

EFFICIENCY MEASURES FOR SPANISH RETAILING FIRMS IN A REGULATED MARKET

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The objective of this work is to analyze the impact on Spanish retail firms' efficiency of the regulatory process experienced in the period 1996-2002. The intangible nature of services makes them more difficult to quantify, so we combine work measurements with the methodology of the stochastic frontier production function for unbalanced panel data, and for which the firm effects are an exponential function of time. Furthermore, we obtain other relevant technological measurements of these productive processes such as the scale and the technical progress parameters. Our econometric results show great heterogeneity in the firms' efficiency but without change over the period and the predominance of decreasing returns to scale. They also indicate that technological progress was produced.

Keywords: Efficiency, Regulation, Retail Sector

JEL Classification: D24, L51, L81

1. INTRODUCTION

In recent decades, efficiency has been a popular topic of theoretical and empirical research. However, empirical evidence is still relatively scarce in service sector, save for the topics of efficiency in banking (see Heshmati (2003) for an excellent survey). This is surprising, especially in light of the major role of the service sector in our modern economies, and this idea is, also, corroborated by the fact that service industries generate over two-thirds of GNP and employment in developed countries and their importance is growing. In Spain, the economy has become more service oriented, and in the last decades the service sector has generated a big proportion of employment, the number of Spanish workers employed in the service sector has gone to approximately 60% of total employment (see Cuadrado Roura *et al.* (1999) for a survey of this sector).

The character of competition differs among service sectors, although the nature of

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competition can be affected by government regulations or rules imposed by professional organizations and associations. This paper discusses the impact of regulatory reforms and their effects on efficiency in the Spanish retail sector. This sector has undergone profound changes, to a certain degree similar to those occurring throughout Europe (see Boylaud (2000)), in particular, Spain has experienced important legislative changes such as the Retail Trade Regulation Act (1996) and the Shop Opening Hours Decree-Law (2000), which have had an impact on retailers' strategies.

This paper estimates levels of technical efficiency reached by Spanish retail firms through an econometric estimation of stochastic frontier production functions from an unbalanced panel (between 1996 and 2002) of 1,050 firms. In addition to these (in)efficiency indicators other important technological measurements of these productive processes are obtained such as the scale and technical progress parameters.

The most usual types of frontiers found in empirical service sector literature are deterministic frontiers computed from mathematical programming. Those methods have a disadvantage that is based on the fact that they do not take random factors into account, and all deviations from the frontier are labeled as inefficiencies. However, this paper estimates stochastic parametric frontiers using a panel data approach for which the firm effects are an exponential function of time, given that this type of frontier has relative advantages over the rest.

The remainder of the paper is organized as follows: in the next section the theoretical framework is developed. Then, the data, the econometric specification and the results of the estimates are dealt with. Finally, the main conclusions are presented.

2. TIME-VARYING MODEL FOR UNBALANCED PANEL DATA

To measure (in)efficiency of Spanish retail firms, we propose a stochastic frontier production function for unbalanced panel data (Battese and Coelli (1992)). This type of frontier and the computation method present advantages with respect to other alternatives, for example the deterministic frontiers.¹ First, the deterministic frontiers are based on the assumption that the only type of explanation for the deviation between the observed output and its frontier output is due to its own inefficiency. This idea is difficult to maintain at the empirical level as it ignores the possibility that the observed output can differ from the potential because of two other factors: stochastic shocks and measurement error in the variables.

Second, the mathematical programming methods have two disadvantages with respect to specifying a statistical relationship between the outputs and the inputs. On one hand, the frontier estimation is made over a subsample of the whole and therefore these

¹The works of Førsund, Lovell and Schmidt (1980) and Kalijaran and Shand (1999) are excellent surveys of efficiency frontiers.

methods are extremely sensitive to the existence of outliers. On the other hand, the estimated coefficients lack statistical properties, so it is not possible to make any statistical inference or establish hypothesis contrasts from them.

The stochastic frontier production function proposed has firm effects which are assumed to be distributed as truncated normal random variables and, also, are allowed to vary systematically with time. The model may be expressed as:

$$Y_{it} = \beta_0 + \sum_{j=1}^k \beta_j X_{jit} + (V_{it} - U_{it}), \quad i = 1, \dots, N, t = 1, \dots, T, \quad (1)$$

where Y_{it} denotes (the logarithm of) the production of the i -th firm in the t -th time period; X_k represents the k -th (transformations of the) input quantities; β_k stands for the output elasticity with respect to the k -th input; the V_{it} is a random variable which is assumed to be independent and identically distributed (i.i.d.) $N(0, \sigma_V^2)$, and distributed independently of the U_{it} which has the specification:

$$U_{it} = U_i \eta_{it} = U_i \exp(-\eta(t - T_i)), \quad (2)$$

where the U_i is a non-negative random variable which is assumed to account for technical inefficiency in production and are assumed to be i.i.d. as truncations at zero of the $N(\mu, \sigma_\mu^2)$ distribution and η is a parameter to be estimated.

The last period ($t=T_i$) for firm i contains the base level of inefficiency for that firm ($U_{it} = U_i$). If $\eta > 0$, then the level of inefficiency decays toward the base level. If $\eta < 0$, then the level of inefficiency increases to the base level, and if $\eta = 0$, then the level of inefficiency remain constant.

We use the parametrization of Battese and Corra (1977) who replace σ_V^2 and σ_μ^2 with $\sigma^2 = \sigma_V^2 + \sigma_\mu^2$ and $\gamma = \sigma_\mu^2 / (\sigma_V^2 + \sigma_\mu^2)$. The parameter γ must lie between 0 and 1.

The imposition of one or more restrictions upon this model formulation can provide a number of special cases of this particular model which have appeared in literature. For example, setting η to be zero provides the time-invariant model. One can also test whether any form of stochastic frontier production function is required at all by testing the significance of the γ parameter. If the null hypothesis, that γ equals zero, is accepted, this would indicate that σ_μ^2 is zero and hence that the U_{it} term should be removed from the model, leaving a specification with parameters that can be consistently estimated using ordinary least squares.

The predictions of individual firm technical efficiencies from the estimated stochastic production frontiers are defined as:

$$\begin{aligned}
EF_{it} &= \exp(-U_{it}) = E[\exp(-U_{it}) / E_i] \\
&= \left\{ \frac{1 - \Phi\left[\eta_{it}\sigma_i^* - (\mu_i^* / \sigma_i^*)\right]}{1 - \Phi\left[-\mu_i^* / \sigma_i^*\right]} \right\} \exp\left[-\eta_{it}\mu_i^* + \frac{1}{2}\eta_{it}^2\sigma_i^{*2}\right], \tag{3}
\end{aligned}$$

where E_i represents the $(T_i \times 1)$ vector of E_{it} 's associated with the time periods observed for the i th firm, where $E_{it} = V_{it} - U_{it}$;

$$\mu_i^* = \frac{\mu\sigma_V^2 - \eta_i' E_i \sigma^2}{\sigma_V^2 + \eta_i' \eta_i \sigma^2}, \tag{4}$$

$$\sigma_i^{*2} = \frac{\sigma_V^2 \sigma^2}{\sigma_V^2 + \eta_i' \eta_i \sigma^2}, \tag{5}$$

where η_i represents the $(T_i \times 1)$ vector of η_{it} 's associated with the time periods observed for the i th firm, and $\Phi(\cdot)$ represents the distribution function for the standard normal random variable. If the firm effects are time invariant, then technical efficiency is obtained by replacing $\eta_{it} = 1$ and $\eta = 0$.

3. EMPIRICAL SPECIFICATION AND RESULTS

In recent years, Spain has experienced important legislative changes such as the Retail Trade Regulation Act (1996) and the Shop Opening Hours Decree-Law (2000). In relation to the Retail Trade Act (*Ley de Comercio Minorista*) 7/1996 has the objective of finding a balance between the different forms of competition. It transfers responsibility in the regulation of commercial establishment opening times to the Autonomous Communities,² which grant the licenses they consider appropriate. This law coexists with the Autonomous Community governments' exclusive responsibilities in the area. The Autonomous Communities define in each case what, in their judgment, is a large retail outlet. In 1996, the Autonomous Communities were authorized to grant licenses essential for opening any major retail outlet, after evaluating the real needs. This does not affect the license that the local councils continue to require. The law 6/2000 (Blue Laws), regarding commercial opening hours' schedules, which extended the number of holiday openings has been one of the most important and relevant in the retail sector.

²The term Autonomous Community refers to a region integrating several counties. Within its competence as a decentralized institution, it assumes the exercise of regional self-government in agreement with the Spanish Constitution.

The study of the consequences of the relaxation of Blue Laws is a very complex question. Literature on the matter is abundant, but very diverse according to the geographic zones, the methodologies and the types of effects. The definitive explanation of effects that the deregulation of opening hours has produced in the retail sector would be in the changes in the consumer behaviour (see Grunhagen and Mittelstaedt (2001)).

There has been a complete commercial restructuring³ that has led to an opportunity for new commercial formats, as well as the extinction of obsolete commercial formats. In Figure 1, we can see that the global number of retailers has decreased (29%), and this decline is most marked among the traditional stores (42%). On the other hand, the size of the stores has increased. The number of hypermarkets has increased (27.9%), followed by supermarkets and self-service stores (14.9%), and the discount stores have made a strong appearance (42%).

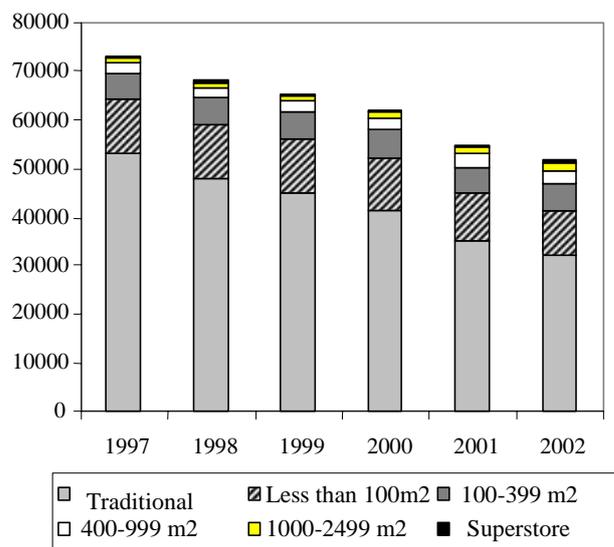
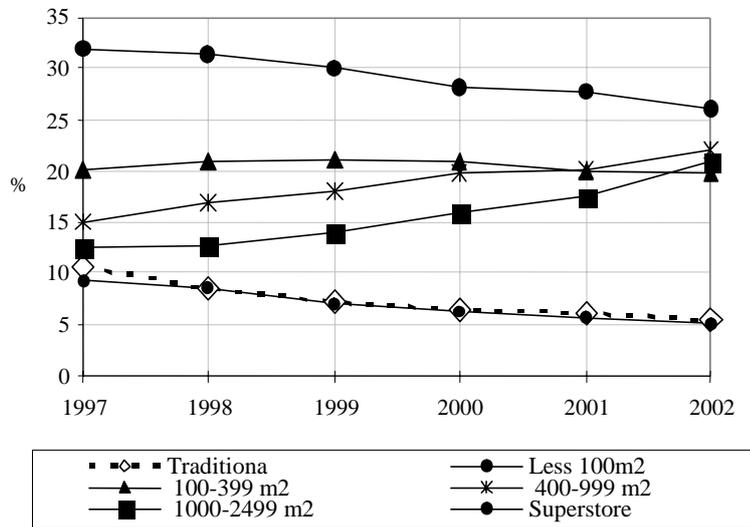


Figure 1. Number of Stores in Each Category

³ See Gómez *et al.* (1999) to appreciate the effect of Spanish legislation on commercial structures, market share and margins.



Source: AC Nielsen, Alimarket 1996-2004

Figure 1-1. Percentage of Market Share per Store

In Figure 1-1, the evolution in market shares of the different types of store can also be observed. The traditional store has lost 4.5 percent of market share in pre-packed food and the hypermarkets have lost 6.6 percent. Nevertheless, supermarkets of between 400 and 2,499 m² have gained ground. This growth trend in Spanish retailing, as well as the concentration effects, has been mirrored by similar behavior in Europe (Aalto-Setälä (2002), Carree and Nijkamp (2001)).

The SABE (*Sistema de Análisis de Balances Españoles*) provides the required data to estimate an efficiency measure. It is an annual survey which looks at a panel of firms representative of Spanish service firms and contains balance sheet, cash flow and qualitative data. The database is an unbalanced panel observed over the period 1996-2002. SABE also provides information about the major two-digit NACE codes⁴ to

⁴NACE codes represent the statistical classification of economic activities within the European Union which serves as a basis for compiling statistics on the production, factors of production (labor, raw materials, energy, etc.), fixed capital formation operations and financial operations of firms and other entities. NACE means "Nomenclature Generale des Activites Economiques dans l'Union Europeenne" (General Name for Economic Activities in the European Union).

which the firms belong. The service sector analysed in this paper is 52 (Retail trade, except for motor vehicles and motorcycles; repair of personal and household goods), there are 1,050 firms and 4,056 observations are effected.

The Cobb-Douglas and Translog functional forms are the most used functional forms in stochastic frontier analyses. In this paper, we wish to estimate the Translog production frontier, since the Cobb-Douglas production function imposes many restrictions.

Output is measured by the yearly added value (AV), defined as sales less cost of goods plus inventories, and is converted into real terms.⁵ Labor (N) is measured as the number of employees. In this type of study, the standard practice is to define labor in terms of hours worked but this information is not available. Capital quantities (K) are defined as the marked value of assets owned by the firms, in constant prices. Table 1 shows a statistics summary of the data used in this study.

Table 1. Summary Statistics^a

Sector classification	Variable	Mean	Standard Deviation	Minimum Value	Maximum Value
52	AV	688.53	6126.89	0.74	186628.1
	N	30.41	203.96	1	6506
	K	1059.35	9531.63	0.79	187612.2

Note: ^a Output (AV) and capital (K) are in thousands of euros.

The translog production function we have:

$$\begin{aligned} \log(AV_{it}) = & \beta_0 + \beta_1 \log(N_{it}) + \beta_2 \log(K_{it}) + \beta_3 \log(N_{it})^2 + \beta_4 \log(K_{it})^2 \\ & + \beta_5 \log(K_{it}) \log(N_{it}) + \beta_6 t + (V_{it} - U_{it}). \end{aligned} \quad (6)$$

We can test whether the form of the production function is required by testing the hypothesis of $\beta_3 = \beta_4 = \beta_5 = 0$. If the null hypothesis is accepted, this would indicate that those terms should be removed from the model, leaving a specification of Cobb-Douglas production function. Also, we can calculate the output elasticities of inputs for the mean values, and the sum of them gives us the elasticity of scale, which indicates the returns to scale. There is also the variable t (Time) which is added here with the intention of registering the effect of technical change in the retail sector, which is common among firms in the same sector. V_{it} and U_{it} are the random variables

⁵The use of added value in the estimation of this production function, which includes only capital and labor inputs, means that changes in non-specified inputs such as the quantities and the prices of materials used in production will be measured as changes in technical efficiency.

whose distributional properties are defined in the last section.

The stochastic frontier model, defined by Equation (6), contains seven β parameters and the four additional parameters associated with the distributions of the V_{it} and U_{it} random variables, and we estimate them by maximum-likelihood estimation methods.

The process of estimation proposed is the following: Model A is the stochastic frontier production function in which the firm effects, U_{it} , has the time-varying structure defined in the last section; Model B is the case in which the U_i 's has half-normal distribution, it assumes that $\mu=0$; Model C is the time-invariant model, it assumes that $\eta=0$; Model D is the time-invariant model in which the U_i 's have half-normal distribution, it assumes that $\mu=\eta=0$; Finally, Model E is the average response function in which firms are assumed to be fully technically efficient, the firm effects are absent from the model, and it assumes that $\gamma=\mu=\eta=0$.

Table 2 displays the estimated coefficients. Presented below the name of the sector, in brackets, is the name for the best model, based on the generalized likelihood-ratio statistic. To determine the most suitable model, we follow various hypothesis tests of restriction on the parameters of the production structure. These generalized likelihood ratio statistics along with the decision are reported in the table.

Table 2. Estimations and Hypothesis Tests (period 1996-2002)

SECTOR 52	Variable	Maximum-likelihood estimates				
		Model A	Model B	Model C	Model D	Model E
(Model C)	C	-6.905 (26.964)	9.233 (15.811)	-60.779 (12.887)**	-51.676 (8.276)**	-36.203 (8.959)**
	N	0.559 (0.031)**	0.553 (0.033)**	0.565 (0.031)**	0.556 (0.033)**	0.613 (0.030)**
	K	0.094 (0.021)**	0.122 (0.022)**	0.094 (0.021)**	0.118 (0.0225)**	0.116 (0.020)**
	N^2	0.063 (0.009)**	0.094 (0.009)**	0.062 (0.009)**	0.093 (0.009)**	0.090 (0.009)**
	K^2	0.020 (0.003)**	0.021 (0.004)**	0.020 (0.003)**	0.021 (0.004)**	0.022 (0.003)**
	$N * K$	-0.045 (0.009)**	-0.065 (0.009)**	-0.045 (0.009)**	-0.062 (0.009)**	-0.066 (0.009)**
	T	0.006 (0.013)	-0.003 (0.008)	0.033 (0.004)**	0.028 (0.004)**	0.020 (0.004)**
	μ	2.113 (0.274)**	-	2.687 (10.236)	-	-
	η	0.014	0.049	-	-	-

$\sigma^2 = \sigma_V^2 + \sigma_\mu^2$	(0.007)** 0.371 (0.013)**	(0.010)** 0.812 (0.049)**	0.379 (0.013)**	0.912 (0.050)**	0.472 (0.010)**
γ	0.589 (0.016)**	0.784 (0.015)**	0.596 (0.016)**	0.806 (0.013)**	-
Log (likelihood)	-2892.271	-3084.562	-2894.384	-3094.963	-3223.810
Hypothesis test for parameters					
Null hypothesis	Assumptions	χ^2 - statistics	Decision		
$\gamma = \mu = \eta = 0$	Model A	663.08	Reject H_0		
$\mu = \eta = 0$	Model A	405.38	Reject H_0		
$\mu = 0$	Model A	384.58	Reject H_0		
$\eta = 0$	Model A	4.22	Accept H_0		
$\gamma = \mu = 0$	Model C ($\eta = 0$)	658.85	Reject H_0		
$\mu = 0$	Model C ($\eta = 0$)	200.58	Reject H_0		

Notes: The estimated standard errors for the parameter estimators are presented below the corresponding estimates. *, ** indicate significance at 10 and 5% respectively.

As can be observed, labor and capital inputs are significant across all the estimations. Furthermore, the hypothesis that the Cobb-Douglas production function is an adequate representation ($H_0 : \beta_3 = \beta_4 = \beta_5 = 0$) is rejected ($\chi^2(3) = 91.43$). The null hypothesis, $H_0 : \gamma = \mu = \eta = 0$, is rejected, it is evident that the traditional average production function is not an adequate representation of the sample. Also, the hypothesis that the half-normal distribution is an adequate representation for the distribution of the firm effects is also rejected ($H_0 : \mu = \eta = 0$ and $H_0 : \mu = 0$). However, the hypothesis that time-invariant models for firm effects is not rejected. Given that in the retail sector the time-invariant is appropriated to the firm effects, the level of inefficiency therefore remains constant over a period characterized by a legislative change.

Table 3 reports the elasticity of scale, the rate of technical progress and the efficiency measure. These results show that the elasticity of scale is 0.805. The rate of technical progress reveals a parameter significantly different from zero and positive (3.3%), indicating that in the period analyzed technological progress was produced, motivated perhaps by the demand fluctuations of the retail sector and/or by the effects of new legislative norms. The technical efficiency rate is obtained by replacing $\eta_{it} = 1$ and $\eta = 0$ in Equation (3) due to the fact that the hypothesis of time-invariant is accepted and therefore the level of inefficiency remains constant over the period. The mean of the efficiency indicator is 0.077 and the standard deviation is 0.04 for the full sample. The histogram (presented in Figure 2) displays a dispersion of efficiency indicator and great divergence for the sector.

Table 3. Relevant Parameters

Sector classification	Elasticity of scale ^a	Rate of technical progress (%)	Efficiency measure		
			Mean	Min. Value	Max. Value
52	0.805	3.3	0.077	0.011	0.471

Note: ^a Calculated for mean values.

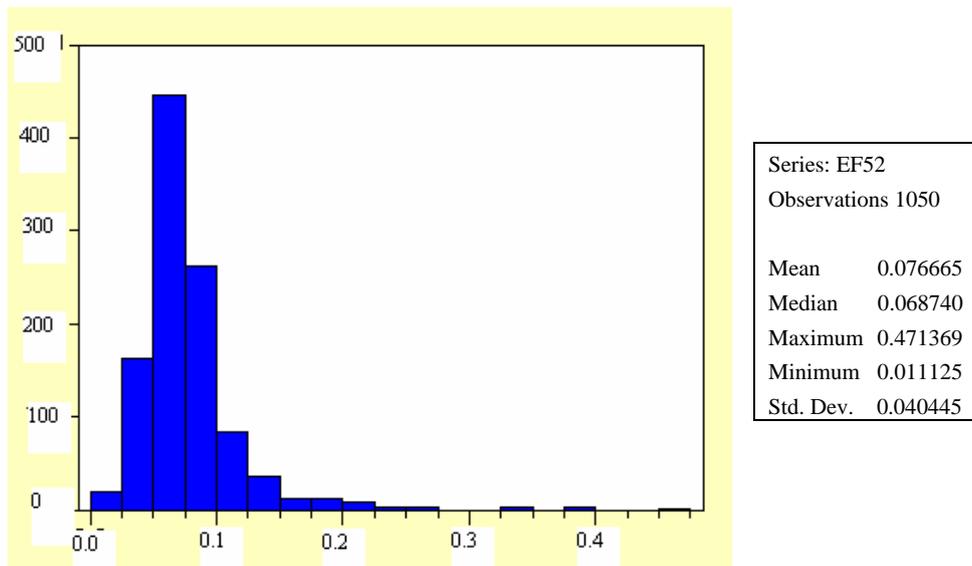


Figure 2. Histogram and Descriptive Statistics of Efficiency Indicator Sector 52: Retail Trade, exc. of Motor Vehicles & Motorcycles; Repair of Personal & Household Goods

Table 4 presents a descriptive approach to the efficiency measure of the retailing firms. We can distinguish between firms according to other variables such as age, size or the export activity and, also, we present an indicator of the efficiency difference according to such characteristics. Firm age is computed as the difference between the calendar year at t and the birth-year reported by the firm, firm size is measured as the number of employees and export activity reports differences between exporters and non-exporters.

Table 4. Efficiency Measure According to Firm Age, Firm Size and Export Activity

Sector classification	Firm Age				
	Less or equal than 5		6-15		More than 15
52	0.067	**	0.076	**	0.095
	Firm Size				
	Less or equal than 10		11-50		More than 50
52	0.071	**	0.082	**	0.112
	Export Activity				
	Exporters			Non-exporters	
52	0.119		**	0.073	

Note: ** indicates significance at 5% (test of the null hypothesis is that the mean of the efficient measures is equal between groups).

Our results confirm the empirical findings of previous papers that use micro panel data to measure the relationship between efficiency and indicators such as age and export activity. Efficiency differentials between younger and older firms are substantial and significant in the Spanish retailing firms. Younger firms have a lower efficiency measure than older firms. We find that the difference in the efficiency measure is 2.8 percent higher for older firms.

There is a positive relationship between the size of firms and their levels of efficiency. The figures reported indicate that the difference in efficiency between large firms and small firms is 4.1 percent.

Looking at the exporting activities, we observe that the exporters have a higher efficiency than domestic-oriented firms. On average the difference in efficiency between exporters and non-exporters is 4.6 percent.

4. CONCLUDING REMARKS

For several decades efficiency has been a popular topic of theoretical and empirical research. This issue has hardly been dealt with in the service sector, especially in view of the major role of the service sector in our developed economies.

The main focus of this paper is to quantify the (in)efficiency level of the Spanish retailing firms using an unbalanced sample observed over the period 1996-2002. Our interest in analysing this period lies in the fact that in this period Spain has experienced important legislative changes. The use of the time-varying model in unbalanced panel data techniques for efficiency frontiers reveals that the mean of the efficiency indicator is around 0.077 and confirms the existence of great heterogeneity among the firms within the sector and also that the level of efficiency remains constant over the regulated period.

Furthermore, the elasticity of scale and the rate of technological progress have been estimated. The Spanish retailing service industry analyzed in this paper, has returns to scale with a parameter of 0.805. We find that the rate of technological progress shows a value of 3.3%.

Finally, our results indicate that exporting firms have, on average, a higher efficiency measure than non-exporting firms. Also, our results show that younger and smaller firms have a lower efficiency measure than older and larger ones, respectively.

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