 3.** Quantile regression ( $q0.50$ ) estimates for specialized dairy farms

	France		Hungary		Slovenia	
	Livestock <sup>a</sup>	Labour <sup>b</sup>	Livestock	Labour	Livestock	Labour
<i>Full period<sup>c</sup></i>						
Size <sup>d</sup>	1.002***	1.000***	0.918***	0.773***	1.020***	0.845***
Constant	-0.018	-0.000	0.523	0.541***	0.019	0.107
Wald test <sup>e</sup>	0.928	0.013	0.217	0.059	0.530	0.000
Wald test <sup>f</sup>	0.839	0.000	0.397	0.282	0.946	0.092
Pseudo $R^2$	0.707	0.547	0.790	0.747	0.7551	0.307
N total <sup>g</sup>	1,267	1,267	100	100	217	217
N censored	850	850	78	78	44	44
N uncensored	417	417	22	22	173	173
<i>First period<sup>c</sup></i>						
Size <sup>d</sup>	0.998***	1.000***	0.954***	0.909***		
Constant	-0.003	-0.000*	0.267	0.276		
Wald test <sup>e</sup>	0.404	0.002	0.004	0.891		
Wald test <sup>f</sup>	0.481	0.000	0.004	0.419		
Pseudo $R^2$	0.755	0.619	0.8495	0.741		
N total <sup>g</sup>	1,267	1,267	100	100		
N censored	666	666	64	64		
N uncensored	601	601	36	36		
<i>Second period<sup>c</sup></i>						
Size <sup>d</sup>	1.005***	1.000***	0.990***	0.961***		
Constant	-0.007	-0.000	0.087	0.045		
Wald test <sup>e</sup>	0.018	0.000	0.329	0.455		
Wald test <sup>f</sup>	0.039	0.000	0.313	0.344		
Pseudo $R^2$	0.866	0.874	0.839	0.739		
N total <sup>g</sup>	973	973	81	81		
N censored	212	212	41	41		
N uncensored	761	761	40	40		

<sup>a</sup> Livestock is size in livestock units. <sup>b</sup> Labour is in AWU. <sup>c,d,e,f,g</sup> See Table 2.

exceptions where the coefficient is greater than one; they apply to the greatest quantile  $q0.90$  for the labour size variable in the post accession period 2005-2008. Yet, four exceptions with the size coefficient greater than one are found for livestock unit size variable: the smallest quantiles  $q0.10$  and  $q0.25$ , respectively, in the period 2001-2008 and in the post accession sub-period 2005-2008. The latter exceptions suggest the farm size-farm growth divergence that in these smallest quantiles larger dairy farms grew faster than smaller ones.

For the Slovenian crop and dairy farms Gibrat's Law is rejected for each of the analyzed quantiles and whatever the size variable is used. For crop farms, the coefficients larger than one when using land as the measure of farm size confirms the farm growth divergence by a faster growth of larger farms than smaller ones. However, except for  $q0.25$ , the coefficients are smaller than one if using labour in AWU

as the measure of farm size suggesting the farm size-farm growth divergence that smaller crop farms grew faster than larger ones. Slovenian larger crop farms grew faster in terms of land, while smaller in terms of labour. On the other hand, for dairy farms, the coefficients are smaller than one when using land as the measure of farm size indicating that the farm size-farm growth convergence that smaller farms grew faster than larger ones. Inversely, the coefficients are greater than one when using livestock units as the measure of farm size indicating the farm size-farm growth divergence that larger dairy farms grew faster than smaller ones. Slovenian smaller dairy farms grew faster in terms of land, while larger farms grew faster in terms of livestock.

To sum up, due to the multi-dimensionality of results (country, commodity, size proxy, time, and quantile) and to make comparisons easier, we constructed Table 5

**Table 4.** Quantile regression estimates ( $\theta[0.10]$ ,  $\theta[0.25]$ ,  $\theta[0.50]$ ,  $\theta[0.75]$ ,  $\theta[0.90]$ ):  $\beta_1$  values for France, Hungary and Slovenia

France	Full period (2001-2007)					First period 2001-2005					Second period (2006-2007)				
Crop farms															
Land	1.028***	1.001***	0.997***	0.960***	0.917***	1.026***	1.000***	0.998***	0.973***	0.934***	1.011***	1.001***	1.000***	0.996***	0.969***
Labour	0.072	0.742***	1.000***	1.085***	0.961***	0.188	0.820***	1.000***	1.029***	0.858***	0.792***	0.965***	1.000***	1.029***	1.095***
Dairy farms															
Livestock	1.003***	1.013***	1.002***	0.990***	1.026***	0.979***	0.976***	0.998***	0.989***	0.994***	0.855***	1.000***	1.000***	1.000***	1.063***
Labour	0.437*	0.792***	1.000***	1.000***	0.784***	0.114	0.877***	1.000***	1.057***	0.851***	1.027***	1.014***	1.005***	0.994***	0.992***
Hungary	Full period (2001-2008)					First period (2001-2004)					Second period (2005-2008)				
Crop farms															
Land	0.878***	0.922***	0.896***	0.771***	0.747***	0.897***	0.959***	0.949***	0.867***	0.791***	0.978***	0.985***	0.990***	0.975***	0.947***
Labour	0.843***	0.818***	0.822***	0.717***	0.671***	0.889***	0.893***	0.843***	0.769***	0.700***	0.989***	0.927***	0.920***	0.883***	0.838***
Dairy farms															
Livestock	0.950***	0.944***	0.918***	0.814***	0.808***	1.081***	1.054***	0.954***	0.915***	0.902***	1.056***	1.048***	0.990***	0.941***	0.992***
Labour	0.885***	0.893***	0.773***	0.717***	0.701***	0.978***	0.946***	0.909***	0.844***	0.767***	0.948***	0.975***	0.961***	0.879***	1.063***
Slovenia	Full period (2004-2008)														
Crop farms															
Land	1.067***	1.053***	1.040***	1.031***	1.074***										
Labour	0.857***	1.219***	0.978***	0.804***	0.483										
Dairy farms															
Livestock	1.027***	1.015***	1.020***	1.036***	1.039***										
Labour	0.716***	0.677***	0.845***	0.734***	0.534***										

For crop farms, size is either in terms of land or in terms of labour; land is UAA in ha, while labour is in AWU. For dairy farms, size is either in terms of livestock or in terms of labour; livestock is size in livestock units, while labour is in AWU. \*\*\*, \*\*, \* significant at 10%, 5%, and 1% respectively.

where these dimensions are jointly summarized and presented. Our results indicate, firstly, that farms in the dairy sector and farms in the crop sector evolve similarly within each country considered. Secondly, our findings suggest different evolutions across the three countries considered and to a lesser extent by the analyzed quantiles. In France, where farming structures have developed along a continuous path since the Second World War and the introduction of the CAP, farm growth is to a lesser extent dependent of farm size. Farm structural change may be influenced by external factors, such as public policies (as shown for example by Piet *et al.*, 2012), which strongly subsidize farms. By contrast, in Hungary and Slovenia, where farming structures had been frozen during the communist period and started evolving again during the transition period, our results suggest that farm growth is not independent of farm size at the end of the transition period (after 2001) and the entry in the enlarged EU (after 2004). In Hungary, small farms grow faster than larger farms as also found by Rizov & Mathijs (2003), a finding which

holds true also for Slovenia when size is considered in terms of labour. In the latter country, when land (for crop farms) or livestock units (for dairy farms) are used as the size proxy, larger farms grow faster than smaller farms. A more rapid growth for smaller farms than for larger farms in Hungary suggests that the current bi-modal farming structure of very small farms (mainly family farms) and very large farms (mainly corporate farms) may be mitigated in the future, with a convergence towards more middle-sized farm units. In Slovenia, the future picture of farming structures is difficult to predict as opposite forces are in action, depending on the size aspect. Results suggest that, in the future, farms using less labour may increase their labour force in a greater proportion than labour-intensive farms might do, but on the other hand, that there may be a move towards a bi-modal farming system, as in other EU New Member States (NMS), when land and livestock size are considered, with larger farms growing faster. Thirdly, our analysis does not provide evidence of substantial discrepancy in size

**Table 5.** Summary of findings about the multi-dimensionality of the validity of Gibrat's Law

		France		Hungary		Slovenia	
		Land	Labour	Land	Labour	Land	Labour
		2001-2007		2001-2008		2004-2008	
<b>Crop farms</b>	$\theta[0.10]$	rej D	Insig	rej C	rej C	rej D	rej C
	$\theta[0.25]$	rej D	rej C	rej C	rej C	rej D	rej D
	$\theta[0.50]$	rej C	not rej	rej C	rej C	rej D	rej C
	$\theta[0.75]$	rej C	rej	rej C	rej C	rej D	rej C
	$\theta[0.90]$	rej C	rej C	rej C	rej C	rej D	rej C
		2001-2005		2001-2003			
	$\theta[0.10]$	rej D	Insig	rej C	rej C		
	$\theta[0.25]$	not rej	rej C	rej C	rej C		
	$\theta[0.50]$	rej C	not rej	rej C	rej C		
	$\theta[0.75]$	rej C	rej D	rej C	rej C		
	$\theta[0.90]$	rej C	rej C	rej C	rej C		
		2006-2007		2004-2008			
	$\theta[0.10]$	rej D	rej C	rej C	rej C		
	$\theta[0.25]$	rej D	rej C	rej C	rej C		
	$\theta[0.50]$	not rej	not rej	rej C	rej C		
$\theta[0.75]$	rej C	rej D	rej C	rej C			
$\theta[0.90]$	rej C	rej D	rej C	rej C			
		France		Hungary		Slovenia	
		Livestock	Labour	Livestock	Labour	Livestock	Labour
		2001-2007		2001-2008		2004-2008	
<b>Dairy farms</b>	$\theta[0.10]$	rej D	rej C	rej C	rej C	rej D	rej C
	$\theta[0.25]$	rej D	rej C	rej C	rej C	rej D	rej C
	$\theta[0.50]$	rej D	not rej	rej C	rej C	rej D	rej C
	$\theta[0.75]$	rej C	not rej	rej C	rej C	rej D	rej C
	$\theta[0.90]$	rej D	rej C	rej C	rej C	rej D	rej C
		2001-2005		2001-2003			
	$\theta[0.10]$	rej C	Insig	rej D	rej C		
	$\theta[0.25]$	rej C	rej C	rej D	rej C		
	$\theta[0.50]$	rej C	not rej	rej C	rej C		
	$\theta[0.75]$	rej C	rej D	rej C	rej C		
	$\theta[0.90]$	rej C	rej C	rej C	rej C		
		2006-2007		2004-2008			
	$\theta[0.10]$	rej C	rej D	rej D	rej C		
	$\theta[0.25]$	not rej	rej D	rej D	rej C		
	$\theta[0.50]$	not rej	rej D	rej C	rej C		
$\theta[0.75]$	not rej	rej C	rej C	rej C			
$\theta[0.90]$	rej D	rej C	rej C	rej D			

not rej: not rejected, when equal to 1 and significant (Gibrat's Law is not rejected); rej C: rejected C, when significantly < 1, implying convergence in the farm growth; rej D: rejected D, when significantly > 1, suggesting divergence in the farm growth; Insig: statistically insignificant at 10% level.

developments across sub-periods for Hungary and France. Results suggest that the accession to the EU in 2004 did not change the rejection of Gibrat's Law in Hungary, and that the introduction of the decoupled CAP payment in France did not change the validity of Gibrat's Law. However, for France, investigations for longer periods would be needed, as policy effects may not be felt immediately.

## Discussion

To our knowledge, this paper is the first one to provide comparative analysis and comparative results with respect to the relationship between farm size and farm growth by testing the validity of Gibrat's Law in three different countries (France, Hungary and Slovenia) for two commodity sectors (crops and dairy) using multi-year farm level FADN data and employing quantile regressions. Results point to substantial heterogeneity across countries, inter-commodity sector farms, inter-period and inter-quantiles. Based on our analysis and estimation results, five novelties and the contributions to the empirical literature may be identified. First, while there are a number of studies aimed at analyzing the validity of Gibrat's Law, we provide additional comparative empirical results to this literature as there is no study comparing the results between non-transition (France) and transition agriculture (Hungary and Slovenia). In this paper we analyze and compare farm size-farm growth in three countries with rather different historical and institutional development (socialist agriculture than transition for Hungary and Slovenia and CAP dominated market oriented agriculture in France). The results confirmed discrepancies in the farm size-farm growth relationship among non-transition France and transition Hungary and Slovenia, commodity sectors and periods (pre vs. post-accession to the EU), and also that the transition countries are not a uniform group in terms of such relationship. Therefore, future research should also investigate some other Central and Eastern European Countries in terms of farm structures, farm size and farm growth. Second, contrary to most studies analyzing farm growth rate, we focus on specialized crop and dairy farms rather than the whole farming sector, thus eliminating possible biases within agricultural farm diversity due to heterogeneous farm structures across the agricultural sector. Third, unlike previous studies, we use different size indicators (by

five different size quantiles) on the grounds that size in agriculture is not an unambiguous concept. The relationship is sensitive to farm size proxy and size quantiles. Fourth, the comparative findings from the selected three countries may be applied in a more general setting of farming in different historical-institutional developments. The results provide comparative insight into the validity of Gibrat's Law in the inter-economy type, inter-commodity sector, inter-period and inter-quantile comparative across transition economies, and transition versus non-transition economies. Finally, the empirical results and findings have importance for agricultural policies and implications upon restructuring. Our results strongly reject the validity of Gibrat's Law for crop and dairy farms in Hungary, providing evidence on farm size convergence that smaller farms grew faster than larger ones over the period studied. Empirical results for Slovenia depend on the size proxy: divergence (land and livestock size) and convergence (Annual Work Units). Estimations confirm the validity of Gibrat's Law for French crop and dairy farms, which suggests the maturity and steadiness of farm size-farm growth equilibrium. These results highlight the heterogeneity in the development of farm structures depending on the production specialization, not only between non-transition and transition countries, but also between transition countries. In addition, for similar analysis set in different countries, among issues for future research is the analysis of spatial-temporal variation characteristics to study if the wide standard deviation in farm size distribution is due to an existing spatial variability.

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