Research article

What drives family farm size growth in Hungary?

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HIGHLIGHTS

- Decline in the number, and increase in the average size of family farms.
- Farm-size and non-linear impact of type of farming on farm size growth.
- Weak link between farm growth and the education and skills of heads of farms.
- Gender imbalance in family farm leadership.
- Potential to encourage young and women heads of farms.

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ABSTRACT

During the last two decades, the number of Hungarian family farms has declined, while average farm size has grown. To identify the drivers of farm size growth, the paper investigates the importance of human capital along with leadership skills, farm and spatial farm regional location characteristics, and government subsidies for Hungarian family farms using a Farm Accountancy Data Network dataset for the period 2007 to 2015. The application of quantile regression models and their findings suggest that leadership skills have little effect on the growth of Hungarian family farms. In contrast to the effect of skills, the general characteristics of the family farms (such as farm size, farm type, and state subsidies) determine their growth. Smaller family farms grew faster than bigger family farms. The non-linear relationship between farm size growth and farm type as well as state subsidies is confirmed for different quantiles of farm size. The findings suggest that the ongoing process of family farm restructuring depends on the latter's size and pertains to family farm characteristics and government policies. The market selection process of farms and farm restructuring, along with a decline in the number of farms and their size growth, is likely to continue due in part to climate change and the robotization and digitalization of farms and will be affected by the resilience of different farm types.

1. Introduction

The literature on farm growth has been developed particularly in relation to developed countries and so less for the former ex-socialist countries with formerly large-scale state and collective farms (Rizov and Mathijs, 2003; Bakucs and Fertő, 2009; Akimowicz et al., 2013). The relationship between farm size and farm size growth indicates the structural changes of farms and has implications for farm policy and managerial farm practices and competitiveness. Most of the empirical studies on farm growth use Gibrat's Law as a theoretical departure point in their analysis (Gibrat, 1931). This law states that firm growth is a stochastic process

resulting from many unobserved random variables; therefore, the growth rate of firms (farms) is independent of their initial size at the beginning of the period. Empirical studies have identified several factors that influence farm structural change, including relative prices, technological change, economies of scale, farm debt, sunk costs, policy variables, demographic variables, and indicators related to off-farm employment, region al-specific patterns, and spatial dependencies. The present paper investigates the drivers and importance of human capital and farm characteristics and agricultural subsidies in relation to the growth of family farms in Hungary in the period 2007–2015. Hungarian agriculture represents an interesting case study for several reasons.

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Hungarian agriculture during the socialist period was collectivized and the transition process involved agrarian de-collectivization, agricultural privatization, and economic liberalization at the beginning of the 1990s. It was expected that these reforming and transformation processes would contribute to a rise in the number and importance of family farms (Csaki and Lerman, 1997; Swinnen, 1999). Hungary adopted a compensation rather than restitution approach in respect of land privatization (Fleming, 1995). This unique process of agrarian de-collectivization and agricultural privatization in comparison to in other CEE countries led to less radical farm and agricultural structural changes, as former landowners may be compensated for but not have land restituted.

The later development path of individual/family farms has followed a pattern that is typical of developed countries; namely, a decline in the number of farms and an increase in average farm size (Bojnec and Fertő, 2021a; 2021b). Therefore, the main research question is the following: What are the main drivers of family farm growth in the Hungarian context? To answer this research question, we follow the approach of earlier literature (Rizov and Mathijs, 2003; Akimowicz et al., 2013; Bojnec and Fertő, 2021a) but make adjustments due to the specificity of Hungarian individual/family farms. The focus is on the internal human capital and farm-characteristic factors of family farm growth, as well as spatial farm regional location characteristics and government subsidies.

The process of de-collectivization in Hungary without land restitution played a unique role in the setting up and developing of individual farms using land vouchers and land auctions in the land market, and land-lease market developments (Swinnen et al., 1997). Therefore, Hungarian family farms may be excellent subjects for a case study comparison with farms in other countries with a typical dual farm structure consisting of a small number of privatized, more developed corporate farms coexisting alongside a large number of smaller farms that developed particularly because of the transition process, involving agricultural and farm transformation.

More specifically, the paper contributes to the literature in the following three ways. First, it identifies drivers of family farm growth, focusing on human capital variables that may be important for family farm-, agricultural-, and rural entrepreneurship that relies on managerial skills or entrepreneurial knowledge. While some studies have investigated the roles of human capital in the technical efficiency (Mathijs and Vranken, 2001) and farm survival and growth of Hungarian farms (Rizov and Mathijs, 2003), our focus is on the leaders of the farms and their role in family farm growth. Second, the relationship between family farm growth and the heads of farms is controlled by personal and farm characteristics, including spatial regional farm locational characteristics, and government subsidies. Finally, family farms can play multifunctional roles in rural communities, including creating jobs and income through on- and off-farm diversification (Bojnec and Knific, 2021). Understanding family farm growth (and thus the survival of the latter) is important for research, policy, and practice aimed at maintaining the prosperity of rural communities and the populated landscape of the countryside (Zurek et al., 2022).

The rest of the paper is organized as follows. In the following section, the development of the number of farms and their average size is presented, indicating the dual farm structure in Hungary. The third section describes the drivers that determine the growth of farms and develops hypotheses. The fourth section presents the methodology and data used in the research, whilst the fifth section details the empirical results of the econometric analysis. The sixth section discusses results and findings, and the final section concludes.

2. The number of farms and farm size

Over the past half-century, the number of agricultural farms in developed countries has declined significantly (Goddard et al., 1993; Lowder et al., 2016). A similar trend has been observed in Hungary during the last two decades (Bojnec and Fertő, 2021b). After the shock of the first decade of the transition in the 1990s, the number of farms continued to decline. The number of individual farms was 959 thousand

in 2000, but had dropped to 416 thousand by 2016. The number of corporate economic organizations, on the other hand, has tended to increase (from 8,382 in 2000 to 9,388 in 2016). Interestingly, the extent of corporate farms as a proportion of agricultural land has decreased with the increase in ownership, and vice versa for individual farms. The average size of agricultural area has moved in the opposite direction in each farm category. The average agricultural area of individual farms increased from 4.6 ha to 7.6 ha, while the average area of corporate farms decreased from 326 ha to 248 ha between 2000 and 2016.

An important agricultural policy goal of the government is to increase the role of family farms in domestic agriculture. While an earlier paper by Rizov and Mathijs (2003) concluded that larger farms are more likely to grow faster and are more likely to survive than smaller ones, later studies for the period of 2001–2007 contrastingly show that smaller farms are growing faster than larger ones, and subsidies and the age of farm managers significantly influence the growth of farms (Bakucs and Fertő, 2009; Fertő and Bakucs, 2009; Bakucs et al., 2013).

Research on farm growth may also be important for policy and practice in terms of implications for agricultural policymakers and farm managers. The role of the agricultural sector is declining in the share of gross domestic product (GDP) and farms are facing competitive pressure from domestic and international markets (Goddard et al., 1993; Weerahewa and Jacque, 2022). Structural changes in farm size can have implications for the demand for labor and rural labor markets (Salam and Bauer, 2018), for land use and land markets (von Solms and van der Merwe, 2020), and for polycentric and resilient sustainable development (Gatto, 2022). Despite Common Agricultural Policy (CAP) subsidies, competition within European Union (EU) markets creates market-selection pressures for farm restructuring that are more severe for less well market-integrated and less competitive smaller and medium-sized family farms.

The increasing competitive pressures and need for income growth is forcing smaller individual farmers to increase the size of their holdings or supplement their income outside the agricultural sector and, in extreme cases, to exit farming (Petrick and Tyran, 2003; Blancard et al., 2016).

3. Factors determining the growth of farms

The growth of farms is a multidimensional phenomenon that can be examined using different theoretical perspectives. The theoretical basis for empirical studies of corporate growth is the widely used Gibrat's law. According to Gibrat's law, the growth of companies is a stochastic process that is the result of several unobservable random variables. Therefore, the growth rate of firms/farms is independent of their initial size at the beginning of a given period (Gibrat, 1931). We thus define the first hypothesis (H1) as:

H1. Farm growth is independent of initial farm size.

Stochastic models of corporate growth have generally approached the issue of firm/farm growth in one of two ways. On the one hand, they have investigated whether the actual size distribution of companies follows a lognormal form. The other approach investigates the relationship between the growth of companies and their size using econometric methods. In connection with the second type of approach, some empirical literature, using various theoretical considerations, has explicitly attempted to model the factors that influence the growth of companies. For example, one group of researchers has assumed and argued that the human capital of business leaders is heterogeneous (Penrose, 1959; Lucas, 1978; Jovanovic, 1982), or that sunk-costs may result from changes in capacity and technology (Cabral, 1995). Others use the results of evolutionary economics (Nelson and Winter, 1982), emphasizing the importance of path dependence (Balmann et al., 1996) or the importance of transaction costs within a firm (Pollack, 1985).

The effects of human capital variables on farm size growth have been found to be mixed. Human factors may play a prominent role in the growth of farms (Huffman, 2001). Forgács (2007) in the case of two agricultural cooperatives in Hungary found that leadership and social capital were

important. Relevant leadership skills and human capital can increase a farmer's managerial ability to efficiently adapt to a continuously changing economic environment (Byma and Tauer, 2010). At the same time, opportunities outside of agriculture can also be related to a farmer's human capital and the potential outflow of younger, better educated, and more flexible labor from farms to other non-agricultural activities (Bojnec and Dries, 2005). Consequently, the net effect of human capital on farm growth in practice can be mixed (Bojnec and Fertő, 2021a).

Farmers' human capital is usually measured by age and education. Rodgers (1994) suggests that a distinction should be made between specific and general human capital in explaining agricultural structures. He argues that general human capital determines farmers' expected nonfarm income, while farming-specific human capital determines their productivity in farming. Weiss (1999) finds that general and agricultural training is positively correlated with increasing farm size. However, agricultural training has less of an effect on farm size than the level of general education.

Farmers' age (young) is positively correlated with an increase in farm size, and vice versa (e.g., Weiss, 1999). In summary, previous empirical research points out that the relationship between human capital and farm size growth remains unclear. Accordingly, we define the following H2 and H3:

H2. Farm growth is positively associated with farmers' education.

H3. Farm growth is nonlinearly associated with farmers' age.

Other factors may also be significantly correlated with farm size growth. These include the legal status of farms and non-agricultural job opportunities for family members. The general economic situation (demography, employment, and interest rates) can also influence the growth strategies of farms. Factors influencing farm growth can be divided into three major groups. First, market factors that affect input and output prices. Second, technological factors that affect yield or economies of scale. Third, institutional factors such as laws, agricultural policy, and vertical relationships with other sectors (Haque, 2022). Among all these factors, we focus on the association between farm growth and CAP subsidies. We define the following hypothesis:

H4. Farm growth is positively associated with CAP subsidies.

In addition to CAP subsidies, heterogeneous farm-size dynamics can be biased in line with different types of farming (Saint-Cyr, 2022). We therefore define the following hypothesis:

H5. Farm growth is particularly associated with some types of farming.

Akimowicz et al. (2013) draw attention to the fact that spatial locational factors can also influence farm growth. Their results show that the proximity of urban areas significantly influences farm growth in France. We therefore define the following hypothesis:

H6. Farm growth is linked to spatial farm location and regional characteristics.

Following Akimowicz et al. (2013) for France and Bojnec and Fertő (2021a) for Slovenia, and hypotheses H1 to H6 our focus is on family farm size growth in Hungary in relation to human capital factors controlled for farm size. This enables testing the validity of Gibrat's law and the influence of CAP subsidies, different types of farming, and selected spatial farm location regional characteristics.

4. Methodology and data

The factors determining the growth of family farms are estimated using an econometric model. The standard econometric specification for testing the validity of Gibrat's Law is the following:

$$\log S_{i,t} = \beta_0 + \beta_1 \log S_{i,t-1} + \mu_{it} \tag{1}$$

where $S_{i,t}$ and $S_{i,t-1}$ are the size of the ith farm in the period t and in the previous period t-1, respectively. $\varepsilon_{i,t}$ is the disturbance in period t, independent of $S_{i,t-1}$. if $\beta_1 = 1$ (i.e., if Gibrat's Law holds), then positive

(negative) values of β_0 indicate growth (decrease) in average farm size. If, however, $\beta_1 < 1$, then smaller farms tend to grow faster than larger ones.

The growth model in Eq. (2) is modified by redefining the dependent variable as the first difference of the logarithm of farm size in Eq. (1):

$$\log S_{it} - \log S_{it-n} = \beta_0 + \beta_1 S_{it-n} + X_{it-n}\gamma + \mu_{it} \tag{2}$$

where X_{it-1} represents a group of additional covariates, and the n superscripts denote the starting period of our analysis (2007).

In this paper, family farms are defined as individual farms. The size of family farms is measured in European units of size (ESU or EUME in Hungarian conditions). The dependent variable is the natural logarithm of the growth intensity between the initial year 2007 and the final year 2015 of the analysis, which covers the post-accession period of Hungary to the EU. Increases in farm growth intensity occurred when ln EUME $_{2015-2007}$ was a positive value. The use of the natural logarithm improves the normality of the distribution of variables and is therefore more in line with model assumptions. The first explanatory variable is the natural logarithm of the size of the family farm in 2007 expressed in EUME. We add the following covariates to the empirical model. The human capital of farms is measured by two dummy variables. The value of the agricultural graduation variable is one if the head of the farm has a higher-level agricultural education, and is otherwise zero. Similarly, the value of the general education variable is one if the head of the farm has a non-agricultural higher-level education, and is otherwise zero.

The value of the gender variable is one if the head of farm is a woman and zero if it is a man. Some previous studies have argued that young female farmers can be more agri-environmental aware and entrepreneurial than their male counterparts (Unay-Gailhard and Bojnec, 2021) – this finding serves to justify assigning a score of '1' to female gender.

As the distribution of subsidies is unequal across farms – typically, 20 percent of farms receive eighty percent of subsidies (Fertő et al., 2022) – the potential impact of subsidies on the growth of family farms is examined. In the model, the natural logarithm of all forms of support is used as a control variable.

Each agricultural sector is appraised by types of farming that involve different technologies. They are controlled with dummy variables as a basis for comparison is the poultry sector.

Finally, the spatial regional location of the farms is considered. Eurostat divides regions into three categories: urban, intermediate, and rural. In the model, the effect of spatial regional farm location is controlled with dummy variables, considering farms located in urban regions as a basis for comparison.

In the OLS regression estimation, error terms are assumed to follow the same distribution irrespective of the value of the explanatory variables. Since we can only analyze surviving farms, estimations are conditional on survival (*conditional objects*, see Lotti et al., 2003).

Following recent studies, quantile regression is used to distinguish samples and divide the heterogenous sample into farm-size groups. The θth sample quantile, where $0 < \theta < 1$, can be defined as:

$$\min_{b \in R} \left[\sum_{i \in \{i: y_i \geq b\}} \theta |y_i - b| + \sum_{i \in \{i: y_i < b\}} (1-\theta)|y_i - b| \right] \tag{3}$$

where y_i and b in Eq. (3) are estimated for any quantile within the range of zero and one.

For a linear model such as fx1, the θth regression quantile is the solution of the minimization problem, similarly to with Eq. (4):

Solving Eq. (4) for b provides a robust estimate of β.

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

If we maintain the same farms in the balanced panel dataset during the period of analysis, the sample size is considerably reduced. We addressed a smaller sample size applying bootstrapped quantile

regression models with bootstrapped standard errors using 1,000 replications. Finally, we estimated Eq. (2) using an ordinary least squares (OLS) model as a benchmark for our quantile estimations.

4.1. Sample selection

Another challenge in the empirical analysis is sample selection. Since the farm size growth rate can only be examined in terms of surviving farms (i.e., those which are still operational at time t), and the farms that are most likely to disappear are among the slow-growing ones, small, fast-growing farms may be overrepresented in the sample, which may skew the results. This issue is particularly relevant in the present investigation as the proportion of smaller family farms in transition economies, including in Hungary, is much greater than in developed countries. Wald tests were used to check that the coefficients of the variables differed between each quantile.

The analysis is based on cross-sectional data obtained from the Hungarian Farm Accountancy Data Network (FADN) database. We investigate the same farms between the two years 2007 and 2015. The selection of farms is based on the agricultural structural censuses implemented by the Hungarian National Central Statistical Office (HNCSO). Since reaching national coverage, data on about 2,000 agricultural enterprises have been collected on an annual basis. In addition to accounting and financial data, the scope of data collection includes land use, labor force, production data, and sector-level data. In 2015, the FADN database contained 1,585 individual farms and 377 corporate farms, of which only 1,207 agricultural farms were the same as in the 2007 sample: 978 in the category of individual farms and 229 in the category of corporate farms. Price indices as deflators were obtained from the HNCSO. They are used to transform current forint values into constant forint values using 2010 as the base year. Data on types of regions were also obtained from the HNCSO.

Figure 1 shows the growth rate Kernel density function. However, the Shapiro-Wilk W (1965) test, Shapiro-Francia W' (1972) test, and Chen-Shapiro QH* (1995) test imply rejection of the assumption of the normal distribution of the farm growth rate variable at a one percent significance level. This confirms the importance of using quantile regressions (Table 1).

Table 1. Tests for the normal distribution of the farm growth rate variable.

Shapiro–Wilk W test for normal data					
Variable	Obs	W	V	Z	Prob > z
lnsizegr	978	0.965	25.522	8.083	0.0000
Shapiro–Francia W' test for normal data					
Variable	Obs	W'	V'	Z	Prob > z
lnsizegr	978	0.964	28.135	7.741	0.0000
Chen-Shapiro QH* test for normal data					
Variable	Obs	QH	QH*	P value	
lnsizegr	978	0.984	0.5295	<0.0001	

Source: Authors' calculations based on the Hungarian FADN database.

4.2. Descriptive statistics of variables

Table 2 illustrates the averages of farm size and explanatory variables in the reference initial year 2007 and the final year 2015. The average age of family farmers was 51 years in 2007 and 58 years in 2015. The majority of farmers (66 percent in 2007 and 68 percent in 2015) had an agricultural college degree, and 5 percent had completed general higher education, while 91 per cent of farmers were male in 2007 and 90 percent in 2015. This latter finding highlights the gender imbalance in family farm leadership. CAP subsidies are an important source of farm income, reaching 16,868 euros per farm in 2007 and 29,526 euros per farm in 2015 for the analyzed sample. Nine types of farming dummy variables are compared with the poultry sector dummy variable as a benchmark of comparison. The type-of-farming dummy variables indicate slightly greater or similar farm size growth for milk and mixed farms, and higher farm size growth for farms specialized in grass, fruit, and mixed farming, and particularly in crop production, but lower farm size growth for farms specialized in vegetables, pigs, grapes, and vegetable fields. There are considerable differences in the spatial regional farm location dummy variables, with a relatively low value for the benchmark urban region farms vis-à-vis intermediate regions, and lower than in rural regions. The highest mean value of the dummy variable for the intermediate regions is equal to 0.81, suggesting that in 81% of such regions, family farms are present.
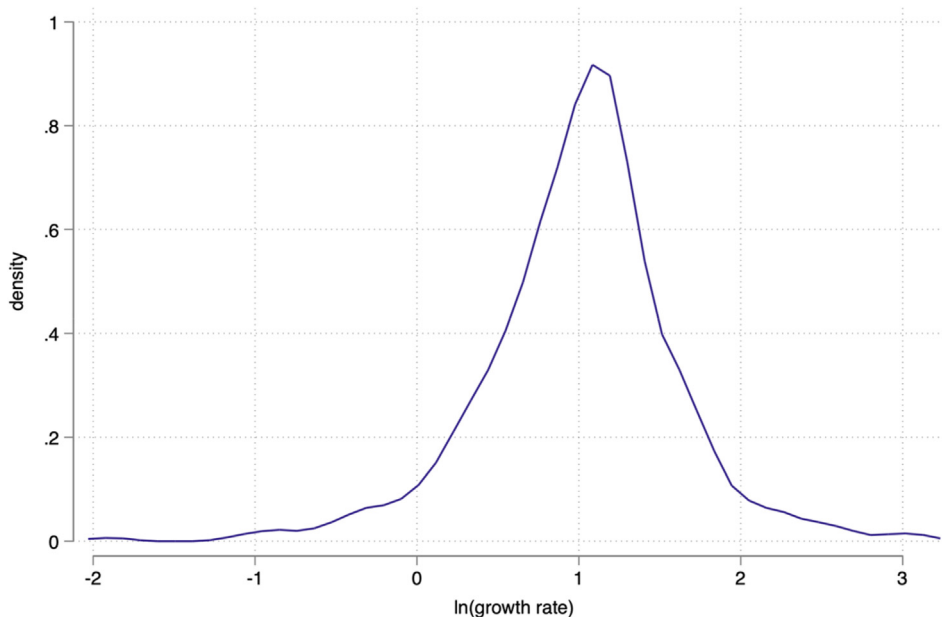
Figure 1. Kernel density of family farm size growth rate. Source: Authors' calculations based on the Hungarian FADN database.

Table 2. Descriptive Statistics of Variables for reference initial year 2007 and final year 2015.

	2007									
Variable	Obs	Mean	Std. dev.	Min	Max	P50	P10	P25	P75	P90
farm size (in EUME)	979	30.9	32.7	2.2	380.0	56.0	5.8	10.6	40.5	64.4
age (years)	979	50.7	10.6	23.0	82.0	58.0	36.0	44.0	58.0	64.0
agricultural education	979	0.66	0.47	0	1	1	0	0	1	1
general education	979	0.05	0.22	0	1	0	0	0	0	0
gender (woman = 1)	979	0.09	0.28	0	1	0	0	0	0	0
total CAP subsidy (in EUME)	979	16868	21234	0	243907	17675	1528	3819	23656	39582
farm-type dummy										
Poultry	979	0.05	0.22	0	1	0	0	0	0	0
Fruit	979	0.09	0.29	0	1	0	0	0	0	0
Grass	979	0.08	0.27	0	1	0	0	0	0	0
crop production	979	0.53	0.50	0	1	1	0	0	1	1
Pigs	979	0.03	0.16	0	1	0	0	0	0	0
Grapes	979	0.03	0.18	0	1	0	0	0	0	0
Milk	979	0.06	0.23	0	1	0	0	0	0	0
Mixed	979	0.08	0.28	0	1	0	0	0	0	1
Vegetables	979	0.02	0.13	0	1	0	0	0	0	0
vegetable field	979	0.04	0.19	0	1	0	0	0	0	0
region-type dummy										
urban region	979	0.09	0.29	0	1	0	0	0	0	1
intermediate region	979	0.81	0.39	0	1	1	0	1	1	1
rural region	979	0.10	0.30	0	1	0	0	0	0	0
2015										
Variable	Obs	Mean	Std. Dev.	Min	Max	P50	P10	P25	P75	P90
farm size (in EUME)	978	93.1	106.0	4.3	1125.4	40.3	12.5	26.2	121.6	213.5
age (years)	977	57.6	10.9	20.0	90.0	55.0	42.0	50.0	65.0	71.0
agricultural education	978	0.68	0.47	0	1	1	0	0	1	1
general education	978	0.05	0.22	0	1	0	0	0	0	0
gender (woman = 1)	978	0.10	0.29	0	1	0	0	0	0	0
total CAP subsidy (in EUME)	978	29526	35433	0	361550	15534	2480	6532	38151	72404
farm-type dummy										
Poultry	978	0.05	0.21	0	1	0	0	0	0	0
Fruit	978	0.09	0.28	0	1	0	0	0	0	0
Grass	978	0.08	0.26	0	1	0	0	0	0	0
crop production	978	0.58	0.49	0	1	1	0	0	1	1
Pigs	978	0.02	0.15	0	1	0	0	0	0	0
Grapes	978	0.03	0.18	0	1	0	0	0	0	0
Milk	978	0.05	0.22	0	1	0	0	0	0	0
Mixed	978	0.05	0.22	0	1	0	0	0	0	1
Vegetables	978	0.01	0.11	0	1	0	0	0	0	0
vegetable field	978	0.04	0.20	0	1	0	0	0	0	0
region-type dummy										
urban region	978	0.09	0.29	0	1	0	0	0	0	1
intermediate region	978	0.81	0.40	0	1	1	0	1	1	1
rural region	978	0.10	0.30	0	1	0	0	0	0	0

Source: Authors' calculations based on the Hungarian FADN database.

Farm size in EUME and total CAP subsidy in EUME both at 2010 values as the base-year, and average age of head of farms increased between 2007 and 2015, but there was less change in terms of gender – the role of women even slightly increased –, as well as education, farm type, and region type.

Kernel density functions were applied for ln farm size in EUME in 2007 and 2015 to show the difference between the two years under analysis. Figure 2 presents a slight shift in average farm size concentration towards the right, suggesting a slightly larger average farm size in EUME in 2015 than in 2007.

A Kruskal-Wallis test was used to check the equality of means between these two years: this confirmed that there was a significant change in the distribution of farm size along with the overall numerical increase between the analyzed years 2007 and 2015. In addition, Table 3 shows a significant increase between the same years for farm head age and total CAP subsidies, as well as for the crop-production dummy, and a significant decline for the mixed-farm dummy. Like agricultural education, general education and gender, all other farm-type dummies and region-type dummies did not change significantly over the period of analysis.

5. Econometric empirical results

Table 4 shows the results of quantile regressions for family farm size growth rate according to five quantiles and OLS regression as a
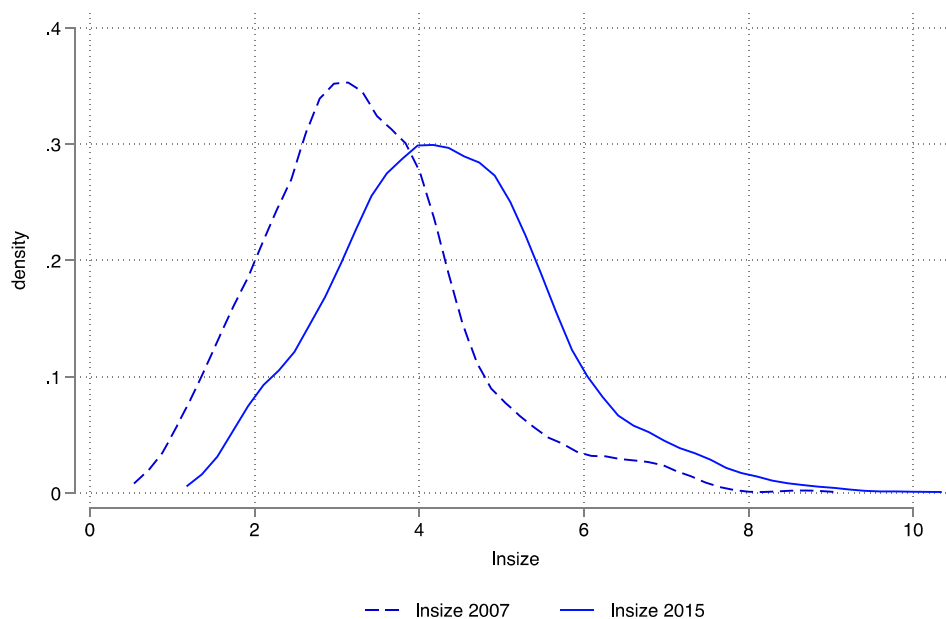
Figure 2. Kernel density of ln farm size in EUME. Source: Authors' calculations based on the Hungarian FADN database.

Table 3. Kruskal-Wallis test of the equality of mean values of variables between the initial (2007) and final (2015) years of analysis.

Variable	Kruskal-Wallis test (p value)
farm size (in EUMU)	0.0001
age (years)	0.0001
agricultural education	0.3286
general education	0.8339
gender (woman = 1)	0.8117
total subsidy (in EUMU)	0.0001
farm type dummy	
poultry	0.6794
Fruit	0.8170
grass	0.8725
crop production	0.0244
Pigs	0.7749
grapes	0.9034
Milk	0.5447
mixed	0.0022
vegetables	0.5789
vegetable field	0.7258
region-type dummy	
urban region	0.9318
intermediate region	1.0000
rural region	0.9499

Source: Authors' calculations based on the Hungarian FADN database.

benchmark. Machado and Santos Silva (2000) tests confirm the presence of heteroskedasticity for the upper quantiles. To deal with heteroskedasticity we estimated our quantile models with robust standard errors. The size of family farms has a positive effect on their growth in each quantile, although the value of the coefficients decreases towards the higher quantiles, thus rejecting the validity of Gibrat's law and suggesting that smaller family farms grew faster than bigger family farms. The rejection of the validity of Gibrat's law is inconsistent with earlier work by Rizov and Mathijs (2003) that used cross-sectional data, but consistent with later studies that used more comprehensive and representative FADN data samples to examine family farm growth in Hungary (Bakucs and Fertő, 2009; Bojnec and Fertő, 2021b).

The age of the head of the farm has a negative effect on farm growth from the median quantile upwards. This suggests that farms with younger heads are growing faster than those with older ones. This finding confirms the results for the previous period (Bakucs and Fertő, 2009). However, it contradicts the claim of Jovanovic (1982), who argues that learning and experience are positively correlated with the growth of firms. In our case, we argue that the farming society associated with family farms in Hungary is an aging one (the average age of heads of farms is 54 years), and that farmers older than the median may no longer be expected to increase the size of their farms.

Farms managed by women were less liable to grow than farms managed by men in the 25th and 50th quantiles. This finding does not support that of Unay-Gailhard and Bojnec (2021) regarding the gender on Slovenian family farms. This striking finding might suggest that gender imbalances in Hungarian family farm leadership are a potential source of family farm entrepreneurship, including on- and off-farm activities such as farm tourism and other farm-related supplementary activities.

CAP subsidies reduce the growth of family farms. This surprising result may be because larger farms receive the vast majority of subsidies, while their growth potential is less than that of smaller farms (Bojnec and Fertő, 2019; Fertő et al., 2022). Previous studies also confirm that smaller farms grow faster than larger ones (Bakucs and Fertő, 2009; Bakucs et al., 2013; Fertő and Bakucs, 2009; Bojnec and Fertő, 2021b).

The majority of farming types of dummy regression coefficients are significant and negative at various points in the distribution. This suggests that the other nine types of farms have on average grown more slowly than poultry sector farms.

The spatial regional location of the farms has no significant influence on the growth of family farms, a finding which contrasts with the results of Akimowicz et al. (2013) for France. The reason for this may be the structural differences between Hungarian and French agriculture. In Hungary, the demand for land in urban regions had less effect on family farm size growth in the period under review.

Quantile regressions are not significantly different by quantile although farm size is not normally distributed, thus we applied quantile regressions instead of the OLS regression method. To test the robustness of the quantile regression results, OLS regression was applied. As can be seen from column 6 in Table 4, OLS regression generates similar results to the quantile regressions, so our results are rather robust. The regression coefficient is significantly positive for ln farm size in EUME 2007;

Table 4. Results of quantile and ordinary least squares (OLS) regression models.

Variable	(1) Q10	(2) Q25	(3) Q50	(4) Q75	(5) Q90	(6) OLS
ln EUME_2007	0.468*** (0.102)	0.390*** (0.0539)	0.357*** (0.0526)	0.333*** (0.0535)	0.233*** (0.0843)	0.396*** (0.0438)
Age	-0.004 (0.00400)	-6.12e-05 (0.00154)	-0.003** (0.00125)	-0.005*** (0.00156)	-0.008*** (0.00285)	-0.00262* (0.00140)
Agricultural education	-0.086 (0.0999)	-0.008 (0.0494)	-0.070** (0.0352)	-0.079** (0.0341)	-0.036 (0.0602)	-0.0664* (0.0361)
General education	-0.187 (0.186)	-0.034 (0.103)	0.048 (0.0900)	0.008 (0.0595)	-0.135 (0.126)	-0.0176 (0.0751)
Gender	-0.190 (0.147)	-0.118* (0.0699)	-0.151** (0.0724)	-0.080 (0.0542)	-0.008 (0.0974)	-0.0839 (0.0574)
lnSubsidy	-0.156* (0.0915)	-0.147*** (0.0496)	-0.169*** (0.0491)	-0.161*** (0.0491)	-0.0884 (0.0826)	-0.161*** (0.0407)
Fruit	-0.445 (0.314)	-0.619*** (0.125)	-0.823*** (0.133)	-0.894*** (0.138)	-1.180*** (0.281)	-0.698*** (0.114)
Grass	-0.132 (0.361)	-0.275 (0.170)	-0.304* (0.169)	-0.376** (0.179)	-0.785** (0.334)	-0.282* (0.148)
Crop production	-0.330 (0.310)	-0.479*** (0.130)	-0.484*** (0.137)	-0.561*** (0.145)	-0.874*** (0.281)	-0.470*** (0.119)
Pigs	-0.549 (0.438)	-0.0936 (0.296)	-0.241 (0.158)	-0.319** (0.145)	-0.514* (0.266)	-0.297** (0.147)
Grapes	-0.446 (0.324)	-0.738*** (0.139)	-0.993*** (0.142)	-1.153*** (0.188)	-1.292*** (0.289)	-0.809*** (0.124)
Milk	-0.0107 (0.334)	-0.294** (0.137)	-0.394*** (0.137)	-0.553*** (0.149)	-0.892*** (0.288)	-0.368*** (0.121)
Mixed	-0.327 (0.360)	-0.354** (0.146)	-0.511*** (0.136)	-0.575*** (0.144)	-0.772** (0.314)	-0.431*** (0.125)
Vegetables	-1.238** (0.574)	-0.996** (0.453)	-0.855*** (0.292)	-1.088*** (0.260)	-0.728* (0.416)	-0.948*** (0.210)
Vegetable field	-0.721** (0.351)	-0.648*** (0.200)	-0.500*** (0.184)	-0.537*** (0.160)	-0.562* (0.288)	-0.569*** (0.135)
Intermediate region	0.0421 (0.128)	0.0155 (0.0787)	-0.0730 (0.0524)	-0.0788* (0.0468)	-0.0291 (0.0841)	-0.00917 (0.0565)
Rural region	-0.0491 (0.169)	0.0154 (0.109)	0.0575 (0.0712)	0.00964 (0.0621)	0.0644 (0.103)	0.0320 (0.0756)
Constant	0.653 (0.610)	1.095*** (0.286)	2.006*** (0.260)	2.441*** (0.251)	2.788*** (0.538)	1.636*** (0.233)
Pseudo R^2	0.1748	0.1926	0.1997	0.2216	0.2465	
R^2						0.336
N	962	962	962	962	962	962
Machado-Santos Silva test						
(p value)	0.000	0.004	0.655	0.833	0.323	0.072
VIF						3.03

Note: robust standard errors in the parentheses, level of significance, ***p < 0.01 = at 1%, **p < 0.05 = at 5%, *p < 0.1 = at 10%.
Source: Authors' calculations based on the Hungarian FADN database.

significantly negative for lnSubsidy, the farm types fruit, crop production, grapes, milk, mixed, vegetables, and vegetable field; negative at a 5% significance level for farm type pigs; and significantly negative at 10% significance level for age, agricultural education, and farm type grapes; and insignificant for general education, gender, intermediate region, and rural region.

Figure 3 shows the results of the quantile and OLS regressions with a 95 percent confidence interval for the key variables in the model: initial farm size, age, agricultural education, general education, gender, and CAP subsidies. The latter are included because they are an important driver of farm growth.

We can see that for most of the variables the coefficients of the quantile regressions are within the confidence interval of the OLS regressions except for the coefficients of farm size in ln EUME and age variables in the high quantiles. This suggests that our results are stable at different points in the distribution, which is also confirmed by the Wald tests used to check equality across quantiles in Table 4 for all variables except for farm-type dummy variables and region-type dummy variables (Table 5). There is a difference only for the age variable at a 10 percent significance level. Family farms in Hungary are rather homogenous in terms of coefficients related to drivers of family farm size growth.

6. Discussion

Within the structure of Hungarian agriculture, a smaller number of large-scale commercial farms play a dominant role in large-scale crop farming, whilst the larger number of family farms is important in relation to many other farming specializations. Similarly to the situation in developed countries, the number of family farms has declined, and their average size has increased. It is likely that similar patterns of farm growth will continue to exist in the future with climate-change-related adjustments, technological changes, and digitalization of the farming sector, which require investment that may only be manageable for farms of at

least a minimum size, and depend on farm-type specialization (Gatto, 2022; Zurek et al., 2022). Whilst small-scale farms might survive as hobby and diversified farms with non-farming activities and incomes on and off farm, it is likely that many of them will exit farming, particularly in less-favored areas for farming (Huber et al., 2015).

Our results are largely consistent with previous studies that have rejected the validity of Gibrat's law for Hungarian family farms, confirming that the smaller family farms have grown faster than larger ones. This finding confirms H1 and implies that farm size growth is independent of initial farm size. The market-driven selection environment can also provide opportunities for the growth and survival of smaller family farms, depending on farm type specialization (Akimowicz et al., 2013; Blancard et al., 2016; Bojnec and Knific, 2021).

However, the focus of our study was not on testing the validity of Gibrat's law for family farm size growth, but underlining the importance of some other drivers in relation to farm size growth. The results about human capital variables – age, agricultural education, and gender – and on CAP subsidies differ considerably between the farm quantiles.

Agricultural education is insignificant for the lowest and highest quantiles, and significantly negative for the 50th and 75th quantiles. General education is insignificant for all quantiles. This finding is largely inconsistent with our theoretical expectation, and suggests rejection of H2. The future growth of Hungarian family farms in relation to farm leaders' age and education structures is not propitious. The farmer population is aging, with little room to improve human capital. However, an agricultural and general education may be important for young heads of farms who enter the agricultural sector. Therefore, human capital improvements and generational renewal may require better educated and trained individuals becoming involved in growing family farms. The young and educated may be more flexible and entrepreneurial than the less-educated elderly heads of farms.

Age is found to be insignificant for lower quantiles and significantly negative for the 50th and higher quantiles. This confirms H3 about the
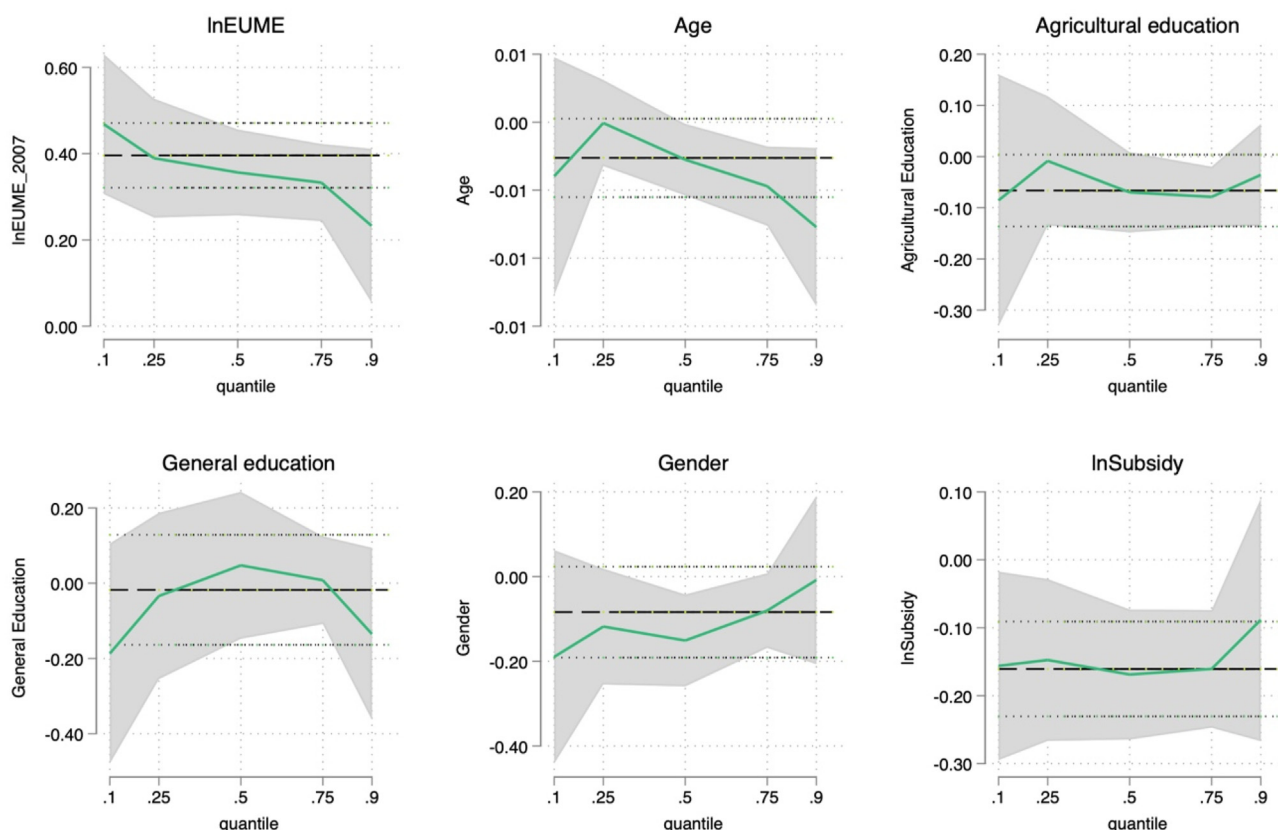
Figure 3. Coefficients and confidence intervals of quantile and ordinary least squares (OLS) regressions. Source: Authors' calculations based on the Hungarian FADN database.

nonlinear association between farm size growth and farmer age. Elderly farmers are less likely to invest effort into increasing family farm size.

Gender is insignificant for the lowest and two highest quantiles and significantly negative for the 50th quantile and to a lesser extent for the 25 quantile. The gender imbalance on Hungarian family farms may have negative implications not only for farming but also in terms of socio-economic and demographic consequences, as well as the survival of farm households, agriculture, and rural areas.

These non-linearities in the role of human capital variables – education, age and gender – on farm size growth according to quantile imply the need for different policies and practical and farm managerial measures regarding individual/family farm size growth.

Previous studies have argued for the different roles of farm subsidies on farm size growth. Except for the 90th quantile and to a lesser extent for the 10 quantile CAP subsidies are found to be highly significant, but with a negative sign of the regression coefficient for the 25th, 50th, and 75th quantiles. These mixed results for CAP subsidies by quantile and their negative effects on individual farm size growth are largely inconsistent with H4. The result might suggest that CAP subsidies can play various roles for farms that are not only efficiency or growth-related (Baráth

et al., 2020; Lillemets et al., 2022). For example, their effect might be less farm size growth oriented, but capable of mitigating farm-related losses on Hungarian farms (Fertő et al., 2022).

Each of the statistically significant associations with type of farming by quantile has a negative sign, suggesting lower farm size growth than for the benchmark poultry type of farming. Only vegetable farms are associated with a significant negative sign for each quantile. Except for the 10th quantile, this also holds true for fruit, crop production, grapes, milk, and mixed farming. Grass and pig farming regression coefficients are significant for the 75th quantile as well as grass for the 90th quantile, and to a lesser extent for pigs, and to a lesser extent for grass for the 50th quantile. Like vegetable farms, vegetable fields are associated with a significant negative sign for each quantile. This heterogeneity in results and findings across types of farming and farm size quantiles supports H5 that farm growth is associated with particular types of farming.

Rural region is statistically insignificant, whilst intermediate region is significant at a 10% significance level for the 75th quantile. These results regarding H6 about farm growth associated with spatial farm location regional characteristics confirm that spatial regional farm location plays a less important role in family farm size growth in Hungary.

During the last two decades, the pattern of farm size growth and development of Hungarian individual farm restructuring – involving a reduction in the number of farms and the increase in the average farm size – has been similar in developed and some transition countries (Plogmann et al., 2022). There may be some spatial territorial differences in agricultural factor endowments and their effects on farm growth between regions and municipalities that are causing the dynamics of farm restructuring (Appel and Balmann, 2022). Among important factors for farm restructuring and family farm size growth, we identify the non-linear and different effects of the prevailing type of farming specialization. This finding can be linked to the previous literature on the role of type of farming on farm efficiency (Jin et al., 2019) and farm

Table 5. Tests of equality of regression coefficients by quantile (p-values).

	Wald test (p-value)
ln farm size in EUME	0.4374
Age	0.0613
Agricultural education	0.4558
General education	0.5387
Gender	0.6584
lnSubsidy in EUME	0.8775

Source: Authors' calculations based on the Hungarian FADN database.

restructuring (Pereira Domingues Martinho et al., 2022). Different types of farming can also be affected differently by climate change (Solymosi et al., 2010), technological change, innovation, the introduction and application of artificial intelligence, and digitalization processes on farms and local food systems (Raheem, 2020). These various drivers can also have non-linear impacts on farm size growth and farm restructuring. This can be an issue for research in the future.

7. Conclusions

The article contributes to the research, policy, and practice related to the main drivers of family farm growth in the Hungarian context and the versatile role of family farms in rural areas. The paper helps identify the drivers of family farm size growth and the extent to which the growth of family farms is influenced by human capital and management skills, controlled for farm size, and tests the validity of Gibrat's law and impact of CAP subsidies, different types of farming, and selected spatial farm location regional characteristics in Hungarian agriculture between 2007 and 2015 using data from the FADN system. Our results – similarly to previous findings (Bakucs and Fertő, 2009) – show that the size of farms has a positive effect, while CAP subsidies have a negative effect on the growth of family farms, suggesting that farms are overdependent on CAP subsidies.

Surprisingly, unlike the study of Forgács (2007) on leadership and social capital in two Hungarian agricultural cooperatives, our in-depth econometric study based on a more comprehensive and representative FADN data sample suggests rejection of the hypothesis of the crucial role of human capital for family farm size growth, as farmers' leadership skills are found to be less important in family farm economic growth strategy. Farmers' agricultural-specific human capital has a more negative effect on the growth of family farms. This may be because the specific human capital of an aging farming society is already obsolete, and therefore an obstacle to the growth of family farms. The finding highlights the need to pay more attention to the renewal of the farming profession with a greater role for the human capital of the young farming generation and its development, especially during succession. This may be a precondition of the survival and growth potential of family farms.

Among the study limitations is the nature of the FADN dataset with its limited number of human capital and managerial or head-of-farm variables and farm-household variables that can be included in the empirical analysis. Growing farms can be agglomerated in space. Studying the agglomeration effects of farm growth would require different datasets obtained from agricultural census data that permit comparison of farm growth with farm location, farmers' and farm households' characteristics, and other variables.

In addition to the FADN dataset limitations, there is room for further analysis. Among the issues for research in the future is an investigation of farm size growth related to financial variables such as the role of liquidity constraints and access to finance. Farm size growth can also be linked to CAP changes regarding support for young farmers and rural development measures. Finally, farm size growth may continue to be caused by climate change and the robotization and digitalization of farms. The adoption of modified production technologies will require investment that is likely to cause further farm restructuring that varies by farm type and spatial regional location.

Declarations

Author contribution statement

Štefan Bojnec: Analyzed and interpreted the data; Wrote the paper.
Imre Fertő: Estimated the empirical model; Analyzed and interpreted the data; Wrote the paper.
Szilárd Podruzsik: Analyzed and interpreted the data; Wrote the paper.

Data availability statement

The authors do not have permission to share data.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

References

Akimowicz, M., Magrini, M.B., Ridier, A., Bergez, J.E., Requier-Desjardins, D., 2013. What influences farm size growth? An illustration in Southwestern France. Appl. Econ. Perspect. Pol. 35 (2), 242–269.

Appel, F., Balmann, A., 2022. Predator or prey? Effects of farm growth on neighbouring farms. J. Agric. Econ. 1–23.

Bakucs, L.Z., Fertő, I., 2009. The growth of family farms in Hungary. Agric. Econ. 40 (s1), 789–795.

Bakucs, Z., Bojnec, S., Latruffe, L., Fertő, I., 2013. Farm size and growth in field crop and dairy farms in France, Hungary and Slovenia. Span. J. Agric. Res. 11 (4), 869–881.

Balmann, A., Odening, M., Weikard, H., Brandes, W., 1996. Path dependence without increasing returns to scale and network externalities. J. Econ. Behav. Organ. 29 (1), 159–172.

Baráth, L., Fertő, I., Bojnec, Š., 2020. The effect of investment, LFA and agri-environmental subsidies on the components of total factor productivity: the case of Slovenian farms. J. Agric. Econ. 71 (3), 853–876.

Blancard, S., Boussemart, J.-P., Chavas, J.-P., Leleu, H., 2016. Potential gains from specialization and diversification further to the reorganization of activities. Omega-Int. J. Manage. Sci. 63, 60–68.

Byma, J.P., Tauer, L.W., 2010. Exploring the role of managerial ability in influencing dairy farm efficiency. Agric. Resour. Econ. Rev. 39 (3), 505–516.

Bojnec, Š., Dries, L., 2005. Causes of changes in agricultural employment in Slovenia: evidence from micro-data. J. Agric. Econ. 56 (3), 399–416.

Bojnec, Š., Fertő, I., 2019. Do CAP subsidies stabilise farm income in Hungary and Slovenia? Agric. Econ. – Czech 65 (3), 103–111.

Bojnec, Š., Fertő, I., 2021a. Does human capital play an important role in farm size growth? The case of Slovenia. New Med. 20 (1), 57–69.

Bojnec, Š., Fertő, I., 2021b. The growth of farms: a Hungarian-Slovenian comparison. Post Commun. Econ. 33 (1), 79–93.

Bojnec, Š., Knific, K., 2021. Farm household income diversification as a survival strategy. Sustainability 13 (11), 6341.

Cabral, L., 1995. Sunk costs, firm size and firm growth. J. Ind. Econ. 43 (2), 161–172.

Csaki, C., Lerman, Z., 1997. Land reform and farm restructuring in East Central Europe and CIS in the 1990s: expectations and achievements after the first five years. Eur. Rev. Agric. Econ. 24 (3-4), 428–452.

Fertő, I., Bakucs, L.Z., 2009. Gibrat's law revisited in a transition economy: the Hungarian case. Empir. Econ. Lett. 8 (3), 13–18.

Fertő, I., Bojnec, Š., Podruzsik, S., 2022. Do subsidies decrease the farm income inequality in Hungary? Agris On-line Pap. Econ. Inf. 14 (2), 49–56.

Fleming, J., 1995. Compensation or restitution? An analysis of the Hungarian land compensation acts 1991-92. J. Prop. Valuat. Invest. 13 (4), 71–78.

Forgács, C., 2007. Leadership and the importance of social capital in the transition of cooperatives: a case study of two cooperatives. Stud. Agric. Econ. 105, 23–38.

Gatto, A., 2022. Polycentric and Resilient Perspectives for Governing the Commons: Strategic and Law and Economics Insights for Sustainable Development. Ambio.

Gibrat, R., 1931. Les Inegalites Economiques. Librairie du Recueil Sirey, Paris.

Goddard, E., Weersink, A., Chen, K., Turvey, C.G., 1993. Economics of structural change in agriculture. Can. J. Agric. Econ. 41 (4), 475–486.

Haque, S., 2022. US federal farm payments and farm size: quantile estimation on panel data. J. Agric. Econ. 73 (1), 139–154.

Huber, R., Flury, C., Finger, R., 2015. Factors affecting farm growth intentions of family farms in mountain regions: empirical evidence for Central Switzerland. Land Use Pol. 47, 188–197.

Huffman, W.E., 2001. Human capital: education and agriculture. In: Gardener, G.L., Rausser, G.C. (Eds.), Handbook of Agricultural Economics. North Holland, New York.

Jin, G., Li, Z., Deng, X., Yang, J., Chen, D., Li, W., 2019. An analysis of spatiotemporal patterns in Chinese agricultural productivity between 2004 and 2014. Ecol. Indic. 105, 591–600.

Jovanovic, B., 1982. Selection and evolution of industry. Econometrica 50 (3), 649–670.

Lillemets, J., Fertő, I., Viira, A.-H., 2022. The socioeconomic impacts of the CAP: systematic literature review. Land Use Pol. 114, 105968.

Lowder, S.K., Skoet, J., Raney, T., 2016. The number, size, and distribution of farms, smallholder farms, and family farms worldwide. World Dev. 87, 16–29.

Lucas, R.E., 1978. On the size distribution of business firms. Bell J. Econ. 9 (2), 508–523.

Machado, J.A.F., Santos Silva, J.M.C., 2000. Glejser's test revisited. J. Econom. 97 (1), 189–202.

Mathijs, E., Vranken, L., 2001. Human capital, gender and organisation in transition agriculture: measuring and explaining the technical efficiency of Bulgarian and Hungarian farms. Post Commun. Econ. 13 (2), 171–187.

Nelson, R.R., Winter, S.G., 1982. An Evolutionary Theory of Economic Change. Belknap Press of Harvard University Press, Cambridge, Mass.

Penrose, E., 1959. The Theory of the Growth of the Firm. Oxford University Press, New York.

Pereira Domingues Martinho, V.J., Reis Mourao, P., Georgantzis, N., 2022. Efficiency of the European Union farm types: scenarios with and without the 2013 CAP measures. Open Agriculture 7 (1), 93–111.

Petrick, M., Tyran, E., 2003. Development Perspectives of Subsistence Farms in South-Eastern Poland: Social Buffer Stock or Commercial Agriculture. Subsistence Agriculture in Central and Eastern Europe: How to Break the Vicious circle. IAMO, Halle, 106–23. https://www.econstor.eu/obitstream/10419/45940/1/475267818.pdf#page=123.

Pollak, R., 1985. A transaction cost approach to families and households. J. Econ. Lit. 23 (2), 581–608.

Plogmann, J., Mußhoff, O., Odening, M., Ritter, M., 2022. Farm growth and land concentration. Land Use Pol. 115, 106036.

Raheem, D., 2020. Digitalisation in a local food system: emphasis on Finnish Lapland. Open Agriculture 5 (1), 496–508.

Rizov, M., Mathijs, E., 2003. Farm survival and growth in transition economies: theory and empirical evidence from Hungary. Post Commun. Econ. 15 (2), 227–242.

Rodgers, J.L., 1994. Differential human capital and structural evolution in agriculture. Agric. Econ. 11 (1), 1–17.

Saint-Cyr, L.D.F., 2022. Heterogeneous farm-size dynamics and impacts of subsidies from agricultural policy: evidence from France. J. Agric. Econ. 73 (3), 893–923.

Salam, S., Bauer, S., 2018. Structural changes of farm size and labor's occupation in Bangladesh- A Markov chain analysis. Open Agriculture 3 (1), 609–617.

Shapiro, S.S., Francia, R.S., 1972. An approximate analysis of variance test for normality. J. Am. Stat. Assoc. 67 (337), 215–216.

Shapiro, S.S., Wilk, M.B., 1965. An analysis of variance test for normality (complete samples). Biometrika 52 (3–4), 591–611.

Solymosi, N., Torma, C., Kern, A., Maroti-Agots, A., Barcza, Z., Konyves, L., Berke, O., Reiczigel, J., 2010. Changing climate in Hungary and trends in the annual number of heat stress days. Int. J. Biometeorol. 54 (4), 423–431.

Swinnen, J.F.M., Buckwell, A., Mathijs, E. (Eds.), 1997. Agricultural Privatisation, Land Reform and Farm Restructuring in Central and Eastern Europe. Ashgate, Aldershot.

Swinnen, J.F.M., 1999. The political economy of land reform choices in Central and Eastern Europe. Econ. Transit. 7 (3), 637–664.

Unay-Gailhard, İ., Bojnec, Š., 2021. Gender and the environmental concerns of young farmers: do young women farmers make a difference on family farms? J. Rural Stud. 88, 71–82.

von Solms, W., van der Merwe, P., 2020. Farm size and its impact on land use: the case of the South African private wildlife industry. Open Agriculture 5 (1), 844–856.

Weiss, C.R., 1999. Farm growth and survival: econometric evidence from for individual farms in upper Austria. Am. J. Agric. Econ. 81 (1), 103–116.

Weerahewa, J., Jacque, A. (Eds.), 2022. Agricultural Policy Analysis. Springer, Singapore.

Zurek, M., Ingram, J., Bellamy, A.S., Goold, C., Lyon, C., Alexander, P., Barnes, A., Bebber, D.P., Breeze, T.D., Bruce, A., Collins, L.M., Davies, J., Doherty, B., Ensor, J., Franco, S.C., Gatto, A., Hess, T., Lamprinopoulou, C., Liu, L., Merkle, M., Norton, L., Oliver, T., Ollerton, J., Potts, S., Reed, M.S., Sutcliffe, C., Withers, P.J.A., 2022. Food system resilience: concepts, issues and challenges. Annu. Rev. Environ. Resour. 47, 511–534.