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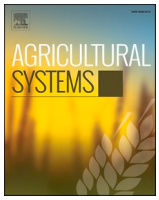

Why do corporate farms survive in Central and Eastern Europe?

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HIGHLIGHTS

- The corporate farm survival may be one of the main drivers of changes in agricultural systems.
- The survival of corporate farms may be associated with farm- and agricultural industry-specific, and other exogenous factors.
- The legal format, ownership structure, and corporate finance indicators are relevant to corporate farm survival.
- The agricultural factor endowments exhibit economically meaningful association with the survival probability.

GRAPHICAL ABSTRACT

Why do corporate farms survive in Central and Eastern Europe?

Context
The evolution of agricultural systems in post-communist CEE countries.

Results
Remarkable differences in survival rates among CEE countries.
Legal format, ownership structure, and corporate finance indicators highly influential.
Non-linear correlation of size and farm age on survival.
Agricultural factor endowments and trade openness significant for survival probability.

Implications
Understanding farm trajectory and factors affecting survival crucial for regional and global food security.
Better agricultural endowments and favorable macroeconomic conditions enhance farm viability and comparative advantages.

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ABSTRACT

CONTEXT: This article examines the process of the transformation of agricultural systems in post-communist Central and Eastern European (CEE) countries. It focuses on the survival of large agricultural firms, known as corporate farms, during periods of economic liberalization, privatization, land reform, and the restructuring of economies and the agricultural sector. The survival of corporate farms plays a significant role in driving structural changes within the farming sector and facilitating the transition from centrally planned to market-driven farming systems in the respective countries.
OBJECTIVE: The study investigates the factors correlated to the survival of corporate farms based on cross-country data analysis for 17 CEE countries. The survival of corporate farms can be correlated with a combination of farm-specific characteristics, sector-specific factors within the agricultural industry, country-specific natural and other resource endowments, and external factors related to a conducive economic environment.
METHODS: The study examines the viability of corporate farms by utilizing a comprehensive dataset encompassing 17 CEE countries between 2007 and 2019. The accelerated failure time model is employed to estimate the survival probabilities of these farms. The study uses the Nelson-Aalen estimator to calculate the cumulative hazard function and Kaplan-Meier survival function. Additionally, the baseline estimation of the two-level

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mixed-effects Weibull accelerated failure time model is utilized. Furthermore, estimations are conducted under various assumptions regarding sample restriction to ensure the robustness of the results.
RESULTS AND CONCLUSIONS: We find remarkable differences in corporate farm survival rates among 17 CEE countries. We document that legal format, ownership structure, and corporate finance indicators are highly relevant to corporate farm survival. Estimations reveal the non-linear correlation between corporate-farm size and age and their survival. We show that agricultural factor endowments and agricultural trade openness exhibit statistically significant and economically meaningful correlations with the survival probability of the sample farms.
SIGNIFICANCE: Farm-, sector- and country-specific factors play a crucial role in agri-food production, as well as regional and global food security. Diverse agricultural system structures may be associated with distinct farm attributes, various agricultural sector- and country-specific factors, and diverse allocations of agricultural resources. Better agricultural factor endowments and a conducive macroeconomic environment can foster comparative advantages and enhance corporate farm viability and survival. The findings of this study may be of significance to scholars and practitioners who are interested in comprehending the shifts in agricultural farm structures within agricultural systems.

1. Introduction

Farm entry, exit, and survival may be some of the main drivers of structural changes in the agricultural sector, involving the prevailing decline in the number of entities and an increase in the size of surviving ones in developed and some developing countries. The literature has focused on drivers of farm entry and exit but less on survival. One striking feature of this structural change process in developed countries is the disappearance of medium-sized farms due to their exit from farming (Weiss, 1999). Survivors are typically transformed from medium-sized ones into smaller or hobby farms and larger farms (Katchova and Ahearn, 2017; Chen et al., 2021). These corporate farm-survival processes and the forces that drive them may differ among countries, a fact that motivated our research based on cross-country corporate farm-level data.

While there are some studies about farm survival for a single country (Weiss, 1999; Bridges and Guariglia, 2008; Arita et al., 2014), to our knowledge, no cross-country studies have investigated the survival of corporate farms, particularly not for countries which can be defined as post-communist Central and Eastern European (CEE) ones. The survival of corporate farms may be driven by various farm-specific, agricultural industry-specific, and other exogenous factors. In cross-country comparison, country-specific factors include the different availability of natural and other factor endowments and the existence of an enabling macroeconomic environment.

Agriculture in the 17 CEE countries plays a more important role in employment and gross domestic product than in Western countries and is of greater importance for regional and global food security (Uzun et al., 2021; OECD, 2023). The legal forms and corporate ownership structures in the 17 CEE countries, which previously had collectivized agricultural firms/farms, underwent changes during the transition period from centrally planned economies. This study thus fills the gap in the literature by investigating the association of farm-, sector- and country-specific characteristics with the survival of corporate farms based on the cross-country data analysis of corporate farms in 17 CEE countries.

The contribution of this study is twofold. First, it empirically analyses a specific sample of 17 post-communist economies from CEE. They are interesting to investigate because of their importance for national and global agri-food production and food security. In addition, they are undergoing a transformation from central planning to market-driven farming systems. However, these countries are not homogenous as they had varying experiences under the old central-planning systems and in relation to transition and transformation processes. Second, compared to previous studies (Weiss, 1999; Arita et al., 2014), this study considers not only farm-specific variables and sector-fixed effects but also the country-specific factors of corporate farm survival. Better agricultural and other country-specific factors can generate comparative advantages and increase the chance of farm survival. On the other hand, agricultural trade openness can generate additional import-related competition from abroad (i.e., foreign competition can increase market selection pressure) and reduce the chance of farm survival. Consideration of the diverse economic geographies and agricultural resources is crucial for promoting the long-term viability of corporate farms in CEE countries. Advanced survival models are applied to analyze the association of farm-, sector- and country-specific variables with corporate farm survival. The research may be of interest to researchers and practitioners who seek to understand agricultural and farm structural changes and agricultural and rural development implications.

The following section summarizes the related studies and our research hypotheses on corporate farm survival. Section 3 describes the data and methodological framework applied in the empirical analysis. Section 4 presents the results, while Section 5 discusses their implications. The final section, 6, concludes.

2. Related studies and research hypotheses

Early studies examined farm structural changes, including entry, exit, or both (Gale and Henderson, 1991; Jackson-Smith, 1999; Rahelizatovo and Gillespie, 1999; Gale, 2003; Foltz, 2004; Stoke, 2006; Devadoss et al., 2016; Katchova and Ahearn, 2017; Chen et al., 2021). The research examined farm survival with entry and exit (Weiss, 1999; Key and Roberts, 2006; Storm et al., 2014; Arita et al., 2014; Key, 2022). Studies on farm entry are scarcer than those on farm exit, but they show a declining trend in the number of farms in developed and, recently, developing countries. Previous research on farm survival, entry, and exit can provide a starting point for further work. These studies used statistical-econometric methods, agricultural censuses, and survey data to identify farm-specific characteristics, types of farming, agricultural endowments, changing climatic conditions, and rural and macroeconomic factors that affect farm structural changes. Our hypotheses are based on empirical studies and theoretical frameworks developed in relation to such farm/firm-level farm/firm survival analyses.

Following Baumöhl et al. (2020), we hypothesize that the survival of corporate farms might depend on various factors such as legal form, corporate ownership, farm performance, total number of employees and farm age, the Statistical Classification of Economic Activities in the European Community (NACE) in which a corporate farm operates, and country-level specific agriculture and food-related characteristics. Compared with previous agricultural economics literature, our model specification includes additional corporate farm characteristics, NACE-related characteristics, and country-specific explanatory variables.

The legal form of firms (used as a risk indicator associated with firm growth and exit) was investigated by Harhoff et al. (1998) for West German companies in different economic sectors using the Cox proportional hazards model. The authors found that limited liability companies have higher insolvency rates than full liability ones. Similarly, Baumöhl et al. (2020) demonstrated that limited liability firms tend to

survive longer. Consistent with Baumöhl et al. (2020), we define limited liability as the default legal form for corporate farms. The first hypothesis is specified as follows:

H1. *Corporate farm survival is associated with a variety of corporate legal statuses.*

Bridges and Guariglia (2008) and Baumöhl et al. (2020) argue that ownership structure associated with global engagement (such as the presence of an associated foreign-owned or export company) can play a significant role in a firm's survival probability. Foreign direct investment might be less important in the upstream part of the product supply chain for corporate farms due to potential limitations on foreign agricultural land ownership. However, foreign direct investment may be more important in linking midstream (transportation and logistics, processing, and wholesaling) and downstream (retailing and consumption) agri-food value chains (Reardon, 2015). Therefore, the second hypothesis is ambiguous:

H2. *Corporate farm survival is positively associated with foreign ownership.*

Several studies have confirmed that financial health and firm performance are important determinants of firm/farm survival (Stoke, 2006; Glauben et al., 2009; Pushkarskaya and Vedenov, 2009; Dong et al., 2016; Pieralli et al., 2017). Accordingly, we define the following hypothesis:

H3. *Corporate farm survival is positively associated with financial performance.*

The size and age of corporate farms may be important determinants of their exit and survival (Shapiro et al., 1987; Weiss, 1999; Aubert and Perrier-Cornet, 2009; Tiller et al., 2010). Prior research has examined how farmer age affects farm survival (Kimhi and Bollman, 1999; Glauben et al., 2004; Hoppe and Korb, 2006; Gambelli and Bruschi, 2010; Bragg and Dalton, 2004; Mishra et al., 2014; Viira et al., 2013; Mishra et al., 2010). However, it ignores the impact of firms' age. We focus on corporate farms as agricultural firms with attention to the years of operation.

Turning to the size of corporate farms, Ahearn et al. (2005) argue that government commodity payments enable farmers to expand their activities, reduce the share of small farms, increase their exit, and increase the share of large farms. Glauben et al. (2006) and Breustedt and Glauben (2007) report higher farm exit rates in regions with smaller farms and lower farm exit rates in regions with a large share of part-time farms. Zhan et al. (2012) argue that farm exit associated with Chinese grain production depends on family size. Viira et al. (2013) claim a smaller exit probability for larger farms and de novo farms founded at the start of the transition. Landi et al. (2016) report that farm exit is associated with the size and type of holding. Ferjani et al. (2015) showed that the probability of farm exit decreases in line with farm size. Pokharel et al. (2020) argued that the size of cultivated land reduces farm exit and that farmland leasing increases farm exit. In sum, the size of a corporate farm is argued to affect farm survival positively. In contrast, the impact of the age of farms, that is, years of operation, is ambiguous for corporate farm survival. However, empirical evidence also emphasizes that the association of farm size and farm age with corporate farm survival is not necessarily linear (Weiss, 1999; Aubert and Perrier-Cornet, 2009; Tiller et al., 2010; Ferjani et al., 2015). To reflect the ambiguity of this research, we define the following hypothesis:

H4. *Corporate farm survival is non-linearly associated with farm size and farm age.*

Unlike many non-agricultural activities, corporate farm production may be significantly correlated with agricultural and natural factor endowments and agricultural trade openness, including international business networking and diversification, which may thus be related to corporate farm survival.

Several empirical analyses from around the world have highlighted the importance of natural factor endowments for farm exit and survival. Among them, agricultural land availability, the quality of human capital, and/or education are considered important variables (Weiss, 1999; Mishra et al., 2010). Particular attention has traditionally been paid to the extent of off-farm employment and off-farm income or part-time farms (Kimhi and Bollman, 1999; Weiss, 1999; Kimhi, 2000; Goetz and Debertin, 2001; Bragg and Dalton, 2004; Glauben et al., 2006, 2009; Sauer and Park, 2009; Tiller et al., 2010; Möllers and Fritzsch, 2010; Flaten, 2017; Ramsey et al., 2019). Recent studies have highlighted the importance of drought, water scarcity, water prices for irrigators, and the cost of using irrigation due to climate change (Zuo et al., 2015). Appel and Balmann (2023) confirmed effects of farm growth on neighboring farms. Farm exit and survival have also been driven by changing population density in rural areas (Landi et al., 2016) and distance to the nearest city (Carter-Leal et al., 2018). Some studies have also identified the reason for the persistence of subsistence farms as ensuring food security for families (Nag et al., 2018). On the other hand, trade openness during the process of globalization can increase foreign competition (Bollman et al., 1995) and cause the likelihood of farm survival (Arita et al., 2014). Therefore, we include selected country-level agriculture and food-related explanatory variables to explain corporate farm survival with the following hypothesis:

H5. *Corporate farm survival is associated with a variety of country-level specific agriculture and food variables.*

Finally, the nature of agricultural production varies seasonally, cyclically over years, and spatially across regions or countries (Kuhmonen and Kuhmonen, 2023). Accordingly, the structure of agricultural production may depend on the particular agricultural sector in which the corporate farms operate, which can be controlled using NACE sectoral-fixed effects to capture variations in technology and market conditions in the given agricultural market. At the same time, cross-country differences in corporate farm exit and survival can be controlled with the country dummy variable.

3. Data and methodology

We empirically examined the determinants of corporate farm survival. To this end, we constructed a large dataset that covered 17 CEE countries between 2007 and 2019.

Our dataset comprises corporate farm- and sector-specific characteristics and country-level data. We extracted the former data from Bureau van Dijk's ORBIS database, which covers over 400 million companies worldwide. It contains a large sample of listed and unlisted corporate farms in CEE countries, including Russia and Ukraine. It provides information on company profiles, including their legal status, legal form of incorporation, ownership structure, financial performance, size, and age. Based on the related 2006/07 and 2019/20 archives, we identified corporate farms that satisfy the following three conditions: first, they are mainly engaged in agricultural activities that account for a significant part of their total value added and thus have a NACE rev. 2 (four-digit) group code belonging to the Section A (agriculture, forestry, and fishing)[1]; second, they were operating at the end of 2006 in one of 17 CEE countries; last, their survival status was traceable until the end of 2019.[2]

[1] See section 3.1 in the Eurostat guidance: https://ec.europa.eu/eurostat/web/nace-rev2. The principal activity of a corporate farm is defined according to the main value-added producing sector. Governmental organizations and local information providers (IPs) that provide the BvD with farm-level data follow this classification rule in attaching codes to corporate farms, although with country-level variation.

[2] We did not include corporate farms into the dataset that have the legal status of "merged/taken over" without any notification of management failure in the preceding period because these cases may have involved "peaceful" mergers and acquisitions that were not triggered by the financial distress of the acquired corporation.

As a survival analysis always requires a cross-sectional data format, our dataset contains information on the initial profiles of the corporate farms at the end of 2006. Knowledge of their survival status at the end of 2019 enables us to measure the duration of the corporate farms' operation from 2007 to the failure event (if any) or 2019 (if the corporate farm keeps working). Using this dataset, we conducted a survival analysis of corporate farms in 17 CEE countries for the years 2007 to 2019.

The data extraction procedure confirmed that 16,990 corporate farms met the above conditions.[3] The regional breakdown of these 16,990 samples is as follows: early accession ("First-wave New Member States [FWMS]") EU countries (Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, and Slovakia; none from Slovenia or the Mediterranean Cyprus and Malta): 2803 corporate farms; late accession ("Second-wave New Member States [SWMS]") EU countries (Bulgaria, Croatia, and Romania): 1086 corporate farms; Non-EU European countries (Bosnia and Herzegovina, North Macedonia, Moldova, Montenegro, and Serbia; none from Albania): 211 corporate farms; and Russia and Ukraine: 12,890 corporate farms. Finally, 5492 out of the 16,990 corporate farms had failed or exited during the observation period 2007–2019.

First, we used the Kaplan-Meier and the Nelson-Aalen estimators to estimate corporate farm survival and cumulative hazard functions, respectively. The survival function, typically denoted $S(t)$, is a distribution function of the probability that an entity survives beyond a certain point (t) in time, decreasing from 1 at the initial point to zero at the final point. The survival function $S(t)$ is inversely related to the hazard function $h(t)$ and the cumulative hazard function increases from zero to infinity. The Kaplan-Meier and the Nelson-Aalen methods are both non-parametric estimators applied to censored survival data, and their functions graphically show the dynamics of corporate farm survival over time (due to limitations on space, we will not show the results in figures). Their use gives us insights into the probability of survival and the cumulative failure risk for corporate farms.

Second, we estimate the determinants of the corporate farms' survival using the accelerated failure time (AFT) model with the baseline estimation of the two-level mixed-effects Weibull AFT model. An endogeneity issue may arise in the survival analysis under certain conditions (Liu, 2012; Baumöhl et al., 2019): if (i) an independent variable is a future variable, (ii) the estimation period is very short, or (iii) the dependent variable is continuous. Under these circumstances, an instrumental variable (IV) method or a two-stage residual inclusion method (2SRI) should be applied (Liu, 2012; Carlin and Solid, 2014). When all independent variables are predetermined, this rules out an endogeneity problem arising from simultaneity between dependent and independent variables (Iwasaki, 2014). In addition, the estimation period of thirteen years covers a sufficiently long period, and the dependent variable is a discrete (binary) variable observed on a yearly basis. Based on the above arguments, our survival analysis is not subject to any of the three conditions articulated by Liu (2012). Furthermore, estimations are conducted under various assumptions regarding sample restriction to ensure the robustness of the results. In addition to the number of employees, omitted variable bias is controlled with also included NACE branches as approximation which reflects different farming systems.

Table 1 shows the definitions and descriptive statistics for the variables used in the empirical estimations. In addition, Table A1 in Appendix A presents supporting information on aggregated country-level descriptive statistics for corporate farm-level variables by 17 CEE countries.

[3] As the data comes from governmental organizations and local information providers (IPs), the dataset generally encompasses a wide range of corporate farms, providing a representative picture of each country. However, the requirements and criteria for filing accounts with state registration organizations vary among countries, so the coverage and representativeness of the dataset may vary for each country, particularly due to different roles of corporate farms in the agricultural sector.

The legal form (joint-stock or partnership; limited liability or cooperative; other), ownership (large shareholding with a dominant and/or block shareholder(s), foreign, central, or regional government), and size and age of the corporate farms are among the farm-level variables. The average number of employees in the sample farms is 139, and 63% of the farms have more than 50 employees, while petty farmers with less than ten employees do not exceed 1%.

We also include corporate farms' financial performance indicators that are measured in terms of return on assets (ROA), profit margin defined as profit before tax/operating revenue, labor productivity (operating revenue per employee), and solvency ratio defined as shareholder funds divided by total assets. While both ROA and profit margin variables reflect a corporate farm's financial performance, a farm can have a high profit margin but a low ROA if it is not efficiently using its assets, and vice versa. Therefore, these two variables reflect interrelated but different aspects of corporate financial performance, so it is necessary to examine both.

Last, the activity-specific characteristics of corporate farms are controlled using a NACE rev. 2 (four-digit) group code (NACE group-level fixed effects).

In the survival analysis, we also utilize various country-level variables that may significantly affect the survival probability of the sample farms. They consist of agricultural land, employment in agriculture, agriculture value added, labor productivity in agriculture, and agricultural trade openness. The latter is defined as the ratio of agricultural trade volume in 2006 expressed as export plus import in % of GDP. These country-level variables were derived from the World Development Indicators database (World Bank, 2023).

In addition to the survivability of corporate farms, we examined the determinants of their survival. We undertook a survival analysis of 15,266 corporate farms (out of the sample of 16,990) that included the effective values of all the variables used in the estimation. Around 10% of the sample farms were excluded from the regression analysis because some values for the independent variables employed in our survival analysis were lacking. To this end, we employed an AFT model. As a parametric and mixed-effects survival model that can assess covariates' effects multiplicative with survival time, the AFT model has an advantage over the Cox proportional hazards model, which assumes the time-invariant effects of covariates. This may be probably related to the companies' age focusing solely on corporate farms. The key feature of the AFT model is its straightforward interpretation. The model contains a constant rescaling factor to survival time so that covariate impact is multiplicative and can be interpreted as accelerating (negative coefficient) or decelerating (positive coefficient) the time to corporate farm exit. We specified the AFT model using the following equation, in which the natural logarithm of the survival time (t) for the i-th corporate farm is expressed as a linear function of the covariates:

$$logt_{ij} = X_{ij}\beta + Z_{ij}u_i + \varepsilon_{ij}$$

for $j = 1, \ldots, M$ clusters (countries), with cluster j consisting of $i = 1, \ldots, n_i$ observations. X_{ij} is a set of covariates for the fixed effects, β is their regression coefficient(s), Z_{ij} is a set of the covariates for the random effects, u_i is the random effects, and ε_{ij} is the observation-level error term with density $\varphi(\cdot)$. The AFT model has various types of distributional form of the error term (Kalbfleisch and Prentice, 2002; Lee and Wang, 2003; Hosmer and Lemeshow, 2008). The exponential distribution is the simplest assumption that has a constant hazard function, while the Weibull hazard function will monotonically increase or decrease over time. Contrastingly, that with a log-logistic error distribution is a proportional odds model, and its hazard function is non-monotonic and unimodal, while the lognormal survival model has a log-concave probability density function. We also examine the model assuming a Gamma distribution with a concave and increasing or convex and decreasing hazard function. A log-likelihood ratio can be utilized to select the best-fitting model for a given dataset. In the analysis described in this paper,

Table 1
Definitions and descriptive statistics of the variables used in the empirical analysis.

Variable name	Definition	Statistics			
		N	Mean	S.D.	Median
Joint-stock/ partnership company	Dummy variable for open joint-stock companies or partnerships	16,990	0.388	0.487	0
Limited liability/ cooperative company	Dummy variable for limited liability or cooperative companies	16,990	0.435	0.496	0
Large shareholding	Dummy for firms with a dominant and/or block shareholder(s)	16,990	0.700	0.458	1
Foreign ownership	Dummy for firms with foreign investors as the ultimate owner [a]	16,990	0.014	0.116	0
Central state ownership	Dummy for firms with the central government as the ultimate owner [a]	16,990	0.043	0.203	0
Regional state ownership	Dummy for firms with a regional government as the ultimate owner [a]	16,990	0.013	0.113	0
ROA	Return on total assets (%) [b]	16,065	3.981	14.660	2.750
Profit margin	Profit margin (%) [c]	15,881	3.261	18.861	3.790
Labor productivity	Natural logarithm of operating revenue per employee in euros	15,612	2.176	1.298	2.288
Solvency ratio	Solvency ratio (%) [d]	16,028	52.801	33.673	60.015
Total number of employees	Natural logarithm of total number of employees	15,891	4.437	0.940	4.317
Years in operation	Number of years since establishment	16,990	11.634	10.059	10
Agricultural land	Percentage share of agricultural land in 2006 (% of total land, country-level data)	16,990	44.137	26.200	55.068
Employment in agriculture	Percentage share of employment in agriculture in 2006 (% of total employment, country-level data)	16,990	14.118	6.832	9.876
Agriculture value added	Percentage share of agriculture, forestry, and fishing, value added in 2006 (% of GDP, country-level data)	16,990	5.311	2.059	3.861
Labor productivity in agriculture	Natural logarithm of agriculture, forestry, and fishing, value added per worker (constant 2010 US$) in 2006 (country-level data)	16,990	8.595	0.787	8.963
Agricultural trade openness	Ratio of agricultural trade volume in 2006 (export plus import in % of GDP, country-level data)	16,990	5.101	2.463	5.631

Notes
[a] In the ORBIS database, the *ultimate owner* is defined as "the individual or entity that owns more than 50.01% of the equity directly or via subsidiaries."
[b] Computed using the following formula: (profit before tax / total assets) * 100.
[c] Computed using the following formula: (profit before tax / operating revenue) * 100.
[d] Computed using the following formula: (shareholders' funds / total assets) * 100.
Source: Authors' compilation from the ORBIS database and World Bank (2023) database for the country-level variables.

we used the Weibull distribution as a benchmark estimator, as applied in Espenlaub et al. (2015), which we confirmed to have a larger log-likelihood ratio than the exponential, lognormal, and log-logistic distributions.

The firm-level variables are conventional in firm survival analysis and were examined together. Meanwhile, the country-level factors were included in the model in a stepwise manner to investigate which part of regional heterogeneity affects corporate farm survival, an aspect that has been less explored in previous studies. To achieve this, we first examined the same model with and without country dummies and then included various country-level variables one by one. This procedure was repeated using AFT models with different distribution assumptions. Additionally, for a robustness check, we conducted cross-validation using regional subsamples of the dataset.

4. Results

4.1. Descriptive statistics

4.1.1. Corporate farm survival

We first report the survivability of corporate farms in all 17 CEE countries from 2007 to 2019 and by country group according to the country classification stated above. The Nelson-Aalen estimate of the cumulative hazard function increased to 0.383 in 2019 (Table 2), implying that more than one-third of the sample of corporate farms exited in the analyzed period.

The dynamics of exit rates and Nelson-Aalen estimates of the cumulative hazard functions are somewhat different in the four groups of CEE countries (Table 2 and Fig. 1). The exit rate is the highest in Serbia at 47%, then Russia at 44%, Croatia at 38%, Romania at 32%, and Ukraine at 30%. Two reasons may explain this: first, the acquisition of poorly performing farms by agro holdings, particularly in Russia and Ukraine (Ostapchuk et al., 2021), and second, in terms of ownership, the

Table 2
Survival status of corporate farms in 17 CEE countries by country group.

Country group	Number of operating farms in 2006	Number of operating farms at end 2019	Total failures by end 2019	Exit rate	Entire period Nelson-Aalen cumulative hazard function
All 17 CEE countries	16,990	11,498	5,492	0.323	0.383
First-wave New Member States (FWMS)	2,803	2,429	374	0.133	0.142
Second-wave New Member States (SWMS)	1,086	796	290	0.267	0.305
Non-EU European countries	211	155	56	0.265	0.302
Russia and Ukraine	12,890	8,118	4,772	0.370	0.452

Notes: FWMS are Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, and Slovakia; SWMS are Bulgaria, Croatia, and Romania; Non-EU European countries are Bosnia and Herzegovina, North Macedonia, Moldova, Montenegro, and Serbia.
Source: Authors' calculations.

replacement and re-entry of de novo farms or the phenomenon that one farm purchased another's assets and continued under a different company name (Prishchepov et al., 2012; Ostapchuk et al., 2021). In contrast, the FWMS countries enjoyed relatively favorable environments under the umbrella of Common Agricultural Policy (CAP).

4.1.2. Corporate farm legal form and ownership structure

According to the legal form, the majority of corporate farms in Moldova, Montenegro, Slovakia, the Czech Republic, and Russia are joint stock companies (Fig. 2). Limited liability/cooperative companies are important in North Macedonia, Latvia, Poland, Estonia, Romania, Croatia, Bosnia and Herzegovina, and Serbia.

According to ownership structure, large shareholdings are dominant, particularly in Bosnia and Herzegovina, Estonia, Romania, Russia, Serbia, Poland, Bulgaria, North Macedonia, Ukraine, Hungary, and Croatia. In most CEE countries, foreign ownership and central state ownership are less important. The former is slightly more present in Romania, Poland, Serbia, Estonia, and Latvia, while the latter is in Poland, Ukraine, and Bulgaria.

4.1.3. Corporate farm financial-economic performance, farm size, and age

Cross-country differences are more substantial regarding financial performance measures: return on assets (ROA) and profit margin. ROA is the highest in North Macedonia and the lowest in Serbia, while profit margin is the highest in Lithuania and the lowest in Serbia (Fig. 3). Labor productivity is the highest in Croatia, and the solvency rate in Montenegro. The total number of employees as a measure of farm size among the 17 CEE countries varies around the average of 4.4, and the duration of operation as a measure of farm age varies around the average of 11.6 years.

4.2. Econometric results

4.2.1. Legal form

The legal form of corporate farms is an economically significant factor associated with survival (Table 3). The existence of a joint stock company exhibits a significant positive association in the majority of models. This suggests that the legal form of a joint-stock company is a significant preventive factor as it lessens the probability of a farm exiting the market. The coefficient of limited liability is insignificant for six of eight models, implying no particular association between being a limited liability company and the omitted base category of other legal forms. The survival of corporate farms depends on the legal form under which the farm operates. This result suggests that H1 should not be rejected.

4.2.2. Ownership structure

Factors related to ownership structure determine corporate farm survival. Large shareholdings, foreign ownership, and central state ownership are significantly associated with farm survival, but in different directions. A number of large shareholders significantly supports survival in all countries, suggesting that concentrated ownership tends to intensify monitoring by top management in CEE countries and mitigate the risk of management failure. In short, ownership structure plays an important role in the survival of corporate farms. Thus, we cannot reject H2.

4.2.3. Financial performance

In our empirical analysis, we control for financial efficiency by including four farm performance indicators (return on assets [ROA]), profit margin, labor productivity, and the solvency ratio). Our results imply that for corporate farms, the three covariates (ROA, profit margin, and solvency ratio) are positively correlated with survival. We obtain mixed results for labor productivity: the coefficient is insignificant for five of eight specifications, while the remaining results are

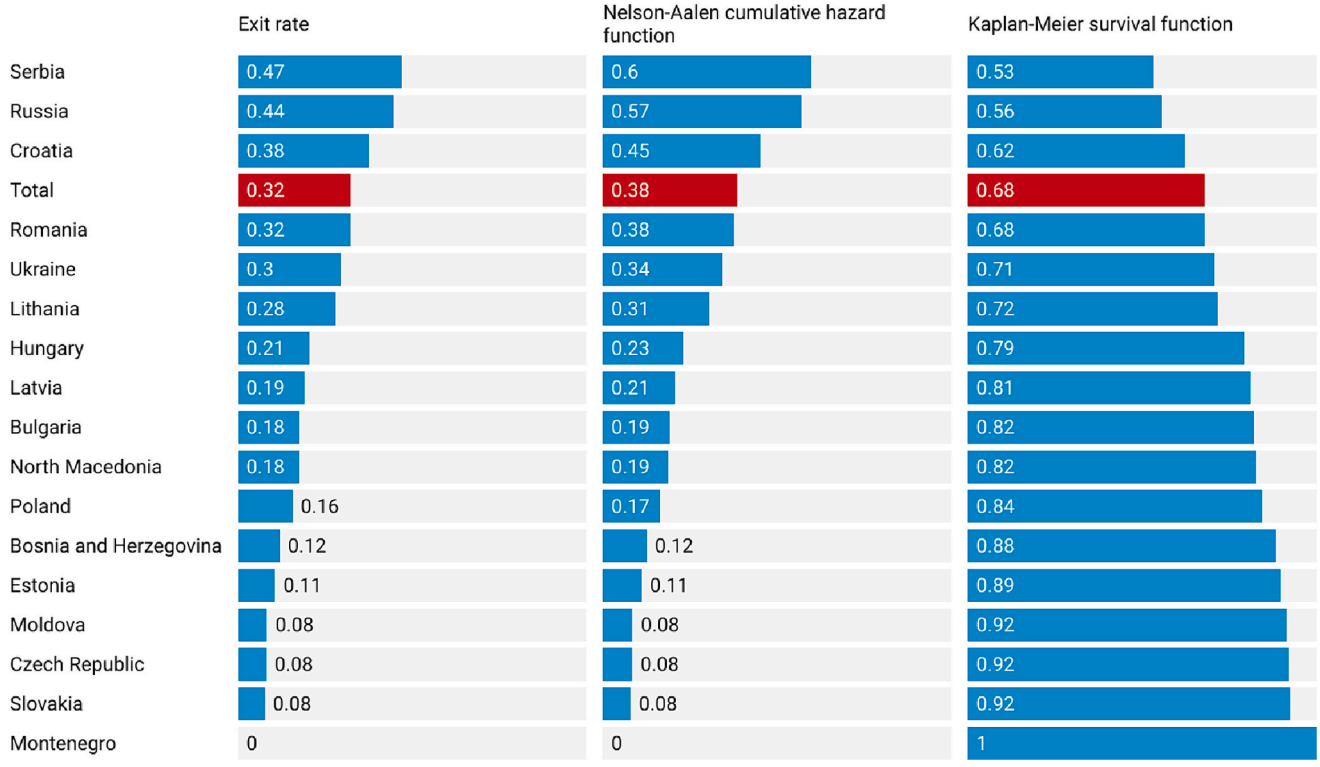

Fig. 1. Survival status of corporate farms in 17 CEE countries.
Source: Authors' calculations.

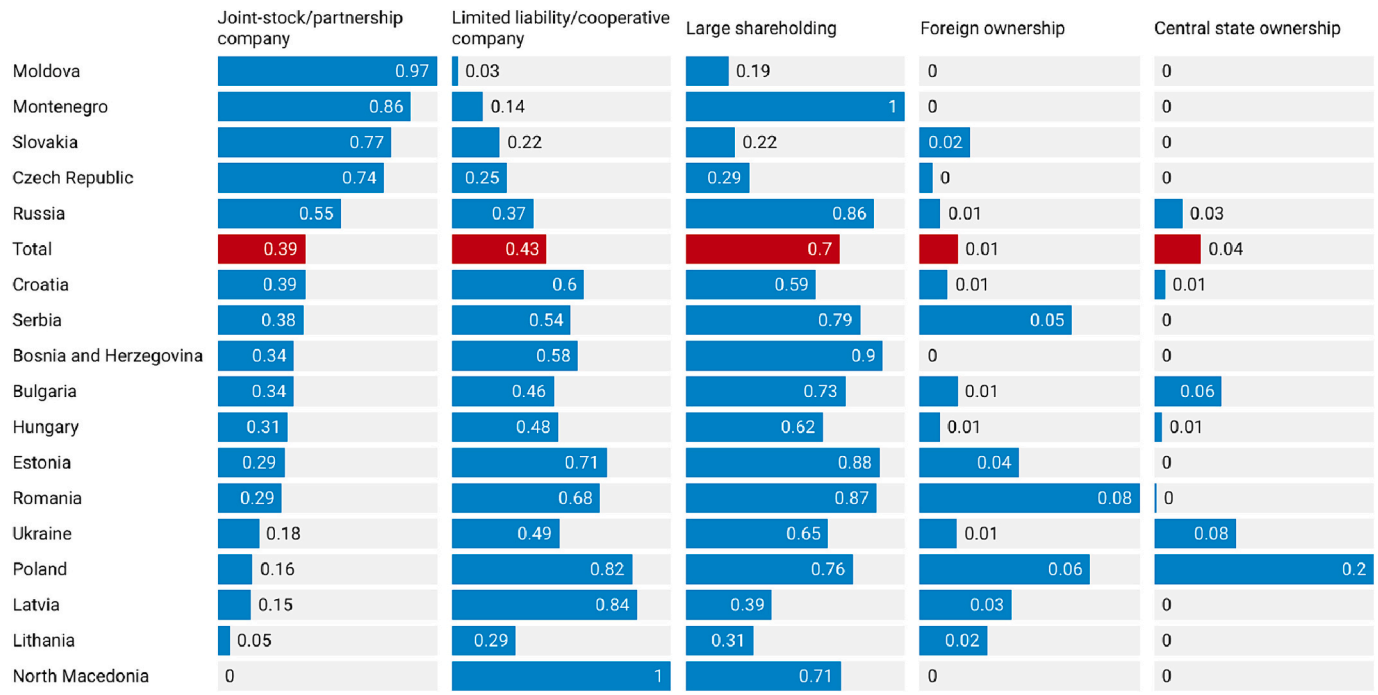

Fig. 2. Difference in legal status and ownership (mean of variables).
Source: Authors' calculations.

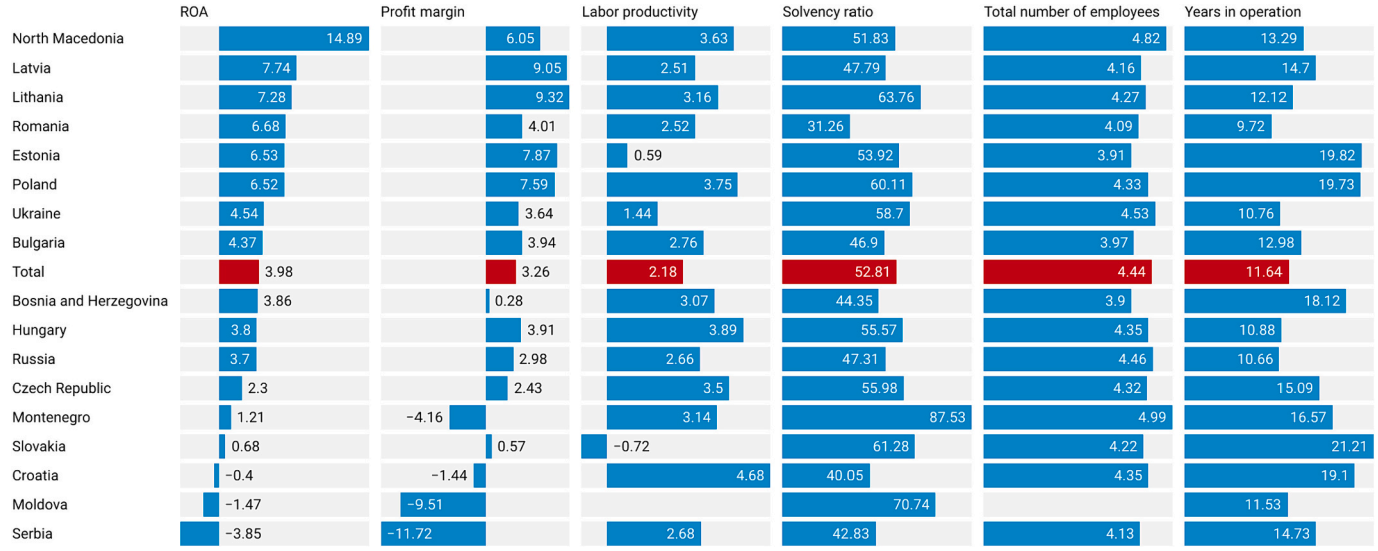

Fig. 3. Difference in financial status and firm characteristics (mean of variables).
Source: Authors' calculations.

contradictory. There is overwhelming evidence of a positive relationship between good financial health and farm survival. H3 cannot be rejected.

4.2.4. *Farm size and farm age*

We measure corporate farm size in terms of total employment. Based on earlier literature, we considered the potentially non-linear relationships between farm size/farm age and farm survival; thus, we introduced the squared terms of both variables into our models. Our results confirm the non-linear relationships between farm survival and farm size/farm age. Farm size growth initially increases the likelihood of leaving agriculture, but larger farms have a better chance of survival beyond a certain point. Accordingly, there is a non-linear relationship between farm survival and farm size; the first part of H4 cannot be rejected.

By contrast, the age of farms is associated with an initial upward survival trajectory followed by a declining trend. It appears that the survivability of young farms is initially enhanced with age until a certain point, followed by more difficult survival conditions. The subsequent downward survival trajectory may be due to the outdated assets of older farms vis-à-vis younger ones that have access to more productive assets and are more profitable and thus have a greater chance of surviving. However, the coefficients of the squared age variable are relatively small, so the magnitude of impact is expected to be marginal, too. It possibly follows that the great majority of corporate farms operate under professional management. Based on this non-linear relationship between farm survival and farm age, the second part of H4 cannot be rejected.

Table 3
Baseline estimation of the two-level mixed-effects Weibull accelerated failure time model.

Target country	All 17 countries							
Model with the dependent variable: Duration of operating survival years	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Legal form (default category: other legal forms)								
Joint-stock/partnership company	−0.1342**	0.0829**	0.0945**	0.0208	0.0901**	0.0704***	0.1037*	0.0942**
	(−2.16)	(2.80)	(2.18)	(0.34)	(2.19)	(4.54)	(1.84)	(2.19)
Limited liability/cooperative company	−0.0840***	−0.0027	−0.0041	−0.0405**	−0.0102	−0.0200	0.0013	0.0099
	(−4.32)	(−0.08)	(−0.19)	(−2.00)	(−0.67)	(−1.54)	(0.04)	(0.26)
Ownership structure								
Large shareholding	0.5512***	0.7006***	0.6829***	0.6263***	0.6710***	0.6583***	0.6912***	0.6995***
	(29.97)	(52.78)	(20.52)	(7.35)	(14.50)	(10.92)	(21.99)	(38.92)
Foreign ownership	−0.0439*	−0.1602**	−0.1979***	−0.1869***	−0.2090***	−0.1960***	−0.1515**	−0.1392*
	(−1.85)	(−2.41)	(−9.45)	(−3.77)	(−14.92)	(−6.90)	(−2.14)	(−1.74)
Central state ownership	−0.0469	−0.1408**	−0.1401***	−0.1045***	−0.1344***	−0.1281***	−0.1389***	−0.1326**
	(−0.77)	(−2.55)	(−3.09)	(−9.04)	(−3.51)	(−3.79)	(−2.57)	(−2.29)
Regional state ownership	−0.1466***	−0.0132	−0.0121	−0.0616	−0.0218**	−0.0326***	−0.0079	0.0016
	(−16.28)	(−0.59)	(−0.63)	(−1.38)	(−2.48)	(−3.61)	(−0.30)	(0.04)
Financial performance								
ROA	0.0012***	0.0017***	0.0015***	0.0013***	0.0015***	0.0015***	0.0017***	0.0016***
	(31.70)	(16.13)	(6.89)	(3.25)	(6.12)	(4.92)	(17.17)	(22.11)
Profit margin	0.0088***	0.0066***	0.0071***	0.0077***	0.0069***	0.0073***	0.0070***	0.0072***
	(26.16)	(19.98)	(8.19)	(6.34)	(9.86)	(6.84)	(8.97)	(7.81)
Labor productivity	−0.0458***	0.0703***	0.0496	0.0216	0.0593**	0.0394	0.0481	0.0415
	(−5.69)	(5.01)	(1.27)	(0.36)	(2.08)	(0.80)	(1.28)	(0.93)
Solvency ratio	0.0059***	0.0051***	0.0051***	0.0054***	0.0052***	0.0052***	0.0050***	0.0050***
	(52.11)	(59.49)	(52.14)	(14.03)	(34.17)	(29.99)	(40.26)	(34.65)
Total number of employees and years of operation								
Total number of employees	−0.2179***	−0.2095***	−0.2065***	−0.1937***	−0.1978***	−0.1985***	−0.2070***	−0.2137***
	(−5.58)	(−5.61)	(−4.68)	(−4.30)	(−3.87)	(−4.06)	(−5.06)	(−6.75)
Total number of employees squared	0.0209***	0.0215***	0.0203***	0.0187***	0.0198***	0.0194***	0.0205***	0.0210***
	(3.74)	(3.91)	(2.99)	(2.70)	(2.68)	(2.60)	(3.08)	(3.66)
Years of operation	0.0084***	0.0104***	0.0118***	0.0109***	0.0117***	0.0117***	0.0111***	0.0109***
	(2.71)	(12.97)	(7.68)	(10.99)	(7.94)	(10.63)	(12.66)	(8.12)
Years of operation squared	−0.0001**	−0.0001***	−0.0001***	−0.0001***	−0.0001***	−0.0001***	−0.0001***	−0.0001***
	(−2.42)	(−6.18)	(−9.03)	(−11.44)	(−9.70)	(−10.13)	(−8.99)	(−7.65)
Agricultural factor endowments and trade openness								
Agricultural land			0.0100***					0.0182***
			(9.14)					(6.38)
Employment in agriculture				0.0349				−0.0016
				(1.38)				(−0.29)
Agriculture value added					0.1556***			−0.0822***
					(7.42)			(−3.35)
Labor productivity in agriculture						−0.3983***		0.4628***
						(−3.10)		(7.80)
Agricultural trade openness							0.1262***	0.0929***
							(8.95)	(4.05)
Constant	3.7589***	4.1417***	2.8197***	2.8870***	2.3721***	6.8502***	2.5378***	−1.6292***
	(13.66)	(50.98)	(7.08)	(4.08)	(4.60)	(7.86)	(6.60)	(−2.77)
NACE group-level fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Country dummies	no	yes	no	no	no	no	no	no
First level	region	region	region	region	region	region	region	region
N	15,266	15,266	15,266	15,266	15,266	15,266	15,266	15,266
Log pseudolikelihood	−21,108.20	−20,776.98	−20,862.16	−20,980.82	−20,874.98	−20,922.21	−20,851.01	−20,819.45

Notes: This table contains results from the survival analysis using the mixed-effects Weibull accelerated failure time model. Regression coefficients quantify whether the survival time accelerates (if positive) or decelerates (if negative) for a one-unit change in the covariate values. Standard errors are computed using the Huber-White sandwich estimator. z statistics are reported in parentheses beneath the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimations.

4.2.5. *Country-level specific agriculture and food-related variables*

We controlled our regressions with four country-level specific agriculture and food-related variables: the share of agricultural land in total land, the share of agriculture in total employment, the share of agriculture in value-added, and agricultural labor productivity. In addition, we employed agricultural trade openness. We estimated our models for each variable separately and finally together. All variables are significant except for the share of agriculture in total employment. The share of agricultural land is positively correlated with farm survival. However, the combined model (Model 8) shows a different picture; only the variable agricultural land endowment is consistently positively correlated with farm survival, while general labor productivity is positively correlated with the chance of farm survival, and a larger share of agriculture in GDP is negatively correlated with farm survival, in contrast to Models [5] and [6], respectively. Finally, agricultural trade openness is positively correlated with farm survival. In more open CEE countries (likely to be more innovative ones), corporate farms have a greater chance of survival. Therefore, the findings regarding H5 are mixed.

4.3. *Robustness analysis*

We undertook additional analysis to assess the robustness of the results presented in the previous section. First, we re-estimated the AFT model for the last specification (Model 8 in Table 3 as a baseline model) with different probability density functions that assume time-variant

effects of covariates for survival distributions, namely exponential, lognormal, log-logistic, and Gamma distributions. The outcome of this robustness analysis using estimated four survival models [1]–[4] is that our main results are robust with respect to different assumptions about survival distribution (see Table 4). The direction of coefficients is the same, but one can observe differences in the statistical significance of legal form, corporate ownership, and the share of agriculture in total employment between models.

Second, the AFT model assumes that the effect of a covariate is to accelerate or decelerate the life course of the event in question (i.e., corporate farm death) by some constant. This assumption can influence regression outcomes. Therefore, we need to relax this assumption by estimating alternative survival models to check the robustness of our baseline estimation results reported in Table 3. Table 5 presents the estimation of an AFT model with several sample restrictions that tests whether one sample group drives the baseline estimation results. We conducted the sample-restricted estimations to avoid possible bias associated with the skewed geographical structure of the dataset. Specifically, we estimated the AFT models without Russia/ Russia and Ukraine/ FWMS/ SWMS/non-EU European countries. Table 5 demonstrates the high level of reliability of the estimates of the AFT model in Table 3. The exclusion of early-comer (FWMS), latecomer (SWMS) EU countries, or Non-EU European countries from the dataset ([3], [4], and [5], respectively) in Table 5 does not change the general picture shown in Table 3. Moreover, nor do the models without Russia or Russia and Ukraine ([1] and [2]) change the general picture, although Russian and Ukrainian farms dominate our dataset (38.4% and 37.4%, respectively). We obtained consistent estimation results regarding large shareholding,

Table 4
Estimations with different assumptions about distribution for the robustness check.

Assumption of the survival distribution	Weibull	Exponential	Lognormal	Loglogistic	Gamma
Model	Table 3 [8]	[1]	[2]	[3]	[4]
Legal form (default category: other legal forms)					
Joint-stock/partnership company	0.0942**	0.1168*	0.0996	0.0804	0.0935*
	(2.19)	(1.84)	(1.21)	(1.44)	(1.84)
Limited liability/cooperative company	0.0099	0.0052	−0.0103	−0.0084	0.0035
	(0.26)	(0.09)	(−0.16)	(−0.18)	(0.08)
Ownership structure					
Large shareholding	0.6995***	0.9087***	0.6254***	0.6435***	0.6799***
	(38.92)	(33.01)	(24.79)	(35.18)	(41.31)
Foreign ownership	−0.1392*	−0.2060*	−0.1356	−0.1612*	−0.1417*
	(−1.74)	(−1.74)	(−1.38)	(−1.67)	(−1.71)
Central state ownership	−0.1326**	−0.1745**	−0.0703	−0.1078*	−0.1195*
	(−2.29)	(−1.96)	(−0.83)	(−1.65)	(−1.88)
Regional state ownership	0.0016	−0.0283	0.0229	−0.0073	0.0057
	(0.04)	(−0.54)	(0.51)	(−0.19)	(0.16)
Financial performance					
ROA	0.0016***	0.0024***	0.0022***	0.0026***	0.0020***
	(22.11)	(12.72)	(11.89)	(16.34)	(28.67)
Profit margin	0.0072***	0.0101***	0.0095***	0.0084***	0.0078***
	(7.81)	(7.90)	(6.82)	(8.35)	(7.62)
Labor productivity	0.0415	0.0623	0.0469	0.0487	0.0437
	(0.93)	(0.94)	(0.68)	(0.87)	(0.87)
Solvency ratio	0.0050***	0.0069***	0.0057***	0.0054***	0.0052***
	(34.65)	(29.84)	(16.19)	(21.86)	(28.69)
Total number of employees and years of operation					
Total number of employees	−0.2137***	−0.2602***	−0.1022***	−0.1471***	−0.1904***
	(−6.75)	(−7.00)	(−3.97)	(−6.98)	(−7.09)
Total number of employees squared	0.0210***	0.0263***	0.0107*	0.0155***	0.0189***
	(3.66)	(3.46)	(1.66)	(3.00)	(3.42)
Years of operation	0.0109***	0.0159***	0.0131***	0.0117***	0.0111***
	(8.12)	(9.06)	(4.95)	(7.92)	(7.40)
Years of operation squared	−0.0001***	−0.0001***	−0.0001***	−0.0001***	−0.0001***
	(−7.65)	(−6.99)	(−7.36)	(−4.15)	(−7.43)
Agricultural factor endowments and trade openness					
Agricultural land	0.0182***	0.0252***	0.0120***	0.0154***	0.0168***
	(6.38)	(5.93)	(5.29)	(5.88)	(6.34)
Employment in agriculture	−0.0016	−0.0016	0.0121	0.0026	0.0012
	(−0.29)	(−0.19)	(1.47)	(0.35)	(0.19)
Agriculture value added	−0.0822***	−0.1164***	−0.0892***	−0.0735***	−0.0810***
	(−3.35)	(−3.75)	(−3.15)	(−2.69)	(−3.34)
Labor productivity in agriculture	0.4628***	0.6773***	0.4639***	0.4881***	0.4679***
	(7.80)	(8.97)	(14.17)	(8.56)	(8.34)
Agricultural trade openness	0.0929***	0.1289***	0.0996***	0.0908***	0.0935***
	(4.05)	(3.85)	(4.54)	(3.99)	(4.07)
Constant	−1.6292***	−3.4982***	−2.0505***	−2.2507***	−1.7679***
	(−2.77)	(−4.52)	(−6.93)	(−3.84)	(−3.21)
NACE group-level fixed effects	yes	yes	yes	yes	yes
First level	region	region	region	region	region
N	15,266	15,266	15,266	15,266	15,266
Log pseudolikelihood	−20,819.45	−21,287.72	−20,844.33	−20,793.32	−20,798.03

Notes: This table contains results from the survival analysis using the mixed-effects accelerated failure time model with different distribution assumptions. Regression coefficients quantify whether the survival time accelerates (if positive) or decelerates (if negative) for a one-unit change in the covariate values. Standard errors are computed using the Huber-White sandwich estimator. z statistics are reported in parentheses beneath the regression coefficients. The Wald test examines the null hypothesis that all coefficients are zero. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimations.

Table 5
Estimation with sample restrictions for robustness check.

Target country	All 17 countries	Without Russia	Without Russia and Ukraine	Without FWMS	Without SWMS	Without Non-EU European countries
Model	Table 2 [8]	[1]	[2]	[3]	[4]	[5]
Legal form (default category: other legal forms)						
Joint-stock/partnership company	0.0942**	−0.1006	0.7728***	0.0721**	0.0805**	0.1015***
	(2.19)	(−1.58)	(5.11)	(2.21)	(2.39)	(3.07)
Limited liability/cooperative company	0.0099	0.0042	0.6780***	0.0003	−0.0109	0.0145
	(0.26)	(0.09)	(4.61)	(0.01)	(−0.34)	(0.47)
Ownership structure						
Large shareholding	0.6995***	0.3554***	0.5667***	0.7098***	0.6940***	0.7041***
	(38.92)	(7.93)	(5.65)	(31.64)	(29.97)	(31.18)
Foreign ownership	−0.1392*	0.0203	0.0649	−0.1415	−0.1969*	−0.1518*
	(−1.74)	(0.14)	(0.34)	(−1.50)	(−1.90)	(−1.64)
Central state ownership	−0.1326**	−0.0825	−0.8197***	−0.1588***	−0.0880	−0.1301**
	(−2.29)	(−0.78)	(−4.00)	(−2.86)	(−1.53)	(−2.33)
Regional state ownership	0.0016	−0.0064***	7.8946***	−0.0135	−0.0167	0.0021
	(0.04)	(−6.52)	(15.79)	(−0.19)	(−0.23)	(0.03)
Financial performance						
ROA	0.0016***	0.0053**	0.0043	0.0018*	0.0016	0.0016*
	(22.11)	(2.51)	(0.87)	(1.74)	(1.58)	(1.64)
Profit margin	0.0072***	0.0108***	0.0086***	0.0065***	0.0070***	0.0072***
	(7.81)	(7.92)	(3.16)	(9.74)	(9.98)	(10.66)
Labor productivity	0.0415	0.0318	−0.1208***	0.0696***	0.0610***	0.0424***
	(0.93)	(1.57)	(−4.20)	(6.31)	(5.15)	(4.05)
Solvency ratio	0.0050***	0.0056***	0.0073***	0.0050***	0.0051***	0.0050***
	(34.65)	(8.65)	(5.16)	(15.59)	(15.48)	(15.35)
Total number of employees and years of operation						
Total number of employees	−0.2137***	−0.1433	−0.2548	−0.2230***	−0.2218**	−0.2162***
	(−6.75)	(−1.22)	(−1.19)	(−2.73)	(−2.56)	(−2.65)
Total number of employees squared	0.0210***	0.0159	0.0113	0.0234***	0.0228**	0.0213**
	(3.66)	(1.27)	(0.53)	(2.74)	(2.50)	(2.50)
Years of operation	0.0109***	0.0063*	0.0230**	0.0113***	0.0104***	0.0108***
	(8.12)	(1.89)	(3.62)	(4.65)	(4.55)	(4.80)
Years of operation squared	−0.0001***	−0.0001**	−0.0001***	−0.0001***	−0.0001***	−0.0001***
	(−7.65)	(−2.08)	(−3.36)	(−4.93)	(−4.39)	(−4.60)
Agricultural factor endowments and trade openness						
Agricultural land	0.0182***	0.0152***	0.0174***	0.0221***	0.0105***	0.0194***
	(6.38)	(3.14)	(4.59)	(4.61)	(3.27)	(9.02)
Employment in agriculture	−0.0016	−0.0086	−0.0115	−0.0011	0.0977	−0.0059
	(−0.29)	(−0.64)	(−0.65)	(−0.16)	(1.45)	(−0.74)
Agriculture value added	−0.0822***	−0.0651*	−0.1106***	−0.1375***	−0.0399*	−0.0673**
	(−3.35)	(−1.70)	(−3.16)	(−2.90)	(−1.73)	(−1.99)
Labor productivity in agriculture	0.4628***	0.5354***	0.0982	0.3935***	1.3270**	0.4667***
	(7.80)	(3.98)	(0.46)	(4.05)	(2.51)	(8.97)
Agricultural trade openness	0.0929***	0.0644*	0.0951***	0.0762***	0.1334***	0.0780***
	(4.05)	(1.82)	(2.70)	(4.81)	(6.57)	(3.36)
Constant	−1.6292***	−1.5909	1.5793	−0.9071	−10.6565*	−1.6707***
	(−2.77)	(−0.92)	(0.66)	(−1.03)	(−1.95)	(−2.90)
NACE group-level fixed effects	yes	yes	yes	yes	yes	yes
First level	region	region	region	region	region	region
N	15,266	8926	2860	13,551	14,415	14,972
Log pseudolikelihood	−20,819.45	−10,208.50	−2148.84	−19,869.04	−19,737.62	−20,608.86

Notes: This table contains results from the survival analysis using the mixed-effects Weibull accelerated failure time model. Regression coefficients quantify whether the survival time accelerates (if positive) or decelerates (if negative) for a one-unit change in the covariate values. Standard errors are computed using the Huber-White sandwich estimator. z statistics are reported in parentheses beneath the regression coefficients. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.
Source: Authors' estimations.

financial performance indicators, farm age, and country-level specific agriculture and food-related variables. We also found that, especially in Russia, large shareholding is an essential preventive factor of corporate farm failure, among others.

5. Discussion of the results and implications

The analysis of corporate farm survival in the 17 CEE countries reveals complex relationships between different factors and farm survival probability. Legal forms and corporate ownership structures in the 17 CEE countries with previously state and collectivized corporate farms/agricultural firms changed during the transition period away from centrally planned economies. The characteristics of farms within each country and among the group of countries have become more heterogeneous: Poland has a dominance of family farms, the Czech Republic and Slovakia a dominance of corporate farms, and Ukraine and Russia an important role for large-scale agro-holding affiliates (Lerman et al., 2004; Gudaj et al., 2020; Uzun et al., 2021; Tleubayev et al., 2022). This is an outcome of the initial conditions, with the evolution of family farms in Poland, Croatia, and Serbia from the past, newly established farms, and the privatization and restructuring of corporate farms in all 17 CEE countries.

Legal Form and its Significance in Survival (H1): In line with the findings of non-agricultural studies (e.g., Baumöhl et al., 2020), the results underline the economic importance of the legal structure of corporate farms. More precisely, the presence of a joint-stock company is strongly correlated with the long-term viability of farms in most of the analyzed models. Conversely, the impact of the limited liability coefficient is mainly negligible. This indicates that the legal structure under which a farm operates is a vital factor in its continued existence. Therefore, policies should acknowledge and adapt to the variety of legal frameworks present in CEE countries.

Ownership Structure and its Impact on Survival (H2): The ownership structure of a corporate farm plays a crucial role in determining its survival. Confirming results by Viira et al. (2013), the concentrated ownership of large shareholdings is strongly linked to corporate farm survival in all countries, suggesting that it improves monitoring by top management and reduces the risk of management failure. The varied effects of foreign and central state ownership highlight the necessity of targeted policy interventions that take into account the distinct ownership dynamics in each CEE country.

Financial Performance and its Role in Survival (H3): Consistent with theoretical expectations, our estimations indicate a strong positive correlation between financial performance indicators (ROA, profit margin, and solvency ratio) and corporate farm survival. This highlights the significance of promoting solid financial well-being to ensure the long-term viability of corporate farms. While labor productivity may have varying outcomes, the predominant evidence supports a positive association between sound financial well-being and long-term viability, underscoring the necessity of policies that address financial factors.

Farm Size and Farm Age with Non-linear Relationships (H4): Farm size and farm age are significantly associated with farm survival. The former positive non-linear association strengthens with increasing farm size, while the latter non-linear association suggests possible constraints such as the financial difficulties of older farms. This could also be related to managerial problems on older corporate farms managed by professional farm managers vis-à-vis de novo start-ups. Both findings related to H4 are linked to the large sample of 17 CEE countries with heterogeneous farm sizes and farm age structures. The findings imply that policies should account for the diverse challenges faced by large and small, as well as young and old, corporate farms. The presence of non-linear relationships poses a challenge to the deployment of a universal approach and highlights the importance of tailored interventions (Huber et al., 2024).

Country-level Specific Agriculture and Food Variables (H5): The positive correlation between agricultural land share and corporate farm survival indicates that implementing policies that promote land-intensive farming could improve the long-term viability of corporate farms. The large share of agricultural land and large corporate farms may be particularly important for crop production specialization and an issue for future research on corporate farm survival (Gagalyuk et al., 2022). Nonetheless, the diverse influence of additional factors in various models underscores the complexity of devising successful policies, emphasizing the significance of taking into account distinct regional circumstances.

We did not directly examine the effects of agricultural and other policies that support or tax farm production through budgetary subsidies, trade, and other government transfers, affecting corporate farm survival. However, various government transfers between the CEE countries under analysis may affect agricultural farm survival. Political preferences may lead to policy bias in allocating state support to large corporate farms vs. newly established de-novo and private family farms, ensuring the survival of transformed or privatized corporate farms.

The lower corporate farm survival rates in Serbia, Russia, and Croatia, and higher ones in first-wave new EU countries from the Baltics (Estonia, Latvia, and Lithuania) and Višegrad-4 (Czech Republic, Hungary, Poland, and Slovakia) suggest the EU's CAP may mitigate selection processes affecting corporate farm survival. In addition, corporate farm survival in Serbia and Croatia can be linked to war-related disruption and market disintegration from the first half of the 1990s and later problems with corporate farm transformation and poor financial performance. In Russia and Ukraine, it can be linked to organizational structure, the lack of market institutions (McNeil and Kerr, 1997), and agroholding's acquisition of poorly performing farms. Since 2022, it may also be associated with the implications of Russia's invasion of Ukraine (Gagalyuk et al., 2022; Berndt et al., 2022).

Agricultural policy reforms may contribute to sustainability – economic, social, and environmental – and "green" farming (De Schutter et al., 2020; Paarlberg, 2022) and improve resilience (Morkūnas et al., 2018; Pörtner et al., 2022). Further, the competitiveness of corporate farms could be increased through promoting the concept of resilience (Meuwissen et al., 2019). Business group affiliation and producer organization membership can increase economies of scale, networking, and diversification through integration in short supply chains and participation in international business, affecting corporate farm performance and growth (Michalek et al., 2018; Tleubayev et al., 2022).

Thus, understanding the forces behind corporate farm survival can inform agricultural policy, with implications for policy measures (Bojnec et al., 2022). Corporate farms are important for ensuring that the 17 CEE countries continue to sustain global food security (Berndt et al., 2022). Depopulation, labor outflow, and rural labor shortages can lead to labor substitution through more advanced mechanization for capital-intensive and land-intensive crops (Otsuka et al., 2016). Corporate farm systems may struggle in hilly or mountainous areas of Montenegro or North Macedonia (and in the not investigated Albania and Slovenia), allowing for the growth of other farm structures (Bojnec and Fertő, 2021).

In addition to the striking finding of the low corporate farm survival rates of Russia and Ukraine, their already large farms have grown. Farms in North-Eastern Ukraine are important for CEE and global cereal and oilseed food security (Gagalyuk et al., 2022; Berndt et al., 2022). Their limited exports may affect food inflation and child mortality in developing nations (Kidane and Woldemichael, 2020). This situation was confirmed by the Russian invasion of Ukraine in 2022, which created CEE and global food security issues, especially in low-income food-importing countries in Africa, the Middle East, and Asia. Future research should address the impact of corporate farm survival on global food security (OECD, 2023).

To conclude, farm-specific variables, country-specific endowments, and the macroeconomic environment help corporate farms in CEE countries survive. Our study found that firm-specific variables (farm size, farm age, legal format, ownership structure, and corporate finance indicators) and country-level comparative advantages affect corporate farm survival. The latter finding about country-level factors affecting corporate farm survival has significant agricultural and food policy implications during global food supply chain disruptions, which affect local and global food security and food price instability.

The study limitations might pertain at least to two dataset biases: first, corporate farm selection, and second, omitted possibly related explanatory variables. The former dataset bias may influence sample size with its coverage, reliability, and representativeness. The requirements and criteria for filing accounts vary among the 17 CEE countries with heterogenous structures of corporate farms. The latter bias is linked to the ORBIS database limitations associated with the unavailability of data on the effective values of all the explanatory variables used in the estimation and because some farm characteristics that can be correlated to corporate farm survival are not present in this database, such as land and technology. However, we considered the kind of agricultural activities (NACE classification), the size of farms in terms of the number of employees, and some performance indicators, which are considered to be closely related to land size or technology. Finally, farm-specific factors are controlled with additional country-specific factors to capture the diverse agricultural sector structures and corporate farm-enabling environment. Agricultural factor endowments and a

conducive macroeconomic environment can potentially foster comparative advantages and enhance the likelihood of corporate farm viability and survival.

6. Conclusions

This study examines the patterns of survival among corporate farms in 17 Central and Eastern European (CEE) countries between 2007 and 2019. The findings reveal a significant exit rate among corporate farms, with over one-third ceasing operations during the examined timeframe. Survival rates differed among the 17 CEE countries, with Serbia, Russia, Croatia, Romania, and Ukraine having lower rates. An analysis was conducted to identify patterns of corporate farm survival by examining the legal form, ownership structure, financial performance, farm size, farm age, and sector- and country-level explanatory variables.

The study highlighted that the legal structure, ownership arrangement, financial performance, size, age of the farm, and variables at the country level are strongly associated with the survival of corporate farms.

The existence of joint stock companies was notably and favorably correlated with the survival of corporate farms, indicating that this legal structure serves as a protective element against leaving the market.

Survival rates were found to be positively correlated with large shareholdings, suggesting that concentrated ownership improves oversight and mitigates the risk of managerial incompetence.

The study found significant positive associations between return on assets, profit margin, solvency ratio, and farm survival, underscoring the criticality of maintaining strong financial well-being.

Non-linear correlations were found between the size of a farm and its likelihood of survival, as well as for age. Initially, larger farms encountered a greater likelihood of exiting, but they enjoyed superior chances of survival once a certain threshold was reached. Established farms underwent an initial period of increasing survival rates, followed by a decline.

The study revealed that the presence of agricultural land resources, overall labor efficiency, and the degree of openness in agricultural trade are crucial determinants of corporate farm survival. The robustness analysis provides assurance regarding the reliability of the study's findings. Consistency across different probability density functions and sample-restricted estimations reaffirms the robust nature of the identified relationships.

While policy measures were not explicitly specified in the analysis, policymaking relevance could be essential for creating a non-distorting competitive enabling environment that contributes to well-functioning upstream, midstream, and downstream agri-food value chains. Differing political landscapes and influences in agriculture, agri-food value chains, and rural areas, including the lobbying pressure of corporate farms, could potentially impact agricultural transformation and corporate farm survival. In relation to country-specific political, legal, and policy frameworks, this could involve investigating aspects like extensive re-privatization efforts or the seamless transition of socialist structures into corresponding legal frameworks (cooperatives). Investigating policy measures potentially affected by political influences and public policy choices can be considered an issue for further research.

Corporate farms' potential survival strategies are relevant factors in relation to agricultural practices, agri-food markets, and food security in the 17 CEE countries and broader regional and global contexts. On the other hand, considering the opportunities that might arise from their exit could open a new window of opportunities and challenges for other farm organizational structures. However, in the current enabling environment in most of the 17 CEE countries, it is less likely that their complete substitutes will be newly established farms, including family farms. The latter could face similar or even stronger constraints compared to established corporate farms due to their potential financial difficulties and challenges with asset renewal and networks related to their potential lack of experience, networks, and access to fresh capital. This implies that, in contrast to some initial expectations at the beginning of the transition process in the early 1990s, corporate farms have survived as they rationalize and optimize their performance at the farm level. It is likely that this trajectory has gained political support, with policy and practical measures tailored to specific country-level subsets of farms.

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CRediT authorship contribution statement

Imre Fertő: Visualization. **Štefan Bojnec:** Writing – review & editing. **Ichiro Iwasaki:** Conceptualization. **Yoshisada Shida:** Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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