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Factors that affect profitability in the Spanish pig farming industry

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Abstract

Aim of study: To identify factors that boost the financial profits of pig producers. These factors refer to the company, the industry and the territory where they are located. We also incorporated an environmental factor according to greenhouse gas emissions.

Area of study: Spain.

Material and methods: The data used came from a sample of 1,810 Spanish entities that provided unbalanced panel data for the 2003-2018 period.

Main results: In recent decades, the pig farming industry has undergone considerable development characterised by an increase in production, exports and in the productivity of pig farms. The study enabled us to detect the factors that most influence the profitability of pig producers, bearing in mind the possible existence of endogeneity problems between some of the variables analysed.

Research highlights: The results obtained have practical implications, insofar as they facilitate decision-making as regards the location and characteristics that farms must possess in order to obtain competitive profitability.

Additional key words: financial profits; pig integration agreement; business effect; industry/subsector effect; territory effect; panel data; endogeneity.

Abbreviations used: DEA (Data Envelopment Analysis); EBI (Earning Before Interests and Taxes); GDP (Gross Domestic Poduct); GHG (Greenhouse Gas Emissions), HHI (Herfindahl-Hirschman Index); PCA (Principal Component Analysis); ROA (Return On Assets); ROE (Return On Equity); SABI (Sistema de Análisis de Balances Ibéricos).

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Introduction

In respect to Spanish livestock farming, pig is the sector with the greatest economic significance, representing 39% of final livestock production, as well as 14% of final agricultural production (MAPAMA, 2019). It has undergone considerable development in recent decades, providing around 14% of the gross domestic product (GDP) from industry, nearly 1.4% of the national GDP and creating nearly 300,000 direct jobs and over 1,000,000 indirect jobs.

Within this sector, in this study we focus exclusively on livestock production companies that in the last decade have carried out a restructuring process in terms of the number of farms. At present, there are 86,000 exploitations registered in the census of the Ministry of Agriculture (INTERPORC, 2019). The majority of these exploitations use the intensive farming system, which implies keeping the animals inside closed facilities, and represents 84% of the registered farms. Despite the fact that the total number of exploitations has fallen over the years – roughly 13,000 pig farms have disappeared since the 2007 financial year – the number of farms with a greater production capacity has grown (close to more than 500 exploitations), corresponding to those with the highest number of animals in their facilities. The intensive farming system is firmly established as it maximises profitability and is concentrated in regions like Catalonia, Aragón and Castilla y León, which have the largest inventories at a state level (Soldevila et al., 2009).

This study aims to obtain the determining factors of the profitability of leading pig producers. This topic have focused their attention on an economy based on the sector, especially agrifood (Schumacher & Boland, 2005; Chaddad & Mondelli, 2013; Elango & Wieland, 2014; Zouaghi et al., 2017), while there are very few studies at the business level (Pindado & Alarcon, 2015).

Companies dedicated to pig farming form part of a complex industrial sector, characterised by a high number of small and medium enterprises (Goldszmidt et al., 2011) that, in certain regions, create centres of activity, with family-owned businesses in rural areas (Pindado & Alarcon, 2015). In this regard, when the economy of a region is mainly linked to agri-food production, it can positively influence the profitability of its companies (Giusti & Grassini, 2007; Baráth et al., 2021). Indeed, when businesses are near production and sale points, their geographical location can provide advantages and favourable conditions in the availability of human and natural resources (García Alvarez-Coque et al., 2013).

According to previous evidence, there is diversity in the financial profits between companies belonging to the same industry, which leads us to wonder what the differentiating factors are (Claver et al., 2002; Pindado & Alarcon, 2015). Studies related to strategic management have demonstrated the relevance of diverse specific factors, in terms of both industries and businesses, which act as profit drivers (Chaddad & Mondelli, 2013). Thus, in literature there is a wide range of results on the industry's effects on the profitability of companies. In this way, existing impacts can be observed that range from 1% in a study on the food industry in the EU, which analyses factors such as the market concentration index of Herfindahl-Hirschman (HHI) or the growth in the number of companies in the industry (Hirsch et al., 2014), to impacts of nearly 17.5% in related studies in Central American countries (Ketelhöhn & Quintanilla, 2012), which incorporate random effects in industries, businesses and countries. However, in literature on strategic management there is consensus that the effects of the company contribute between 20.8% and 82.3% (Molina-Azorin et al., 2010) to the variance in benefits, although research has been scarce at a geographical or territorial level (Zouaghi et al., 2017). Notable exceptions are the works by Lasagni et al. (2015) and Tamminen (2016), who found evidence of significant relationships between the location and the company's performance.

Another interesting aspect is the environmental impact. This is of crucial importance in the swine industry, since it is one of the major polluters in the food industry. Moreover, the proliferation of swine activities in certain territories and their polluting effects on the environment is a debate that is in the public opinion and in the media[1]. From a technical viewpoint, some studies demonstrate how the economic and environmental improvement potentials of pig farms can be estimated using environmental variables such as nutrients applied with manure and nutrients removed with crops (Asmild & Hougaard, 2006; Latruffe et al., 2013). Our study, that aims to identify the factors that drive the financial gains of pig producers, also incorporates the environmental impact in terms of CO_2 emissions. To the best of our knowledge, there is no study in literature that identifies these factors in the swine industry.

Livestock production systems are the cause of 15% of greenhouse gas (GHG) emissions in the world, which mainly come from cattle and pigs. In particular, it is estimated that pig production produces around 668 million tons of CO_2-eq, which represents 9% of emissions from the livestock sector, according to a report by the Food and Agriculture Organization of the United Nations (https://www.fao.org/news/story/en/item/197623/icode/). In this work we process data from the pig farms' balance sheets and, together with economic-financial information, we incorporate data on GHG emissions, according to data obtained from the National Greenhouse Gas Inventory 2022 (MITECO, 2022) and the Spanish Inter-professional Agri-Food Organisation for White Pork (INTERPORC, 2019).

For this purpose, the study is approached in three levels: company, industry/subsector and territory. Economic-financial variables are used that have been obtained from balance sheet data and information about individual characteristics regarding the environment and location of companies.

The analysed data come from an unbalanced panel of Spanish companies observed during the 2003-2018 period. The statistical treatment was carried out by applying statistical tools for panel data, in order to detect the factors that most influence profitability, bearing in mind the possible existence of endogeneity problems between some

[1] We thank one of the evaluators for calling our attention to this point.

Table 1. Descriptive study of the analysed variables

Variable	Definition	Mean	Median	StdDev	Min	Max	Skewness	Kurtosis
ROA	Return on assets	0.0338	0.0314	0.1155	-1.0014	0.9951	-0.42	14.38
LSize	Log(Size)	6.47	6.43	1.39	-0.21	12.50	0.05	1.29
Age	Age	11.39	10.00	9.69	0.00	68.00	0.93	1.04
Incr_Sales	Increase of sales	0.1365	0.0365	0.6640	-0.9997	9.9141	6.18	57.49
Liquidity	Liquidity ratio	1.75	1.16	1.77	0.00	10.00	2.06	4.54
Indeb	Debt ratio	0.73	0.74	0.39	0.00	9.63	4.39	62.99
HHI	Herfindahl-Hirschman index	158.69	165.33	28.84	120.06	218.46	0.23	-0.96
LSales_Sector	Log(Sales Sector)	14.79	14.80	0.35	14.15	15.35	-0.16	-1.14
IncrFirm	Increase of firms	0.0172	-0.0886	0.4264	-0.5938	0.8824	0.53	-0.81
Unemp	Unemployment rate %	15.01	14.09	7.34	3.03	42.31	0.65	-0.13
EdPrim	Primary education level %	47.28	47.75	8.99	27.10	68.30	-0.16	-0.55
EdSec	Secondary education level %	21.42	21.59	3.05	12.48	28.54	-0.27	-0.05
EdHigh	Higher education level %	31.30	29.91	7.25	18.00	49.74	0.53	-0.42
Foreign	Foreign rate %	10.09	10.66	4.57	1.39	21.09	-0.01	-0.72
Density	Population density	531.06	44.80	1599.76	0.90	17041.50	5.55	41.77
CO_2	Emission CO_2	1726.77	330.50	7737.67	0.01	201793.7	14.10	258.65

of the analysed variables. Furthermore, with the purpose of increasing the power of the study and, given the high percentage of missing data that exists (53.15%), new data imputation techniques were applied, based on the use of principal components (Josse & Husson, 2012, 2016). The use of these techniques avoided having to delete a significant part of the analysed companies, which increased the representativeness of the study and weakened the possible existence of survivorship biases.

Material and methods

Data and variables

The SABI (Iberian Balance Sheet Analysis System) database was the main source for obtaining the data on the companies. This database is generated by Bureau van Dijk and contains financial information about Spanish companies. Many previous studies use activity headings in accordance with the Statistical Classification of Economic Activities (Hirsch & Gschwandtner, 2013). Given the specific nature of this research, the primary activity of the firms analysed is the 'Raising of swine/pigs' (code NACE 0146) and they were located in any province throughout Spanish territory during the 2003-2018 period inclusive. This classification was made up of pig farming companies, from birth until the animals are slaughtered and were therefore focused on their production. All kinds of companies were considered, of all sizes, whether or not they were family-owned, thus increasing the level of generality of the results obtained.

Initially, a total of 1,810 companies were observed, with a total of 28,960 observations. We covered a 56% of the population of companies in the swine sector. Subsequently, the database was cleaned, deleting atypical data of the sample so as to prevent biases in the results obtained and increase their robustness. In particular, the

observations with profitability below -100% and above 100% were eliminated. Furthermore, the companies with a number of missing data equal to or greater than four of the variables at company level during the analysed period were also deleted. For the remaining cases, the missing values in both the variables at company level and the profitability itself were imputed, if sufficient information was available. The imputation process was carried out with the R package *missMDA* (Josse & Husson, 2016), which performs a principal component analysis (PCA) with incomplete data and selects their number by minimising the mean squared error of prediction of the data observed, based on the estimated data using the calculated components. For this purpose, the *imputePCA* function was employed, which uses a regularised iterative PCA algorithm described in Josse & Husson (2012). After carrying out these depuration processes, the definitive sample contained 1,802 companies with a total number of 19,617 observations.

The definitions of the analysed variables, as well as their descriptive statistics are displayed in Table 1.

The company's profitability was analysed by the ROA (return on assets), a ratio expressed in a percentage that is calculated as earnings before interest and taxes (EBIT) divided by the total assets. Due to the high availability of this variable and its informative capacity, its use is very common in literature when analysing performance in any sector, including the agri-food sector (Grau & Reig, 2015). ROA gives us information about the amount of money that the company obtains in exchange for each euro invested in the business and shows the ability of the business to produce profit using its assets. In some sectors, the ROA is higher than in others because the amount of capital invested in assets varies (Panigrahi & Vachhani, 2021). In addition, ROA has proven especially useful for comparing pig farms, because it shows the rate of return on assets and, in some cases, the use of financial leverage to support the productive activity of a farm.

For the purposes of this paper, ROA is a better indicator than other alternatives such as Return on Equity (ROE). ROA reports the profitability of all company assets, while the ROE only determines the rate of return on capital invested by its owner.

To explain the evolution of profitability and with comparative purposes, the following explicative or independent company-level variables, most of which have been considered previously in literature, were used: the *size of the company* measured by using the natural logarithm of the total assets (in thousands of euros); the *age* of the company (in years); the *increase in sales (percentage)*; the *liquidity ratio* measured with the logarithm of the quotient between current assets and current liabilities; the *natural logarithm of the debt ratio*, which divides the total debt (both long- and short-term) between the company's total assets; the *natural logarithm of the annual emissions of* CO_2 (in tons of CO_2eq).

Some of the original variables were log-transformed in order to increase their normality and weaken the influence of outliers.

The size is expected to have a positive and significant influence on the ROA, given that larger hog confinements exhibit increasing returns to scale, consistent with the dramatic increase in market share of very large farms in recent years (Yu & Orazem, 2013). Likewise, the age of the company is expected to have a negative relationship with the ROA, as older companies have less capacity to react to technological change (Baráth et al., 2021). In addition, it is expected that growth could help improve employee motivation, thus achieving greater productivity and leading to an increase in the financial profits. Liquidity is expected to have a positive and significant effect on the financial profits while debt should have negative implications, due to companies use their resources reducing financial expenses, thus increasing their profits and making more resources available to renew obsolete investments that could be more productive. Finally, an environmental variable (CO_2 emissions) was included because the swine industry is one of the major polluters in the food industry. To that aim, each year while the study was underway we obtained data on the tons of CO_2 emitted overall by farms to obtain one ton of pork. We believe that the reason certain farms are able to produce lower CO_2 emissions is partly due to their investment in fixed assets for animal housing, and having waste treatment facilities, such as biodigesters that transform biological waste into biodiesel. For this reason, we have taken each farm's investment in these tangible fixed (measured as fixed assets/sales), as a corrector for the average CO_2 emissions obtained from the sector. The corrected amount of CO_2 emissions has been incorporated into the model to see its effect on ROA. We expect the effect of this variable to be positive, that is, the higher the level of pollution, the greater the profitability. This is due to the fact that to reduce pollution, it is necessary to invest in non-productive fixed assets which, very likely, will have a negative impact on profitability.

With the purpose of analysing the impact of the characteristics at an industry/subsector level, we considered their concentration, size and growth. Based on previous studies, the following independent variables at this level were chosen: the *market concentration level* measured by the Herfindahl-Hirschman Index (HHI), thus a high (reduced) value of the index is a sign of a market with a high (low) concentration and un- (very) competitive; the *natural logarithm of the sales in the sector* (in thousands of euros); and the *increase in the number of companies* in the sector.

It can be seen (see Fig. 3 below) that there was an increase of fairly large farms, particularly the biggest pig producers, although there was a considerable drop in the number of small farms, leading to a decrease in the total number of pig production companies. However, increased production in certain financial years could have resulted in sporadic increases in the total number of farms.

For this reason, a significant negative relationship between the industry concentration index (subsector) and the company's profitability was expected, due to these companies' predisposition to group together. Furthermore, the increase in production is expected to lead to a growth in the industry's sales and this will benefit profitability.

At a geographical or territorial level, the following independent variables were used, related to previous literature: the *natural logarithm of the provincial unemployment rate; the level of education* estimated by using the regional (denominated *Comunidad Autónoma* in Spain) educational training percentages; and the *rate of foreigners* measured through the proportion of foreign-born people among the total population in Spain.

These three variables were extracted from the National Statistics Institute (INE, 2018). The following was also analysed: *population density* or number of inhabitants per square metre referring to the municipality in which the company operated, whose data come through the Digital Atlas of Urban Areas in Spain (MITMA, 2022).

We used geographical variables instead of other kind of variables (macroeconomic, political variables) in line with previous studies (e.g. Usai & Paci, 2003; Ollinger et al., 2005; Webber et al., 2009; Schiefer, 2011; Bekeris, 2012; Fairlie, 2013; Fearne et al., 2013; García-Alvarez-Coque et al., 2013; Zouaghi et al., 2017) that provide information about the composition of the labour force and its quality.

The unemployment rate was expected to have an effect related to the workforce in the area where the company was located, and this could affect its financial profits. Likewise, for the reason described in the previous paragraph, both the level of education of the town where the companies were located and the rate of foreigners were expected to exercise a growing influence on profitability. Finally, it was highly likely that the population density would have a positive influence on performance, as labour costs would possibly be lower in populated areas.

In addition, and in order to know the degree of persistence of financial profits over time, the ROA variable was delayed for a period.

Methodology

Previous empirical papers that study the contribution of several factors in the same result have used classic decomposition models, such as the analysis of variance or ANOVA (Hirsch & Schiefer, 2016) or the Variance Components Analysis (Rumelt, 1991; McGahan & Porter, 1997; McNamara et al., 2005). Others have chosen hierarchical linear modelling (Zouaghi et al., 2017), based on a regression model for each level of analysis, decomposing the variance at different levels.

In this article, and given that the dataset corresponded to an unbalanced dynamic panel, dynamic models were used for panel data (Baltagi, 2001; Wooldridge, 2002; Croissant & Millo, 2018), whose statistical treatment was carried out using the *plm* package for the R statistical computing environment (Croissant & Millo, 2008). The main advantages of this type of model is the possibility to control unobservable heterogeneity, as well as model dynamic responses with microdata. Equations with time delays of exogenous and endogenous variables can be specified, making adjustment processes possible (Arellano & Bond, 1991).

The data corresponded to a non-balanced panel of N firms observed over T time periods. The dependent variable was Y (ROA) and there were K independent variables observed at company and year level $X = (X_1,\ldots, X_K)'$; P independent variables observed at the firm level $U = (U_1, \ldots, U_P)'$; Q independent variables observed at the year level, $V = (V_1,\ldots, V_Q)'$ and R independent variables observed at the level of geographical location and year, $W = (W_1, \ldots, W_R)'$. In our case K=11, X = (LSize, $LSize_2$, Age, Age_2, Incr_Sales, $Incr\_Sales_2$, LLiquidity, $LLiquidity_2$, LIndeb, $LIndeb_2$, LCO_2); Q = 4, V = (Year, HHI, LSales_Sector, Incr_Firm)' and R = 4, W = (LDensity, LUnemp, EdPrim, EdHigh, Foreign)' (see Table 1 for the definition of the variables).

The observed data were given by:

$$\{y_{it}, X_{i,t} = (X_{i,t,1},\ldots, X_{i,t,K})', Vt = (Vt_{,1},\ldots, V_{t,Q})';$$
$$W_t = \left(W_{g_1(i),t,1},\ldots, W_{g_R(i),t,R}\right),\ t\in T_i \subseteq \{1,\ldots,T\};\ i=1,\ldots,N\}$$

where $g_r(i)$ = geographic location of the i-th company associated with the variable W_r (Region in the case of EdPrim and EdHigh, province in the case of Foreign and LUnemp and municipality in the case of LDensity), and T_i is the set of time periods for which the i-th company has complete data on all variables.

The model for this study was a dynamic panel model with fixed and temporary effects given by:

$$y_{i,t} = \alpha_i + \delta_t + \rho y_{i,t-1} + \sum_{k=1}^{K}\beta_k X_{i,t,k} + \sum_{r=1}^{R}\varphi_r W_{g(i),t,r} + \sum_{q=1}^{Q}\phi_q V_{t,q} + \varepsilon_{i,t} \quad (1)$$

where $\boldsymbol{\beta}_i = (\beta_1,\ldots, \beta_K)'$ reflects the effects that the characteristics of company X had on its profitability; $\boldsymbol{\varphi} = (\varphi_1, \ldots, \varphi_R)'$ reflects the effects of covariates W on the company's profitability, depending on the geographical areas in which it develops its activity; $\boldsymbol{\phi} = (\phi_1,\ldots, \phi_Q)'$ reflects the effects of temporal covariates V on the company's profitability, depending on its sector of activity; $\boldsymbol{\delta} = (\delta_1,\ldots, \delta_T)'$ which reflects the effect of omitted temporal variables (these effects were either fixed or random, according to whether they were correlated to the rest of independent variables of the model); $\boldsymbol{\alpha}= (\alpha_1, \ldots, \alpha_N)'$ reflects the effect of the company's fixed characteristics omitted in the model (these effects were either fixed or random, according to whether they were correlated to the rest of independent variables of the model); ρ reflected the dynamic effects of profitability obtained in previous periods; and $\boldsymbol{\psi} = (\psi_1, \ldots, \psi_K)'$ reflects the dynamic effects of covariates X on profitability.

Given the existence of possible endogeneity problems of variable Y with the characteristics of the companies fitting within variables X, the model parameters were estimated by applying the generalised method of moments (Roodman, 2009) using the first difference and sys approaches (Blundell & Bond, 1988; Arellano & Bond, 1991; Arellano & Bover, 1995). For this purpose, the *pgmm* function of the *plm* package for the R statistical computing environment (Croissant & Millo, 2008) was used. Specifically, we used the *sys estimation* method, which tends to be more efficient.

In both cases, the delayed values of the ROA and X variables were used as tools, as well as the two-step estimation method of the variance-covariance matrix of the estimator (Croissant & Millo, 2008; Roodman, 2009), as well as the robust option to correct finite sample biases proposed by Windmeijer (2005). The program calculates the Hansen-Sargan test that compares the existence of overidentifying restrictions. It also calculates first- and second-order residual autocorrelations, as considering the fact that Arellano & Bond (1991) demonstrate the non-existence of significant second-order autocorrelations, they determine that the conditions imposed on the moments are valid; therefore, there was no evidence that the model had been badly specified. Furthermore, it calculates the Wald test to analyse the joint significance of the coefficients and, if temporal indicators are included, the Wald test analyses their joint significance.

Table 2. Estimations of the parameters of the model[1]

Variable	Estimate	SE	Pr(>|z|)
Roa(-1)	0.1713	0.0360	0.0000
LSize	-0.0906	0.0283	0.0014
$LSize^2$	0.0061	0.0020	0.0027
Age	-0.0028	0.0010	0.0070
Age^2	0.0000	0.0000	0.1079
Incr_Sales	0.0352	0.0040	0.0000
$Incr\_Sales^2$	0.0045	0.0014	0.0014
LLiquidity	0.0111	0.0041	0.0070
$LLiquidity^2$	0.0024	0.0010	0.0154
LIndeb	-0.0759	0.0214	0.0004
$LIndeb^2$	-0.0265	0.0076	0.0005
HHI	-0.0003	0.0001	0.0001
LSales_Sector	0.0352	0.0065	0.0000
IncrFirm	0.0045	0.0014	0.0018
LUnemp	0.0081	0.0028	0.0039
EdPrim	-0.0023	0.0005	0.0000
EdHigh	-0.0022	0.0008	0.0040
Foreign	-0.0003	0.0003	0.3732
LDensity	-0.0014	0.0007	0.0569
LCO_2	0.0069	0.0014	0.0000
Sargan Test	627.04	Pvalue	1.0000
AC (1)	-9.01	Pvalue	0.0000
AC (2)	-2.01	Pvalue	0.0542
Wald Coeff	1400.19	Pvalue	0.0000

[1] In blue, the significantly positive coefficients. In red, the significantly negative ones at 5%

Results

Annual evolution of the variables

Fig. 1 displays the evolution of the mean profitability throughout the analysed period. It was observed that after a drop in the mean profitability in 2007, during which mean profits of -1.55% were reached as a consequence of the crisis, there was a growing trend after that year with an estimated average compound annual growth rate of 3.29% cumulated between 2007 and 2018. The reasons for this evolution obeyed a notable restructuring in the sector in recent years, during which there was a marked decrease in the number of small pig farms. At the same time, there was an increase of large pig producers due to takeovers and/or mergers of those that already existed, which led to an increase in production and the census, as well as the average profitability for the period (MAPAMA, 2020).

Fig. 2 displays the annual evolution of the mean values of the explicative company-level variables described in the data and variable section. During the 2007-2015 period, a stable trend is observed in the evolution of the mean values of the variables, in terms of the size of the companies, followed by a growing trend from 2016 to 2018 (Fig. 2). The sales increase was stable and positive (around 10%), except in recent years, when they dropped by 5%. A growing trend in liquidity was also seen from 2008, accompanied by a falling trend in the debt ratio. Indeed, the rise in pork consumption in the domestic market enabled companies to increase their cash flow entries on their balance sheets, thus improving their liquidity and showing a lower dependence on bank debt. Finally, it can be appreciated that the average values of CO_2 emissions remained more or less stable throughout the period analysed.

Fig. 3 displays the annual evolution of the concentration, size and growth of the swine subsector. It is observed that there was a clear rising trend in the concentration of the sector (especially from 2007 onwards) and a higher level of sales, and a stationary trend in the new number of companies, with consecutive rises and falls that fluctuated at an average of around -8.86% per year (see Table 2). This is due to the fact that in the recent decades the pig industry had been through a restructuring process in the number of farms.

Fig. 4 displays the annual evolution of the geographical variables described in the data and variables section. In

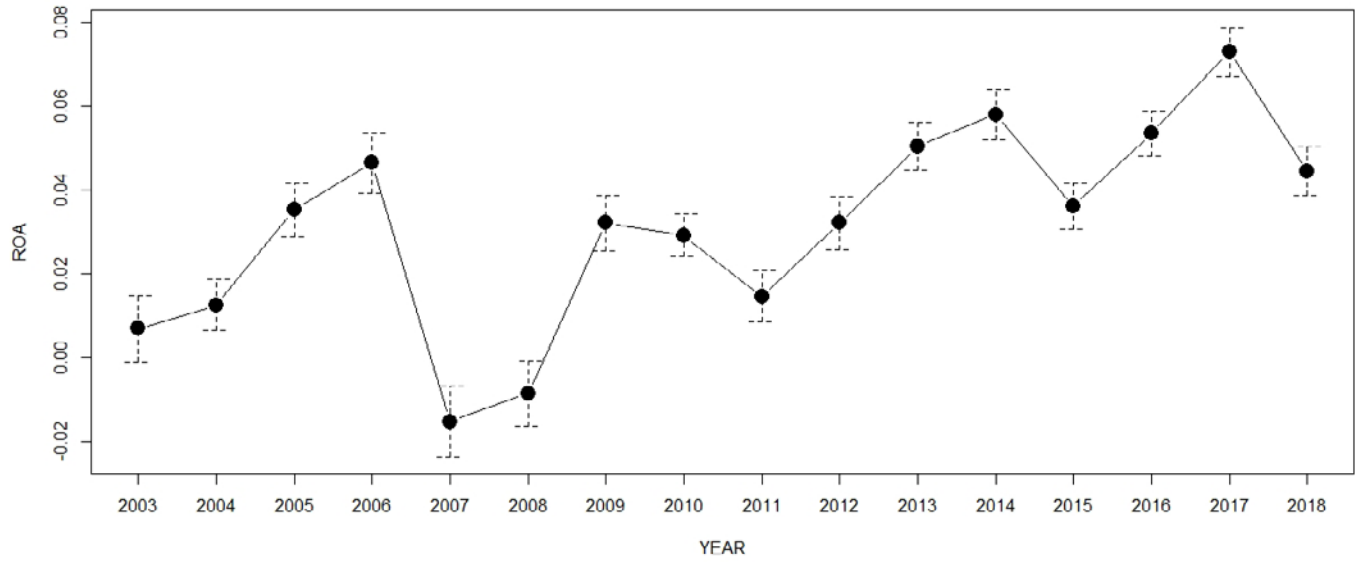

Figure 1. Annual evolution of the mean of ROA (2003-2018). ROA: Return On Assets

2013 the unemployment rate reached a maximum before dropping significantly. However, the population's cultural levels displayed a clear growing trend, which is expressed by a greater percentage of people with a secondary level of studies or higher, accompanied by drop in the percentage of people with primary education. The importance of this growth in the educational level makes workers tend to obtain higher educational achievements, which translates into higher productivity levels and, consequently, in higher profitability levels. In addition, from 2008 onwards, the percentage of foreigners was stable and the same thing happened with the population density, which fell slightly in 2018.

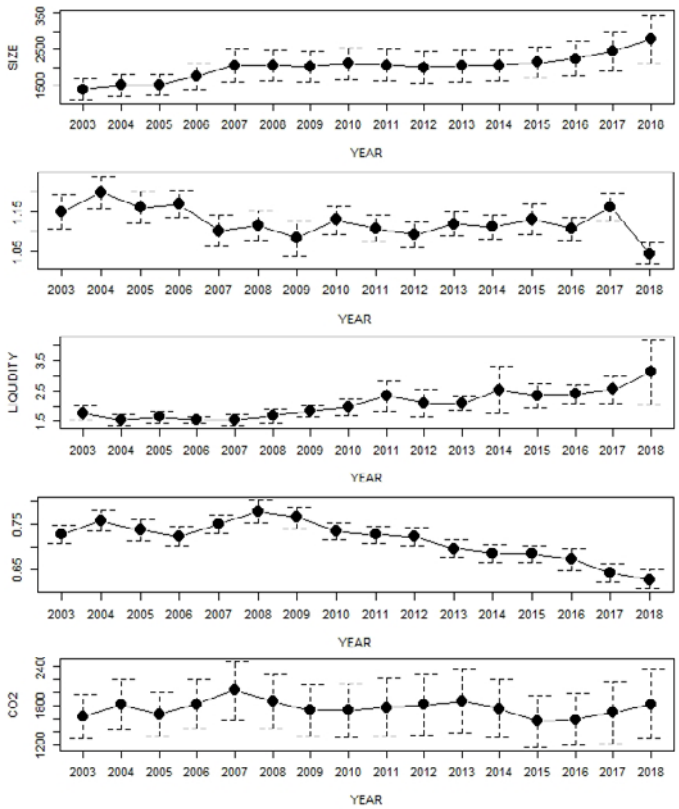

Figure 2. Annual evolution of the average values of the company variables. From top to bottom and from left to right: size, increase in sales, liquidity, indebtedness and CO_2 emissions.

Estimated model

The total number of pig producers analysed was N=1,802 with T=16, giving rise to 19,617 observations of the type of business per year. The estimated model showed an adequate goodness of fit to data since there were no over-identifying problems (the difference with the Sargan-Hansen test was not significant) nor the second-order residual autocorrelation. The results are displayed in Table 2 and show the existence of significant influences on profitability in terms of both companies and sector/industry, and the territorial and/or geographical factors in which the company carried out its activity. It should be noted, however, that the results did not include data from individual farmers or self-business since both of them are not collected by SABI, and this is a limitation to the research.

Discussion

Influence of the business and environmental variables

The size of the company exercised a significant U-shaped influence, reaching minimum profits in companies with total assets of €1,776,000. Therefore, it was observed that up to a certain level of assets, expansion could have negative impacts on profits. Nevertheless, this trend

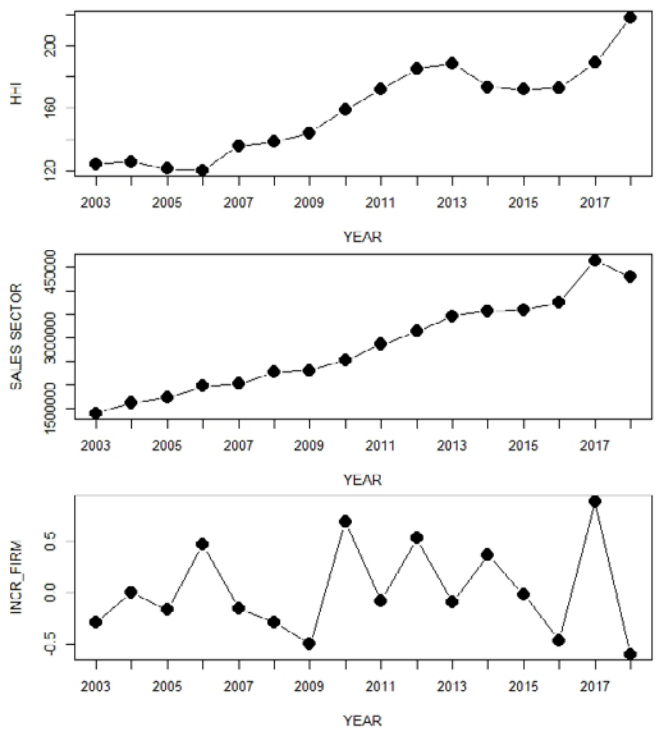

Figure 3. Annual evolution of characteristics at industry/subsector level. From top to bottom and from left to right: Herfindahl-Hirschman Index (HHI), industry sales and the increase in the number of companies.

changed as soon as the company's total assets reached a figure of nearly €1.8 million, thus becoming more profitable as it increased its size.

The reason for this type of effect lies in the growth of the global demand for meat, as new investments are necessary to keep abreast of the latest developments and larger facilities are required to ensure profitability. However, the investment for creating farms and/or extending those that already exist implies a cost that not everyone can afford (Wijnands et al., 2007; Chaddad & Mondelli, 2013; Hirsch et al., 2014). Consequently, companies with a higher turnover will have greater capacity to adapt and mitigate market risks, but small entities are more exposed to these risks, which explains why there was an increasing trend to either change to the integration system and/or disappear (Domínguez & Daudén, 2018). In contrast, expanding by diversifying towards new markets is usually restricted by the capacity of the company's existing management team, as analysed in the first administrative theory of business literature (Penrose, 1995; Marris, 1964). Consequently, the management team may condition the company's trend as regards its size, as traditional livestock farmers can manage their growth up to a certain extent, but afterwards they will need a larger management team that can cover the businesses expansion.

The company's age had a significant negative effect on profitability, in line with previous research (Agarwal & Gort, 2002), with a drop in profitability of 0.28% for each year's increase in the age of the company. This could be due to diverse reasons: rigid organisational structures, slow growth, outdated assets (Loderer & Waelchli, 2010; Hirsch et al., 2014; Zouaghi et al., 2017), lack of quality in business innovation or inertia or bureaucracy (Majumdar, 1997), which can help reduce the ability to react to financial circumstances.

Sales growth is considered to be an indicator related to the company's ability to compete and protect itself from cyclical fluctuations in the market (Rassier & Earnhart, 2015), as well as being a synonym for business success. Previous studies (Pál & Ferrando, 2010; Delmar et al., 2013; Pattitoni et al., 2014; Zouaghi et al., 2017) showed that the growth of sales is associated to the probability of survival, as it represents an increase in the size of the company, and the size lowers the risk of leaving the market. It is also a strengthening process, where previous growth leads to future growth (Delmar et al., 2013), and the dynamics of this growth are an incentive for company employees who will not feel at risk of losing their jobs (Pattitoni et al., 2014; Zouaghi et al., 2017). After the growth, there will be an increase in both productivity and profitability, understanding sales growth as a proxy for investment opportunities and the increase of the size of the company (Pál & Ferrando, 2010). Greiner (1997) considered that this sales growth variable could have negative effects in the event of a break-up in informal relationships between employers due to increased competitiveness.

We also found a U-shape and clearly significant relationship, achieving a minimum profitability of €3.9 million. Given that the corresponding coefficients were significantly positive we conclude that Sales growth is positively related to Profitability but with increasing returns to scale. This multiplying effect is explained by the rise in production that took place in the sector at a time when there was a drop in the number of farms, which had turned into economies of scale, making it possible to increase profitability. This fact, coupled with the rise in the price of pigs in origin, had a positive impact on profitability.

As regards the effect of the financial risk, the influence of the liquidity ratio and debt ratio were analysed. The liquidity ratio, as an indicator of the company's capacity to meet short-term payment obligations (Rees, 1995), was expected to exercise a significant, positive effect on profitability as when companies have a lower risk they have greater capacity to face their short-term debts, and are more profitable in the long run. In our case, this effect had a U-shape and clearly significant relationship. Given that the estimated coefficients were significantly positive, we conclude that liquidity is positively related to profitability but with increasing returns to scale. The companies have greater ability to adapt to changes as a consequence of having the necessary resources to deal with unexpected situations and short-term financial obligations (Goddard et al., 2005). The impact of the financial risk (measured as the opposite of liquidity) was mainly negative and significant in the Spanish agri-food sector (Zouaghi et al., 2017). The results obtained were in the same line as other em-

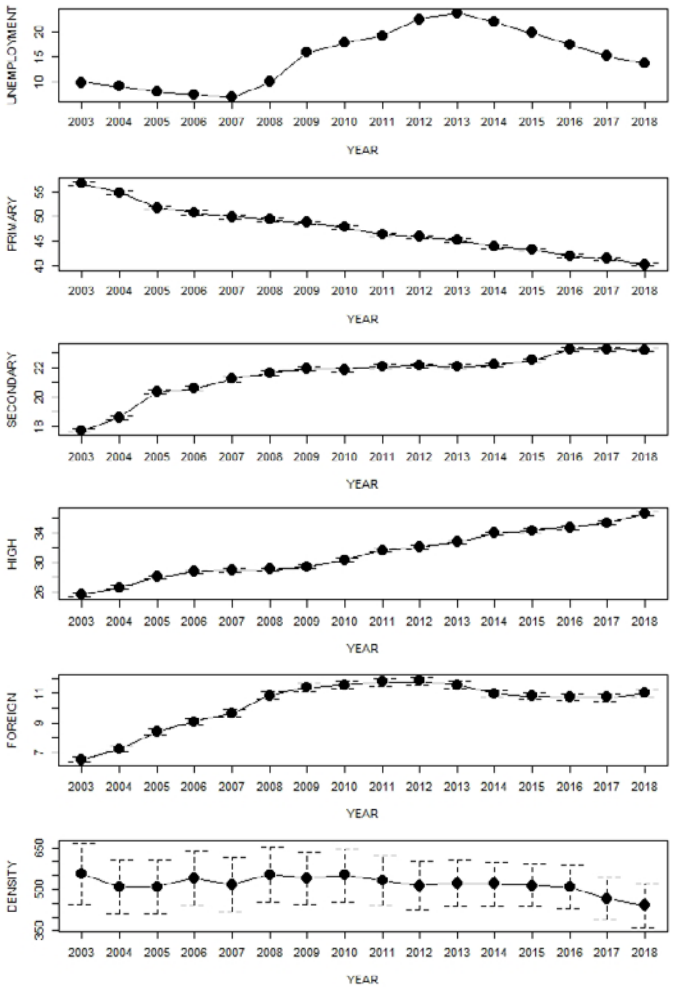

Figure 4. Annual evolution of the geographical characteristics of the companies. From top to bottom and from left to right: unemployment rate, average values of the percentage of primary, secondary and higher education, foreign rate and density.

pirical studies (e.g., Gschwandtner, 2005; Enqvist et al., 2014; Hirsch et al., 2014; Pattitoni et al., 2014), based on the paradox that good business practices can increase the ROA and, at the same time, reduce financial risk (Bowman, 1980). Therefore, when liquidity is managed properly, short-term payment commitments can be addressed and new investments can be carried out with greater security.

Continuing with the financial risk analysis, the company's debt ratio had relevant implications for profitability. It was shaped like an inverted U, reaching a maximum in 0.2390. According to these results, taking on debt had a positive effect on profitability until the maximum was reached but, from that point onwards, it tended to exercise a negative effect on profitability. The higher the level of indebtedness, the stronger the effect. The negative effect is due to the fact that an increase in the financial risk reduces profitability and implies lower profits; therefore, fewer resources are generated (Bowman, 1980). For this reason, a company with high debt levels could decide not to renew new productive investments for the company's performance (Garvey, 1992). In line with previous studies, companies that are not vulnerable to negative financial situations, corresponding to those that do not experience significant reductions in their financial profits during these periods, all have in common the growths of their assets and reductions in their levels of indebtedness (Grau & Reig, 2015).

With respect to the influence of the CO_2 emissions produced by the farms, a significant positive influence on their profitability was observed, in such a way that when CO_2 emissions increase by 1%, profitability can be expected to grow by 0.69% (see Table 2). Therefore, as anticipated, the control of emissions did not have an economic benefit in companies in the pig sector, but on the contrary, the costs of adapting the facilities reduced profitability without compensating the investment effort for environmental purposes. These results denote the lack of sufficient incentives in companies, in the period analysed, to undertake investment projects aimed at environmental improvement.

Influence of the industry/subsector variables

The variables measured in terms of industry and/or subsector exercised a significant influence on the evolution of the companies' profitability. Thus, lower levels of concentration (higher number of companies) and higher sales levels in the sector were directly associated to profitability. This was justified by the synergies created by the proximity between companies. This situation led to reductions in transaction and transport costs, due to the fact that it was easy to work with suppliers in the area. Furthermore, as the integrating businesses needed to put the animals on multiple farms in order to attend to the existing demand, it led to higher markups for the farmers, which helped increase profitability. This result did not coincide with the results presented in other sectors that find a positive and significant impact between concentration and profitability (Bhuyan & McCafferty, 2013; Delmar et al., 2013; Hirsch et al., 2014; Zouaghi et al., 2017). It must be pointed out that literature also shows that strong business dynamism can lead to instability and high volatility in the environment, which has a negative effect on profits (Misangyi et al., 2006).

In our case, the size of the industry acted as an indicator of a heavy demand and high profits (Zouaghi et al., 2017). However, this was a circumstantial result and could have changed had there been a variation in the circumstances of the international market. Therefore, it is advisable to take these results with due precaution.

Influence of the variables of a territorial nature

In relation to territorial variables, significant influences on profitability of a different sign could be observed, with the sole exception of the percentage of foreigners in the area.

As regards the unemployment rate, our results showed a significant positive paradoxical relationship with profitability, with the opposite sign to the one found in previous literature. According to previous evidence, an increase in the regional unemployment rate reduces profitability, especially in small businesses (Bekeris, 2012). High unemployment can make businesses enter the market, with the purpose of completing their staff, which increases competition and causes profitability to drop (Fairlie, 2013). However, in our case, greater competition generates higher financial profit in this kind of company. The reason for this relationship is associated to the workforce, as the companies within this sector have a constant need to hire staff. High unemployment in a specific area can make the company's profitability increase as a result of hiring unqualified unemployed staff who probably demand lower salaries.

Previous research sustains that a higher level of education can lead to a rise in productivity, greater competitiveness and, consequently, an increase in profitability. As a result, the companies located in areas where there is a high educational level can be expected to be more productive and competitive (Usai & Paci, 2003). Nevertheless, it can have the opposite effect; in other words, when the population has a lower educational level, companies tend to be more profitable, due to the existence of workers with lower qualifications (Ollinger et al., 2005; Schiefer, 2011). In our case, a significant relationship with a negative sense was observed, regarding both the percentage of population with higher studies and the percentage of population with primary educational levels, which implies a positive relationship with the percentage of population with secondary level studies. Bearing in mind that, in general terms, the population's educational level had increased (see Fig. 4), these results suggested that the level of education had an overall positive effect on profitability, and an excessively qualified workforce was not required.

In respect to foreign-born population, it was observed that it did not have a significant effect. This could have been due to the fact that foreign manpower is related to other economic activities, such as the meat industry, slaughterhouses or activities related to agriculture (Zouaghi et al., 2017).

It was also considered relevant to examine the effect of density on the ROA, as it would determine the environment in which the most profitable companies were located and would provide information about which areas would be the most appropriate for setting up farms when investing in the business. Our results indicated that this variable exercised a slightly significant negative influence on companies' profitability, with rural areas being the most profitable. In general, companies dedicated to livestock production were located on land not suitable for development near agricultural areas, due to the proximity for accessing raw materials and the subsequent cutting of costs this implied. This feature acts as an element that leads the population to settle in the rural environment, consequently reducing the rural depopulation phenomenon (García-Moreno, 2020). The result was similar to previous studies which affirm that especially in micro-enterprises and small and medium-sized enterprises, the rural environment is not perceived as a limitation for profitability (Fearne et al., 2013; García Alvarez-Coque et al., 2013).

Dynamic effects on the evolution of profitability

Finally, we observed a persistence over the years that was significantly positive, although not very marked, in the evolution of the profitability, with a first-order autocorrelation coefficient of a medium-low type, with a value of around 0.17 (see Table 2). Therefore, in respect to the ROA, effects of the past affect the present day (Hirsch et al., 2013), as it is a sector that does not directly suffer the consequences of external negative situations and its revenue has a certain guarantee of security due to the static demand.

Conclusions

In this paper, certain factors were analysed that determined the profitability of pig producers in Spain during the 2003-2018 period, using statistical panel data analysis techniques. The study was based on three levels: company, industry/subsector and territory.

The economic activity of pig production within the pig industry is a business opportunity, as although it presents fairly low profitability of ~ 3-4%, it is secure and guaranteed. The dynamics of the pig industry generates groups of pig farms. Over the years, there has been an increase in the average size of these undertakings. Thus, the business shows a growth that is reflected in the constant increase in sales, both business and sector-based, meaning that greater infrastructure is necessary to cover the current growing demand. This strengthens the idea of investment, given the good circumstances and consolidation of the sector, and the business' high degree of survival. In a search to increase production capacity, pig farms obtain economies of scale that can increase profitability as soon as the volume of assets surpasses €1.8 million, but the company's age had a significant negative effect on profitability, which fell by 0.28% for each year's increase in the age of the company. This effect may be due to the lack of modernisation of the facilities and/or the absence of processes that incorporate R&D in production. The proper management of financial risk in terms of liquidity had positive effects, exhibiting increasing returns to scale, whereas an excessive level of indebtedness, considering the considerable importance of fixed assets, created risks in unfavourable economic situations, although the sector shows a strong trend to reduce its levels of indebtedness.

Furthermore, a growth was observed in the level of activity in the sector, accompanied by a rise in the levels of profitability. This is justified by the synergies created as a

result of the proximity between companies. This situation has generated profits that are reflected in lower transaction and transport costs, particularly if these companies are located in low-density rural areas. Moreover, the integrating businesses' need to put the animals on multiple farms has led to higher markups for the farmers, which has helped increase profitability. In addition, a relationship between the increase in CO_2 and the returns of pig farms has been observed. These returns are higher when the farmer does not apply techniques aimed at obtaining gas reductions. The application of techniques that are respectful with the environment supposes a greater amount of expenses and a reduction in profitability.

This evidence poses a challenge for public administration entities, producer organizations and regional governments, which must adopt measures to encourage farms to make new investments in assets that reduce gas emissions, promote circular economy and the use of renewable energies, as well as supply farms with thermal, solar or photovoltaic energy, so they may reduce their environmental impact.

Finally, the territorial aspects were also significant. Companies located in areas with high unemployment rates were able to reduce the costs of labour. In addition, it was more profitable to set up a company in areas where there is a dominance of people who have studied secondary education, as this leads to an improvement in business productivity, due to the fact that excessively qualified manpower is not required.

From the results obtained, some recommendations and conclusions can be drawn for management teams to improve business performance. The progressive reduction of indebtedness in exchange for a greater use of own funds will increase financial gains and make the company more profitable. Companies located in areas with high unemployment rates can reduce labour costs, so it is recommended to set up new companies in areas where there is a predominance of workers who have completed secondary school, since this results in an improvement in business productivity, as excessively skilled labour is not required. Regarding the size, it is advisable for companies that can have a certain number of farms to reach an optimal level, as this will enable them to obtain economies of scale, albeit bearing in mind the limits established by regional governments, which for social and environmental reasons are restricting the number of heads per farm. Finally, policymakers are recommended to support extensive livestock farming for reasons related to economic viability and encourage investments in assets capable of reducing the GHG emissions so that these investments did not imply a decrease in the profitability of the companies in the sector.

Future research lines are aimed towards including new variables (level of the diversification of activities and the intensive level of the companies' vertical integration, distance to slaughterhouses, etc.) that have not been considered due to insufficient data, as well as the sector's environmental impact. In the development of our work, we have encountered some data limitations. The scope of the data available from the SABI is restricted to business companies, therefore individual farmers have not been treated in this study. This has resulted in methodological and empirical limitations because it leaves smaller farms out of the study. The period under study also needs to be updated. Finally, other studies have analysed the optimal level of production according to the economic efficiency. This interesting research line, which requires the use of another type of models, such as stochastic frontier models or Data Envelopment Analysis (DEA) techniques to estimate the efficiency of each farm, could bring light on more interesting results. All these are tasks that we will have the opportunity to address in future research.

Authors' contributions

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