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Abstract:

This paper presents empirical evidence on the impact of competition on firm productivity for the Portuguese economy. To that effect, firm-level panel data comprising information between 2010 and 2015 gathered from the Integrated Business Accounts System (Portuguese acronym: SCIE) is used. The database enables the construction of economic and financial indicators, which allow for isolating the impact of competition on firm-level productivity. We find a positive relationship between competition and both total factor productivity and labor productivity. This relationship is found to be robust to different specifications and in accordance with the results in the literature obtained for other countries.

JEL *Classification Numbers*: D40, D24, O47

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1. Introduction

Competition is the process of rivalry between firms with the goal of gaining sales and making or increasing profits. It can have a significant impact on market outcomes. According to Godfrey (2008) "effective competition is a driver of productivity" and "facilitates greater equality of opportunity by breaking down the barriers to fair competition that often help to protect incumbent elites." Several features are critical to guaranteeing a competitive business environment. Free entry implies an increase in allocational efficiency insofar as it drives prices closer to marginal costs (static efficiency). In addition, competition increases the likelihood that firms will reduce the use of inputs in the production process, attaining higher levels of productive efficiency. Firms that cannot make such adjustments tend to lose business, which reduces their market share in favor of more productive firms. Moreover, competition drives firms to innovate through the creation of new products, or the differentiation of existing ones (dynamic efficiency).

Using a firm-level panel database ranging from 2010 to 2015, this paper investigates empirically the effect of competition on firm productivity in the Portuguese economy. The database comprises a set of variables that have been found to be determinants of productivity at the firm level. Thus, we are able to isolate the impact of competition on firm-level productivity. The main results show that market concentration, which proxies for competition, has a negative relation to both total factor productivity and labor productivity.

The paper is organized as follows. Section 2 encompasses a literature review. Section 3 presents the data and methodology used for the calculation of productivity and level of concentration. Results are reported in Section 4. Section 5 provides concluding remarks.

2. Literature Review

The assessment of the impact of competition on productivity at the aggregate and firm levels is widely treated in the literature. This section begins by summarizing the main theoretical and empirical evidence regarding the relationship between the level of competition and productivity. Then, we will describe evidence regarding each of the mechanisms by which competition boosts productivity: across-firm effects, innovation, and within-firm effects.

The theoretical research on endogenous growth presents distinctive results regarding the link between competition and productivity. Romer (1986) states that an increase in competition between producers reduces the expected duration of innovation, expected future profits due to innovation, and the rate of technical change. Thus, in his framework, competition reduces the incentives to innovate. On the other hand, using an extension of the standard model of endogenous technological change Aghion (2001) concludes that the incentive to innovate in order to beat the competition is higher if a firm is closer to the technological frontier. In other words, firms that present higher levels of productivity tend to have more incentive to innovate than do low productivity firms, which tend to adopt low-cost technologies. In short, the direction of the impact of competition on productivity is not the same across all theoretical models.

Some empirical literature examines the impact of a change in the competitive environment on productivity at the aggregate level. Barseghyan (2008) estimates that an increase of 8% in income per capita in entry costs reduces total factor productivity by 22%. However, the use of micro-level data provides larger sample sizes, which helps to reduce the issue of unobserved firm heterogeneity while allowing for a more detailed analysis. However, firm-level databases do not exist for all countries. Moreover, not all that do exist have the variables needed to calculate the level of competition or productivity. Haskel (1991) was one of the first authors to use micro-level data to examine the impact of competition on productivity across product markets. Using UK panel data between 1980 and 1986, he finds that both higher levels of concentration and market share have a negative impact on total factor productivity. Nickell (1996) found that a 10% increase in price markups has a negative impact of 1.2 to 1.6 percentage points (on average) on total factor productivity growth in 700 British manufacturing firms between 1972 and 1986. He also found a positive impact of the number of competitors on productivity. This corroborates Haskel's findings that there is a negative relationship between market power and productivity. Disney et al. (2003) use a more extensive dataset comprising approximately 140,000 UK manufacturing firms between 1980 and 1992. This allows them to capture the contribution of low productivity firms that may exit the market due to high levels of competition. The authors corroborate the previous studies by demonstrating that a reduction in market share and past profits have a negative impact on productivity. More recently, Ospina and Schiffbauer (2010) used firm observations compiled by the World Bank Enterprise Survey database from countries in Eastern Europe and Central Asia. They found that firms with a 20 percent higher markup have, on average, a 1.2 percent lower total factor productivity level and a 8 percent lower labor productivity. They test the stability of these results using a survey-based approach, based on the level of competition reported by each firm's manager.

The studies highlighted above strongly suggest a positive relationship between competition and productivity. Nevertheless, they do not pinpoint the mechanisms by which competition impacts productivity. There are three mechanisms through which stronger competition leads to higher productivity: between-firm effects, within-firm effects and innovation.

The first mechanism is the "between-firm," "across-firm" or "market sorting" effect. When low productivity firms exit the market, their market share is captured by high-productivity firms, entailing a subsequent positive cross-firm impact on productivity. Competition guarantees that low-productivity firms exit the market to be replaced by more productive firms.

Moreover, competition can place pressure on firms to reduce the gap between their practice and the most efficient practice. In other words, competition reduces X-inefficiency. This is the "within-firm" effect. In a competitive environment, inefficient firms are unable to stay in the market in the long run. Therefore, competition can act as a discipline device, placing pressure on managers. These will face an incentive to avoid slack in the production process, thereby using resources more efficiently. In markets in which the level of competition is lower, managers can reduce their effort without unduly increasing the likelihood of going out of business or being replaced.

Competition might also drive firms to innovate. Innovation creates dynamic efficiency through the creation of new products, differentiation of existing ones, or technological progress in general. This mechanism is complex. On the one hand, in the presence of strong competition firms will have an incentive to innovate to gain a competitive advantage. This advantage can be achieved by differentiating their products, creating new ones, or reducing costs. On the other hand, this incentive is only present if the firm garners a positive return from its move, which requires a need for *ex post* market power.

Several authors have looked into each of these three mechanisms empirically, rather than considering them simultaneously. Regarding the between-firm effect, Syverson (2004) finds evidence in the case of the United States that competition drives low-productivity firms out of business. He observes that in competitive geographic markets there is a smaller tail of low-productivity plants. Arnold et al. (2011) argue that the between-firm effect has a more substantial impact on productivity growth than within-firm improvements. Furthermore, several empirical studies have quantified the impact of this mechanism on productivity growth. As an illustration, Baldwin and Gu (2006) estimate that approximately 70% of productivity growth in the Canadian manufacturing industry (between 1979 and 1999) is due to the market-sorting effect. Disney et al. (2003) suggest that this effect accounts for between 80% and 90% of total factor productivity growth and roughly 50% of labor productivity growth in UK manufacturing firms between 1980 and 1992. Harris and Li (2008) found that 79% of UK productivity growth is due to the market-sorting effect. Scarpetta et al. (2002) conducted work on ten OECD countries for varying periods and observed that the between-firm effect accounted for 20% to 40% of total productivity growth. It is important to underscore that the impact of the market-sorting effect varies with the degree of maturity of the market. This mechanism tends to have a more significant impact in less mature industries.

The link between competition and productivity through innovation is also relatively well studied in the literature. Cameron (2003) found that a 1% increase in R&D, which proxies for innovation, raises total factor productivity by 0.2% to 0.3% in UK manufacturing firms. Griffith et al. (2010) look at the effect of the introduction of the Single Market Program in Europe. They conclude that it is associated with an increase of 1.2% in R&D intensity, which is responsible for a growth of 0.7 percentage points in total factor productivity in the UK metal industry. Moreover, the effect of increased competition is stronger in countries that are closer to the global technological frontier.

Correa and Ornaghi (2014) found a positive relationship between competition and patent count, which proxies for innovation, leading to higher levels of labor productivity and total factor productivity. Aghion et al. (2005, 2009) found an inverted U-shape relationship between competition and innovation. When markets are highly concentrated, an increase in competition leads to an increase in innovation. Nevertheless, beyond a certain threshold, a positive increase in competition can have a negative impact on innovation. Bearing in mind Aghion's findings, one may wonder if competition authorities are encouraging "too much" competition. Nevertheless, the interventions of competition authorities target markets in which the level of competition is relatively low. All in all, the literature tends to suggest that competition spurs innovation, which in turn drives higher productivity.

A negative relationship between competition and X-inefficiency was also found empirically by several authors. Using 580 UK manufacturing firms, Nickell et al. (1997) show that competition is a substitute for financial pressure and other discipline devices regarding the impact on productivity. They also show that the effect of competition on X-inefficiency is weaker in the presence of other discipline devices. Griffith (2001) finds that in firms in which management and ownership are separated (giving rise to the well-known principal-agent problem) competition increases productivity, while firms which are owned by the manager do not display growth. On the whole, the literature suggests a positive impact of competition through all the three channels (between-firm effects, within-firm effects and innovation) on firm-level productivity.

3. Dataset and Empirical Methodology to Calculate Productivity and Competition

Our firm-level panel data set was constructed from *Sistema de Contas Integrado das Empresas* (Integrated Business Accounts System, Portuguese acronym: SCIE). SCIE contains information on firm-specific characteristics, such as turnover, services, materials, number of employees, and industry. It comprises all Portuguese firms between 2010 and 2015. This enables the computation of economic and financial indicators, which are used to isolate the impact of competition on firm-level productivity.

Following Correia and Gouveia (2016), firms in the financial industry, public sector, education, health, entertainment-related activities, other services, international organizations and other institutions, and all the non-specified cases were excluded since the level of competition and/or productivity cannot be adequately captured with the methodology used. Firms which do *not* report labor costs, external supplies and services, non-positive fixed tangible and intangible assets, current and non-current assets and liabilities were excluded. Moreover, following Barbosa and Pinho (2016), firms with less than five workers were not considered either. The data was further treated after its descriptive analysis, as detailed below.

3.1 Productivity

Two types of firm productivity are considered, namely, total factor productivity (TFP) and Labor Productivity. To calculate total factor productivity, we use three different approaches: Levinsohn and Petrin's approach, the conventional OLS procedure and an OLS procedure using year and industry fixed-effects (henceforth, LevPet, OLS and Fixed-effects, respectively).

According to the OECD (2017), total factor productivity "reflects the overall efficiency with which labor and capital inputs are used together in the production process." Therefore, this measure of productivity can be impacted by management practices, network effects, and economies of scale, among others. The calculation of total factor productivity requires the computation of a residual of the production function. Thus, the results depend on the choice of functional form, the definition and measurement of the variables used in the calculation and the estimation procedure.

A standard manner of calculating total factor productivity was suggested by Olley and Pakes (1996). This approach addresses simultaneity and selection bias, generating consistent estimates of the production function elasticities,[3] which neither OLS approach does. Nevertheless, one of the conditions that must be met for this method to be applied is a strictly monotonous relationship between the proxy for unobserved productivity shocks, which in this case is investment, and output. As a result, any firm with a zero investment in one year would has to be dropped.

Another approach is the Levinsohn and Petrin (2003) method. This methodology follows a semi-parametric approach and addresses simultaneity and selection bias. It also assumes that productivity is the only unobservable variable. It uses intermediate inputs as a proxy for unobserved productivity shocks, instead of investments was the case in Olley and Pakes (1996).

SCIE contains fewer zero observations in external supplies and services than in investment. Therefore, Levinsohn and Petrin's approach was the method selected to calculate total factor productivity.

In the estimation process, turnover was used as the output measure. One could have used value added instead. Nevertheless, Basu and Fernald (1997) prove the existence of biased returns to scale under value added production functions unless price equals marginal costs and the elasticity between inputs and materials equals zero. These conditions are violated in several Portuguese markets.

The net book value of fixed tangible assets was used as physical capital, labor costs as labor and external supplies and services as materials. No measures of human capital were included due to lack of information in the database. Therefore, the estimation assumes homogeneity of the labor force.

[3] For more information regarding the main issues concerning TFP estimation it is suggested as reference Olley and Pakes (1996) and Eberhardt and Helmers (2010).

Total factor productivity was also calculated using the conventional OLS procedure and the OLS procedure using market and year fixed effects. Labor productivity is measured as the ratio of gross value added at factor costs to the number of employees. Due to the absence of information regarding the number of hours of work, it was assumed that a full-time employee was equivalent to two part-time employees.

The estimated coefficients for the inputs, labor, capital and material can be found in Table 1 for the three different methods of estimating the production function. As expected, one can observe a significant difference between the coefficients of the variable capital and materials across the three regressions. The coefficient of the variable materials is higher in both OLS procedures than in the one based on the Levinsohn and Petrin approach, which is in line with the results in Muendler (2004).

Regarding returns to scale, the LevPet approach presents decreasing returns to scale, while the conventional OLS and the OLS with fixed effects display constant returns to scale. These results are consistent with those obtained by Levinsohn and Petrin (2003) regarding the sum of elasticities: the LevPet approach presents lower values than both OLS approaches.

Table 2 displays the correlation coefficients between the measures of total factor productivity and labor productivity. The correlation between the conventional OLS procedure and the OLS procedure using relevant market and year fixed effects is higher than 0.99. Therefore, we opted to report the results of the three different methodologies while excluding the conventional OLS procedure.[4]

Figure 1 plots the distribution of the logarithm of the three different measures of productivity. One can observe the differences in dispersion and range. There seems to be a considerable amount of heterogeneity in productivity at the firm level.

[4] For more information about correlation coefficients of different measures of productivity see Van Biesebroeck (2003).

3.2 Competition

The Herfindahl-Hirschman Index, HHI, is one of the most widely used empirical indicators of a market's level of competition. This index assesses market concentration as a function of the number of competitors and the distribution of market shares among them. It is defined as:

$$HHI_j = \sum_{i=1}^{N} s_i^2 \ , \qquad (1)$$

where N stands for the total number of firms in market j, and s_i denotes the market share of firm i.

In a monopoly, HHI equals one, while in a perfect competition scenario the index takes a value close to zero. The presumed link between market concentration and the level of competition is the following: there is a higher likelihood of the market being less competitive, allowing firms to set relatively high prices, when concentration is higher.

The Herfindahl-Hirschman Index has some methodological limitations. One of them is that to compute the HHI correctly one needs to have information about *all* firms in the market. Another methodological issue is that national databases do not have information about external competitors. This is particularly important in markets exposed to international trade. Therefore, in the case of tradables, the conclusions are particularly limited. Finally, defining the relevant market for which to compute the index can be quite difficult.

These problems were partially solved. First, the dataset includes all firms in the Portuguese economy. Secondly, following the Amador and Soares (2012) approach, the relevant geographic market is assumed to be the Portuguese domestic market. Each relevant product market is assumed to be consistent with the CAE (Classification of Economic Activity) 3.1 classification at the 3-digit level. This assumption means that each firm sells one good and competes in one market. In the case of a multi-product firm, if products are not close substitutes, this assumption may be a source of bias. Different market definitions, of course, will lead to different results when computing the Herfindahl-Hirschman Index.

Moreover, in certain cases, the direction of change in the HHI can be the opposite of the change in the level of competition. As an illustration, take a decrease in the cost of entry leading a multinational firm to enter the market. The level of competition increases because of the reduction in entry barriers, yet the level of concentration, measured by the HHI, may have increased.

Despite all these limitations, we assume that the HHI can capture the level of competition in a market with a reasonable degree of precision. To check for the robustness of the results obtained with the HHI, we also used the concentration ratios C_{10} and C_4 as a proxy for the level of competition.

3.3 Further treatments of the database

Due to the complexity of the database, SCIE, we had no choice but to treat the data. We did not include firms whose levels of productivity are too high. For this purpose, technological companies such as Google and Apple were used as a benchmark. Any firm with labor productivity above 1.7 Million euros per employee per year was excluded from our final model. Typically, these are holding companies. While financial indicators refer to all the subsidiaries, the number of employees refers to the parent firm.[5] Clearly, productivity cannot be accurately calculated in these situations. Firms that went out of business in one year and returned in a following year were also excluded.

There is a set of firms whose market changed over the years. This could have a significant impact on the HHI of both markets. We decided to exclude all the relevant markets where this occurred and the firms did not belong to a competitive fringe, i.e., were not small. We assume that a firm is small if it has a market share at most twenty times smaller than the largest firm operating in its market.

Table 3 defines several variables used in calculating the empirical relationship between productivity and competition in 2010 and 2015. Table 4 reports the descriptive statistics.

[5] However, the calculation of the measures of the levels of concentration does consider these firms.

4. Empirical Relation between Firm Productivity and Competition

The previous section described the measures of firm productivity and competition that were used in the second-stage regression. The estimation of the empirical model allows us to compute how much of the variation in firm-level total factor productivity and labor productivity is related to variations in competition.

The empirical model is described by equation (2) below. The model includes a set of firm-specific control variables (X_{it}). These controls were identified by Gonçalves and Martins (2016) as determinants of total factor productivity. Further variables identified in the literature were also considered. These determinants are the size of the firm, export and import status, the ratio of debt-to-equity, subsidies and wages. We used the size of the firm according to the European Commission definition. The criterium of the Bank of Portugal is used to define if a company is an exporter. Several authors, such as Correia and Gouveia (2016), take the level of a firm's internationalization as a proxy for competitiveness. Detailed information about the computation of the variables can be found in Table 3. The inclusion of these specific controls allows us to isolate the effect of competition on firm-level productivity.

$$y_{itj} = \beta_0 + \beta_c C_{itj} + \beta_x X_{itj} + \mu_t + \eta_j + \omega_i + \varepsilon_{itj}. \qquad (2)$$

Industry (η_j), years (μ_t), and firm (ω_i) fixed effects were introduced to account for unobservable heterogeneity among industries, years, and firms. The inclusion of year and industry fixed effects is a standard method as economic shocks can have an asymmetric impact in different years and industries. In addition, the use of firm fixed effects accounts for the heterogeneity among firms that cannot be captured by the data. One example is two otherwise similar firms with CEOs whose level of sophistication differs. Moreover, both the Hausman test and the robust version of the Hausman test indicate that firm fixed effects should be used.

The ultimate goal of this work is to estimate the sign of β_c. When the level of competition is measured using the logarithm of the Herfindahl-Hirschman Index, the *a priori* hypothesis is that an increase in the HHI is associated with a decrease in productivity. Therefore, we expect the sign of β_c to be negative and significantly different from zero.

Table 5 reports the results of our models. The coefficients show that the Herfindahl-Hirschman Index is negatively correlated with all the measures of productivity used. Firms operating in a market with a 1 percent higher HHI will have, on average, a 1.3 percent lower total factor productivity based on Levinsohn and Petrin's approach and a 1.1 percent lower TFP based on the OLS procedure using year and industry fixed effects, *ceteris paribus*. Regarding labor productivity, a 1% increase in the HHI lowers it, on average, by 1.7%.

Several tests were run to check the robustness of the results. We test the same model using the concentration ratio C_{10} and C_4. The results are to be found in Table 6. We also used other econometric specifications, namely a random effects model. The results were found to be robust in all cases. A model that included a quadratic term of the HHI was also tested. No quadratic relationship between competition and productivity was found.

The effects of the additional control variables on productivity are broadly consistent with the theoretical predictions and the empirical findings in the literature.

Regarding the models using TFP, they show that firms that are exporters and importers are more productive. This result is consistent with the findings of Gonçalves and Martins (2016), Melitz (2003) and Helpman et al. (2004). Gehringer et al. (2013) and Gonçalves and Martins (2016) also found a positive relationship between wages and TFP. Again, Gonçalves and Martins (2016) also suggest a negative association between the debt-to-equity ratio and TFP.

5. Conclusion

This paper uses firm-level data from 2010 to 2015 to isolate the effect of competition on productivity using data for the Portuguese economy. The results suggest a negative relationship between the Herfindahl-Hirschman Index and three different measures of productivity. Markets that have a 10 percent higher HHI have, on average, firms with 13 (TFP LevPet) and 11.2 (TPF OLS fixed effects) percent lower total factor productivity and 17 percent lower labor productivity.

The results are in line with Ospina and Schiffbauer (2010), who found a negative association between price-cost margins and total factor productivity and labor productivity for 27 countries.

Further research should assess which of the three mechanisms (between-firm effects, within-firm effects and innovation) has a higher impact on firm-level productivity.

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Appendix

FIGURE 1: Histograms

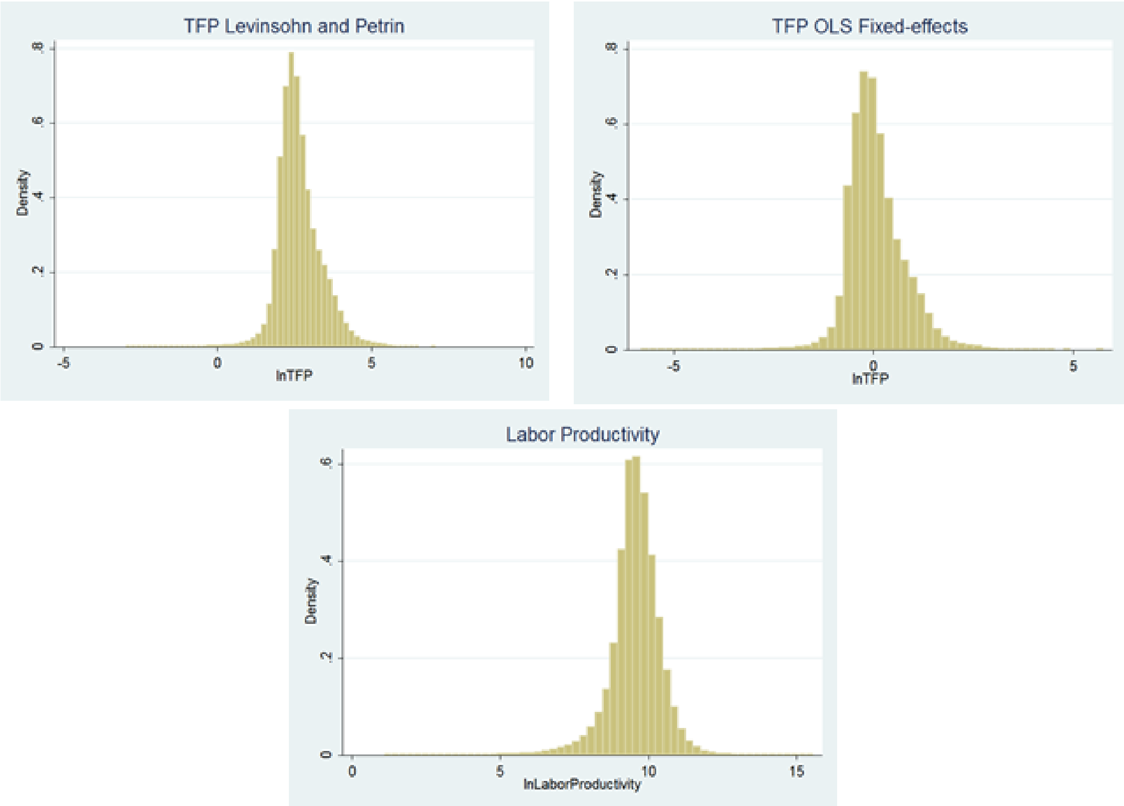

TABLE 1: Comparison of alternative production function estimates

Variables	LevPet	OLS	Fixed-effects
Capital (k)	0.07***	0.038259***	0.032265***
	(0.004819)	(0.004131)	(0.0003685)
Labor (l)	0.394091***	0.391949***	0.361015***
	(0.001629)	(0.0007601)	(0.0006835)
Material (m)	0.44***	0.575819***	0.612551***
	(0.023482)	(0.0007754)	(0.006952)
Sum of elasticities	0.904091	1.006027	1.005831

TABLE 2: Correlation coefficients for productivity measures

	TFP LevPet	TFP OLS	TFP fixed effects	Labor productivity
TFP LevPet	1.0000			
TFP OLS	0.9699	1.0000		
TFP fixed effects	0.9694	0.9995	1.0000	
Labor productivity	0.3264	0.2154	0.2139	1.0000

TABLE 3: Description of several variables

Micro – takes value 1 if a firm has less than ten employees and a turnover and balance sheet total less than 2 million euro, 0 otherwise.

Small – takes value 1 if a firm has less than 50 employees and a turnover and balance sheet total less than 2 million euro and micro takes value 0, 0 otherwise.

Medium – takes value 1 if a firm has less than 250 employees and a turnover and balance sheet total less than 43 million euro, less than 50 million euros turnover and both micro and medium take value 0, 0 otherwise.

Large – takes value 1 if micro, small and large take value 0, 0 otherwise.

dumexportbdp – Takes value 1 if at least 50% of annual turnover is from exports or at least 10% of annual turnover is from exports with a value higher than 150.000€, 0 otherwise.

Dumimports – Takes value 1 if the firm imported any quantity of input, 0 otherwise.

Dumsubsidies – Takes value 1 if the firm received any subsidy, 0 otherwise.

Lnwages – Logarithm of the wage per worker.

Lndebttoequity – Logarithm of the ratio Debt to Equity.

TABLE 4: Descriptive statistics

	Obs	Mean	S.D.	Obs 2015	Mean 2015	S.D. 2015
lnTFPLevPet	282838	2.668434	0.7465825	45247	2.699476	0.7375017
lnTFP FE	282838	0.0817256	0.7305094	45247	0.0848798	0.7229256
lnLabor Prod.	283116	9.501782	0.8582338	45978	9.579484	0.8351969
lnhhi	295732	-4.867674	1.657148	47789	-4.842326	1.660887
micro	295732	0.6205314	0.4852556	47789	0.6118981	0.4873231
small	295732	0.3221396	0.4672969	47789	0.3285275	0.4696827
medium	295732	0.0494333	0.2167713	47789	0.0512461	0.2205016
large	295732	0.0078957	0.0885062	47789	0.0083283	0.0908795
dumexportbdp	295732	0.0662424	0.2487058	47789	0.0720668	0.2586012
dumimports	295732	0.2468417	0.4311746	47789	0.2592647	0.4382357
lndebttoequity	235026	0.603142	1.469037	37804	0.4517403	1.439234
lnwages	294202	8.870233	0.614079	47549	8.908375	0.5988192
dumsubsidies	295732	0.1757537	0.3806111	47789	0.3072464	0. 4613573

TABLE 5: Fixed effect estimator: competition and productivity

VARIABLES	(1) lnTFP LevPet	(2) lnTFP OLS Fixed-effects	(3) lnLabor Productivity
lnhhi	-0.0130**	-0.0112*	-0.0170***
	(0.00603)	(0.00619)	(0.00652)
small	0.0576***	0.0248***	-0.0521***
	(0.00393)	(0.00390)	(0.00507)
medium	0.155***	0.0817***	-0.0512***
	(0.00926)	(0.00912)	(0.0118)
large	0.257***	0.137***	-0.0207
	(0.0223)	(0.0222)	(0.0332)
dumexportbdp	0.103***	0.0872***	0.0734***
	(0.00662)	(0.00653)	(0.00842)
lndebttoequity	-0.0270***	-0.0244***	-0.0823***
	(0.00125)	(0.00124)	(0.00198)
dumimports	0.0302***	0.0235***	0.0163***
	(0.00264)	(0.00262)	(0.00371)
lnwages	0.0432***	-0.00197	0.673***
	(0.00617)	(0.00620)	(0.00930)
dummysubsidies	-0.00925***	-0.0160***	0.0129***
	(0.00223)	(0.00226)	(0.00305)
Constant	2.703***	0.540***	3.910***
	(0.0812)	(0.0850)	(0.134)
Observations	226,287	226,287	230,438
Number of firms	58,906	58,906	60,041
R-squared	0.940	0.937	0.844
Industry and Year Fixed Effects	Yes	Yes	Yes

Heteroscedasticity robust standard errors t-statistics in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1

TABLE 6: Fixed effect estimator: competition and productivity (robustness test)

VARIABLES	(1) lnTFP LevPet	(2) lnTFP LevPet	(3) lnTFP OLS Fixed effects	(4) lnTFP OLS Fixed-effects	(5) lnLabor Productivity	(6) lnLabor Productivity
lnc4	-0.0223**		-0.0193**		-0.0173*	
	(0.00876)		(0.00893)		(0.00961)	
lnc10		-0.0358***		-0.0287**		-0.0704***
		(0.0125)		(0.0127)		(0.0138)
small	0.0722***	0.0721***	0.0185***	0.0185***	-0.0376***	-0.0377***
	(0.00323)	(0.00323)	(0.00320)	(0.00320)	(0.00360)	(0.00360)
medium	0.201***	0.201***	0.0572***	0.0570***	-0.0149*	-0.0150*
	(0.00727)	(0.00727)	(0.00717)	(0.00717)	(0.00765)	(0.00765)
large	0.363***	0.363***	0.0974***	0.0975***	0.0684***	0.0683***
	(0.0169)	(0.0169)	(0.0168)	(0.0168)	(0.0218)	(0.0219)
dumexportbdp	0.113***	0.113***	0.0844***	0.0843***	0.111***	0.111***
	(0.00583)	(0.00584)	(0.00576)	(0.00577)	(0.00671)	(0.00672)
dumimports	0.0470***	0.0469***	0.0361***	0.0360***	0.0453***	0.0453***
	(0.00251)	(0.00251)	(0.00249)	(0.00249)	(0.00322)	(0.00322)
lndebttoequity	-0.0243***	-0.0243***	-0.022***	-0.022***	-0.0660***	-0.0660***
	(0.00102)	(0.00102)	(0.00102)	(0.00102)	(0.00130)	(0.00130)
lnwages	0.0520***	0.0520***	-0.00921*	-0.00924*	0.690***	0.690***
	(0.00476)	(0.00476)	(0.00476)	(0.00476)	(0.00616)	(0.00616)
dumsubsidies	-0.0160***	-0.0161***	-0.023***	-0.023***	0.0148***	0.0148***
	(0.00214)	(0.00214)	(0.00216)	(0.00216)	(0.00273)	(0.00273)
Constant	2.516***	2.518***	0.494***	0.496***	3.938***	3.915***
	(0.182)	(0.182)	(0.184)	(0.184)	(0.0953)	(0.0950)
Observations	226,261	226,181	226,261	226,181	230,412	230,334
Number of id	58,092	58,885	58,902	58,885	60,037	60,020
R-squared	0.939	0.939	0.937	0.937	0.844	0.844
Industry and Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Heteroscedasticity robust standard errors t-statistics in parenthesis.

*** p<0.01, ** p<0.05, * p<0.1