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Does Competition Spur Innovation in Developing Countries?

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Abstract

Using the Climate Investment Survey from the World Bank, we analyze the effect of competition on technological innovation in developing countries. We deal with endogeneity of competition by using the interaction between industry turnover and entry regulation as an instrument. The basic idea for this instrument is that entry regulations have a negative and more pronounced effect on competition in those industries with more natural turnover. Our results indicate a negative impact of competition on several measures of innovation outputs and inputs, which are robust across industries and using alternative measures of competition.

JEL Codes: O31, O32, D22, L10, Q55

Keywords: Competition; Product and Process Innovation; Firm Behavior.

1. Introduction

The literature on economic growth suggests that innovation is one of the main drivers of productivity and economic growth (Aghion *et al.*, 2006). In the case of developing countries, it has been argued that non-frontier innovation may help them to “catch-up” with developed nations (Cameron, 1998; Griliches, 1998; and Bravo-Ortega and García, 2011). However, what the factors are that inhibit innovation is a topic of great interest and debate. One of the potential determinants of innovation is product market competition. Though the relationship between innovation and competition has been largely analyzed (Schumpeter, 1934 and 1942; Arrow, 1962; and Aghion and Howitt, 1992 and 2006; among others), the empirical evidence on competition’s impact on innovation is not yet conclusive.

Schumpeter (1942), based on the idea of creative destruction, argued that higher competition could be detrimental to innovation. A monopolist has a higher incentive to innovate than competitive firms, because it captures the total gains from its innovations. Later Arrow (1962), Scherer (1980), and Porter (1990) questioned Schumpeter’s results, suggesting that incumbent´s fears of being run out the market explain how competition could be positively associated with innovation. The incumbent firms need to innovate in order to survive the entrants´ competition.

Some papers have found evidence of a negative impact of competition on innovation (Hamberg, 1964; Mansfield, 1964; Kraft, 1989; Crepon, *et al.*, 1998; Campante and Katz, 2007) and others show that higher competition may increase innovation (Geroski, 1990; Blundell *et al.* 1995, 1999; Nickell, 1996; Carlin *et al.*, 2004). More recently, Aghion *et al.* (2005), following Scherer (1967), produce a non-linear (U-inverted) relationship between competition and innovation. In this framework, a positive or negative effect of increased competition on innovation is found depending on the initial level of competition. Several subsequent works have studied this non-linear relationship between competition and innovation, also finding mixed evidence. Some show that this relationship holds (Hashmi, 2005; Lee, 2005; Lee and Sung, 2005; and Polder and Veldhuizen, 2012) and others that it does not (Aiginger and Falk, 2005; Tingvall and Poldahl, 2006). The original results by Aghion *et al.* (2005) have been recently challenged by Correa (2012) by showing evidence of a structural break in the middle of the sample and that, when this break is taken into account, the inverted-U relationship disappears.

In summary, the empirical literature on this issue is not yet conclusive.[1] In addition, evidence of this relationship is very scarce for developing countries. Few papers use a large sample of developing countries to explore this issue. Moreover, although some researchers have acknowledged the endogenous nature of competition, not all of them have dealt with this problem. Surveys of this literature indicate that better efforts need to be done to uncover the causal impact of competition on innovation (Cohen and Levin, 1989; Cohen, 2010).

[1] For a complete literature review see Cohen and Levin (1989), Gilbert (2006), and Cohen (2010).

Our paper contributes to the literature on competition and innovation in three main directions. First, we expand the evidence to other countries by using firm-level data for more than 24,000 firms from 70 developing economies. Second, we deal with endogeneity of competition by providing an instrument that varies across industries, countries, and time. Third, we analyze whether the effect of competition is heterogeneous among different industries. There are some previous papers using the same dataset, but they focus on different issues. Almeida and Fernandes (2008) examine the relationship between international technology transfer and technological innovation in developing countries. Gorodnichenko *et al.* (2010) look at the impact of foreign market competition on innovation, but they restrict the analysis to 27 emerging market economies. Ayyagari *et al.* (2012) analyze the impact of access to finance, competition, and governance, but do not deal with the endogeneity of competition.

We find evidence of a negative and robust effect of competition on the level of innovation and the probability to engage in product or process innovation. This is probably in line with ideas of Schumpeter (1942) that competition may reduce incentives to innovate. It is also consistent with modern self-discovery theories developed by Hausmann and Rodrik (2003) indicating that too much ex-post entry (competition) may reduce incentives to explore new activities in developing countries.[2]

The rest of the paper is structured as follows. The next section describes the dataset and presents some relevant definitions (innovation, competition, and covariates) and descriptive statistics. The third section presents the methodology and how the endogeneity is addressed. The fourth section gives and discusses the econometrics results for the relationship between competition and innovation. Finally section five provides the main conclusions and findings.

2. Data

We use the World Bank Investment Climate Survey (ICS) pooled cross-section database[3] that consists of firm survey responses for over 24,000 firms classified at the 2-digit industry level in 70 developing countries between the years of 2002 and 2006.[4] This data comes from a random size/industry/location stratified survey that captures information about characteristics of local businesses, the investment climate faced by firms, and the climate's impact on performance. This survey reports detailed information on firm employment, age, industry, ownership, legal status, number of establishments, and other relevant variables. Also, as we discuss below, it includes several measures of innovation, allowing us to

[2] Klinder and Lederman (2011) have provided empirical evidence about the negative impact of competition on the discoveries of new export activities.
[3] Available upon previous registration at http://www.enterprisesurveys.org/.
[4] The original version of this database consists of more than 70,000 2-digit sector firms in more than 90 countries. We restrict it to developing countries, manufactures, and for those without missing data.

estimate a time-varying measure of competition that is country and industry specific.

2.1 Innovation definition

A great advantage of this survey over other available ones is its broad coverage of the extent of innovation activities undertaken by firms. Previously, there has been very little consistent data across countries on the nature of innovative activities undertaken by firms. Moreover, the available data typically only covers developed countries and focuses on patents or R&D expenditures. This survey includes not only R&D expenditure data but also data on different kinds of innovative activities that a firm undertook three years prior to the survey.[5] This allows us to measure the level of innovation with three different variables reflecting output measures of innovation that allow us to analyze the intensive margin (probability to undertake innovative activities) and the extensive margin (the level of innovation carried out by the firm).

For the intensive margin, we use two variables: the first corresponds to a product innovation dummy equal to 1 when the firm "developed a major new product line" or "upgraded an existing product line," and zero otherwise. The second corresponds to a process dummy that is equal to 1 when the firm reports that it "introduced new technology that changed the way that the main product is produced," and zero otherwise. The extensive margin is addressed using a count index that corresponds to the sum of these 3 innovative activities.

[5] The most recent version of the Enterprises Survey carried by the World Bank lacks information about innovative activities.

Table 1 presents the descriptive statistics for the sample used in the estimations. Regarding innovation variables, we have that the average amount of innovation is 1.34 innovative activities over a maximum of 3 and minimum of 0. The survey indicates that 52% of the firms have performed some type of product innovations, and 39% of firms have carried out process innovations. The probability of introducing innovations is relatively large and higher than other indicators such as the percentage of firms that apply for patents, but it is not different from figures from other comparable innovation surveys, such as the Community Innovation Survey for European countries or those carried out in some Latin American countries (Mairesse and Mohnen, 2010).

2.2 Competition definition

In this paper, the definition of competition plays a very important role. There are different methodologies to measure the level of industry competition.[6] The most common measures are the price-cost margin (The Lerner Index) and indicators of market concentration such as the Herfindahl-Hirschman (HH) index. These measures suffer from various theoretical and empirical problems. Specifically, the HH Index is not well suited to measure competition in open economies because it only captures market concentration in the domestic market and does not necessarily represent the competition pressure coming from international markets. In the case of the Lerner index, it has been argued that it is not well founded

[6] For a complete discussion of different measures and their problems, see Boone (2000) and Boone *et al.* (2005).

in theory (Boone 2008). In addition, it has found to be poorly correlated with other measures of competition (Boone *et al.*, 2005; Boone *et al.*, 2007; Duhamel and Kelly, 2011).

Boone (2008) proposed a new measure based on profits-cost elasticity that takes the heterogeneity of firms' efficiency into account. The approach is based on the idea that competition rewards efficiency. Thus, more efficient firms will have higher market share and profits than less efficient ones. This relationship should be stronger in a more competitive market. We are not the first paper to use this measure of competition. Previous applications of this indicator have been done by Gustavsson and Karpaty (2011), Boone *et al.* (2011), Schiersch and Schmidt-Ehmcke (2010), Polder and Veldhuizen (2012), and Peroni and Gomes Ferreira (2012).

For each country c, industry j and year t, the Boone-index is derived from the following regression using firm-level data:

$$\log\pi_i = \alpha_i + \beta_1 * \log\left(\frac{TVC_i}{Sales_i}\right) + \beta_2 \log\left(\frac{Sales_i}{Employment_i}\right) + \epsilon_i \qquad \forall j,c,t$$

Where $\log\pi_i$ correspond to the logarithm of the profits of the firm i, and TVC_i correspond to total variable cost and ϵ_i correspond to a firm robust standard error. Following Bérubé *et al.* (2012), we also include the variable $log(Sales/Employment)$ to control for firm size[7].

The Boone index corresponds to the coefficient $\widetilde{\beta_1}$ from the country-industry-year estimations shown above and represents the profit-cost elasticity. As total variable cost is negatively related with profits, the Boone Index is always negative. Nevertheless, and for the purpose of the analysis and estimations, we use the absolute value of this index for a more interpretable estimator. Thus, a higher value for the Boone index indicates a greater sensitivity of firm profits to cost and therefore higher competition intensity.

This index corresponds to a measure of competition intensity and does not allow for the perfect identification of extreme cases such as monopoly and perfect competition. Nevertheless, in theory, a Boone Index near infinity could be related to perfect competition and near zero to more uncompetitive conditions.

This index is monotonously related to various competition parameters, unlike other commonly used measures such as the Lerner index or the HH index (Boone *et al.,* 2007). Table 2 shows the pair-wise correlation matrix between different, usual measures of competition or concentration (HH Index, Lerner, and Boone Index). It also shows some variables associated with competition: number of competitors, suppliers, and customers; existence of state owned firms or foreign competitors; and the self-reported influence of these

[7] To ensure robust Boone index estimates, industries with less than 20 firms were dropped from the dataset.

competitors on prices, products, and processes. As Table 2 shows, there is a significant correlation between these competition parameters and the Boone Index. We also find that, in general, the value and the statistical significance of this correlation are higher for the Boone index than the Lerner and the HH indexes.

To understand the sources of variation in the Boone Index, Table 3 presents an analysis of the variance of the index. This variance decomposition shows that the country effect explains more than 67.0%, while industry effect explains 8.3%. The year and residuals of the model represent 10.6% and 14.0% respectively. This is an interesting result, telling us that most of differences in competition across countries and industries are explained by country-specific factors. Given this result, we do not use country-year fixed effects that would capture most of the competition measure variance in our empirical strategy.[8]

2.3 Endogeneity: Instrument definition

As Aghion *et al.* (2005) and others note, there is a problem of endogeneity when estimating the effect of competition on innovation. There can be a reverse causality effect from innovation on industry competition. Competition may change as a result of firms' innovation decisions. There can be also omitted variables affecting both innovation and competition. In such a case, the endogeneity problem needs to be addressed in the estimations. We use instrumental

[8] When we run the regressions including country-year fixed effects, the Boone index lost statistical significance. These regressions are available upon request.

variable (IV) to deal with endogeneity. The proposed instrument has to fulfill two main conditions to get unbiased estimators of the competition over innovation. First, it must be correlated with the endogenous explanatory variables, conditional on the other covariates. Second the instrument should not be correlated with the error term.

Following the approaches of Rajan and Zingales (1998) and Micco and Pages (2006), we construct an instrument that allows us to exploit differences across sectors and countries based on the interaction between countries' entry regulation data from the Doing Business Project from the World Bank[9] and U.S. industry turnover data taken from Fisman and Sarría-Allende (2004). This instrument is based on the idea that higher entry regulations reduce industry competition, but this effect is larger for those industries with more natural entry (and exit). Using data from the U.S. as a frictionless and baseline measure of industry turnover gives us an exogenous measure of industry exposure to entry regulations.

Thus, the first stage regression should show a negative and strong relationship between our measure of competition and the interaction between entry regulations and industry natural turnover. The identification assumption is that changes in entry regulations only affect technological innovation through its differential impact on competition across industries. We think that this is a reasonable assumption because we have not found any theoretical models or

[9] The Doing Business Project from the World Bank takes the methodology from Djankov *et al.* (2002) and covers more countries and years.

empirical analysis showing that entry regulation changes affect innovations through other mechanisms rather than those we highlight in this paper.

3. Empirical Strategy

To look at the impact of competition on innovation, we estimate this equation:

$$Y_{icjt} = \beta_0 + \beta_1 comp_{cjt} + \beta_2 comp_{cjt}^2 + \beta_3 X_{icjt} + \beta_4 \mu_{jt} + \epsilon_{icjt}$$

where Y_{icj} represents the innovation of firm i in country c, industry j and year t, and it corresponds to a continuous or dichotomic variable depending whether it is defined as the number of innovations or the probability of innovating, $comp_{cj}$ corresponds to the Boone Index from the estimation described in the previous section. For testing the non-linear effect of competition on innovation, we also include the square of the Boone index. X_{icjt} corresponds to the usual covariates in literature, μ_{jt} to industry-year fixed effects, and ϵ_{icjt} to country-industry-year error term. In the estimation, standard errors are clustered at country-industry-year level.

We estimate this equation following two approaches and using instrumental variables to deal with endogeneity of competition. First, following Aghion *et al.* (2005), we estimate a Poisson count model with a control function for the aggregated innovation index, i.e. number of innovations. Second, we estimate a Probit model with instrumental variables using product and process innovation dummies as dependent variables to analyze the effect of competition on the probability of innovating.

The vector X of firm-specific variables includes characteristics that are expected to affect innovation and are part of standard covariates used in the literature (Hamberg, 1964; Kraft, 1989; Ayyagari *et al.*, 2012; Gustavsson and Karpaty, 2011; Polder and Veldhuizen, 2012, among others). We include the following variables: size, age, exporter status, firm capacity utilization, proportion of employees who are white-collar, and employee (or manager) ownership.

The white-collar proportion is percentage of white-collar workers over total employment. Size is measured as log of total employment. Firm capacity utilization corresponds to three dummies for 0 to 50%, 50 to 80%, and more than 80%. Employee (or manager) ownership corresponds to a dummy variable equal to 1 if the owners of the firm are either employees or managers, and zero otherwise. Finally, exporter status and state and foreign ownership correspond to dummy variables equal to 1 if the firm sells abroad, belongs to the state, or a foreigner respectively.[10]

As Table 1 shows, 31% of the firms are exporters, while 4% are state, 9% are foreign, and 3% are employee (or manager) owned. On average firms are about 19 years old with around 308 employees; 5% of

[10] Table 4 shows the variables' definitions.

total employment is white-collar. The average firm is running at a medium scale, using between 50% and 80% of installed capacity.

We are interested in evaluating the potential heterogeneous effects of competition on innovation. In addition to the basic model, we also estimate this effect across types of industries. First, we use the OECD classification of technology-intensity carried out by Hatzichronoglou (1997) and analyze whether competition has a lower or higher impact on high-tech industries compared to low-tech industries.

Second, we use the Pavitt's (1984) taxonomy -updated by Bérubé, et al. (2012)- to look at the impact of competition depending on industry differences in innovation sources.[11] We consider three types of industries from this updated classification, First, supplier dominated sectors which rely on external sources of innovation (*e.g.* from mostly traditional manufacturing, such as textiles and agriculture). These are divided into labor-intensive and resource-intensive sectors. The final industry is composed by scale-intensive sectors, characterized by large firms that produce basic materials and consumer durables. These sectors rely on both external and internal sources for innovation and have a medium-level of appropriability (*e.g.* automotive sector). Given these characteristics, we expect heterogeneous effects because competition in the same industry should be more important for scale-intensive

[11] The industries and their classification according to these two taxonomies are shown in the appendix.

sectors rather than for supplier dominated sectors (both labor and resource-intensive industries).[12]

Finally, in the spirit of Aghion *et al.* (2005), we use a measure to characterize industries where, on average, firms are close to or far away from the technological frontier. We characterize these industries by calculating the proportional distance from the technological frontier as measured by labor productivity. For each firm i and industry j, we compute:

$$D_{ijt} = LP_{it}/\max(LP_{ijt})$$

Where LP is labor productivity and max(LP) is the maximum value of labor productivity across countries in the industry where the firm operates. We use an industry measure of D_{ijt} that is the average across firms. Then we define neck-and-neck industries as those where this indicator is higher than the median across industries in the same country. Non-neck-and-neck industries are those below this indicator's median.

4. Results

In this section we present and discuss the results of our empirical estimations. We first present the estimation results for the number of innovations, using a Poisson model, and then show the results using a probability model for product and process innovation.

[12] The other two industries in the Pavitt´s taxonomy, specialized and science-intensive sectors, were not incorporated because there are few observations for each in the sample.

In Table 5, we present the results for the aggregated index of innovation using a Poisson count model with a control function. As it can be appreciated from the four specifications, which differ in the number of covariates included in the estimation, the parameters for the Boone index and the square of this variable (in absolute value) are both negative. This result suggests that higher competition is associated with a reduction in the number of innovations carried out by firms in developing countries. Given that both parameters are negative, in contrast to previous evidence by Aghion *et al.* (2005), this detrimental effect of higher competition is monotonic and not dependent on the level of competition.[13]

We also find results supporting Schumpeterian ideas that larger firms tend to innovate more. Our research shows that state and foreign owned firms tend to innovate less and exporters tend to innovate more. Additionally, manager and employee ownership are associated with lower innovation. Finally, our results suggest that higher utilization capacity is associated with higher innovation, and that this effect is larger in the variable's intermediate range.

Table 6 presents the results for a probability model with instrumental variables for product and process innovation.[14] The results are quite similar to those of the Poisson estimations. Across specifications, we find a negative and significant effect of the

[13] In order to check for robustness excluding the more developed countries in the sample, we re-estimate ommiting the 10th decile of GDP per capita. We also estimate sequential specifications from basic to a complete set of covariates, without significant changes in the main results regarding the impact of competition.

[14] As in Poisson model, we restrict the sample by excluding developing countries with high income and varying the specifications without finding remarkable changes in the results.

level of competition on the probability of innovation for both product and process innovation. Given that the square of the Boone index is also negative, we show the results excluding this variable. In quantitative terms, our results show that moving from the 10th to the 90th percentile of competition implies an average decrease in product innovation by 20.4% and a probability decrease by 24.3% for process innovation.

Regarding the other control variable, we also find support for the Schumpeterian idea that larger firms tend to carry on more innovation activities. In the case of firm age, we do not find any relationships with respect to process innovation, while in the case of product innovation we find a positive and significant effect of age. As in the preview estimations, exporter status positively affects the probability of process and product innovation. State owned firms are less likely to conduct any kind of innovation. Results also show that being a foreign-owned firm is negatively associated with process innovation. Finally, we find that there exists a kind of non-linear effect of firm capacity utilization over the probability of innovation, where a firm is more likely to innovate if its capacity utilization is more than 50% but less than 80%.

For instrumental variables estimations, it is necessary to analyze the instruments' quality. Thus we present two tests for the instrumental variables. One is Cragg-Donald (2009) statistics that test null hypothesis of weak instruments against the alternative of strong instruments. This statistic is defined as the lowest eigenvalue of the concentration matrix. If this *eigenvalue* is higher than the Stock and Yogo (2002) critic value at a bias size, number of endogenous repressors, and number of instruments, we can reject the hypothesis of weak instruments. The literature also uses *F*-Statistics for the first stage regression as a weak instrument test and, when this statistic is above 10, the instruments are not weak. As shown in the tables, all Cragg-Donald statistics remain above their critical value at 10% of bias (the lower number)[15] and all *F*-statistics remain over 10. Thus, we can conclude that we do not have a weak instruments problem.

4.1. Heterogeneous effects across industries

We show the results using OECD taxonomy for technological intensity by grouping the firms into two categories -the Low-Tech and High-Tech industries- by using medium-low to medium-high industries (Table 7).[16] In Table 8, we show the results using an updated version of Pavitt´s taxonomy. Finally in Table 9, we present the results for industries classified according to average distance to the technological frontier.

For both low- and high-tech industries, we find similar results regarding the impact of competition on innovation. There exists a negative and robust effect of competition on innovation. To appreciate the magnitude of this effect, consider that moving from a

[15] Critical values for one endogenous regressor and one excluded instrument are (i) 10% maximal bias size=16.38; 15% maximal bias size=8.96; 20% maximal bias size=6.66; and 25% maximal bias size=5.53.
[16] There are not firms in very high-tech industries in this sample.

sector with low competition (10% lowest value of the Boone index) to a sector with high competition (10% highest value), we find a 19.3% reduction in the probability of product innovation and 23.7% for process innovation for low-tech sectors. In the case of high-tech sectors, the reduction in innovation probability is 13.4% for products and 16.0% for process.

Considering the classification of industries according to Pavitt´s taxonomy (Table 8), our results generally show a negative effect of competition on innovation, which is common across types of industries. In the case of labor-intensive industries; the results show a negative and significant effect of competition only for process innovation. In contrast, we find that competition reduces product and process innovation for both resource- and scale-intensive industries. Similar to the calculations explained above, moving from a low-competition to a highly competitive industry leads to an average decrease in the probability of innovation of 19.7% for product innovation and 19.8% for process innovation for resource-intensive industries. In the case of scale-intensive industries, we find reductions of 14.3% for product innovation and 17.3% for process innovation.[17]

For both, neck and no-neck industries, we find that there exists a negative and significant effect of competition on both product and process innovation. On average moving from a very uncompetitive

[17] The results for labor-intensive industries must be taken with caution because they may be driven by weak instruments. The Cragg-Donald statistics are below the 10% bias Stock and Yogo critic value, and the instrument is not significant in the first-stage regression.

industry to a very competitive one implies an average decrease of 17.4% for product and 25.6% for process innovation probabilities. In the case of no-neck-to-neck industries, the reduction in innovation probability is 22.2% for products and 24.6% for process. Thus, both set of industries are similarly affected by increases in competition.

4.2. Robustness analysis and extensions

To check the robustness of our previous results, we undertake a set of three new regressions. First, instead of using the Boone index to measure the degree of competition, we use a more traditional measure, the is the Lerner index. Second, we use an alternative measure of innovation defined as “any innovation,” which is dummy variable equal to 1 if the firm performed either product or process innovation, and zero otherwise. Third, we use the probability of investing in R&D as a proxy for innovation.

The results are presented in Table 10 and are very consistent with previous findings. Regarding the Lerner index (column 1), we also find that more competition is associated with a lower probability of product and process innovation, although the IV results tend to be less reliable due to evidence of weak instruments. In the case of any innovation (column 2), we find that both indicators of competition are associated with a lower probability of innovation. Finally, using the probability of investing in R&D as proxy generates similar results (column 3), although we find that only the Lerner index has a negative and significant effect.

In sum, all of these regressions are generally consistent with the idea that competition does not increase innovation in developing countries. This remains true even considering alternative competition measures and different variables capturing firms' innovation efforts.

5. Conclusions

Using the Climate Investment Survey from the World Bank, we find a negative and robust effect of competition on innovation. These results are different from those in developed countries where some recent findings indicate a non-linear or even positive effect of competition on innovation. Unlike other studies, our paper uses three main characteristics. First, we focus on developing countries, where the empirical evidence is more scant than for developed countries. Second, we use several innovation measures and not patents, which are less likely to capture technological innovation in developing countries. Third, we use a new measure of competition, the Boone index, which has not been typically used in this literature and has several advantages over other more traditional indicators.

Our findings reveal a negative and robust impact of competition on innovation, and we do not find any evidence of a non-linear relationship between these two variables. These results hold across different industry groups and are robust to alternative measures of competition and innovation. This result may come from the fact that we are focusing on developing countries most of which are characterized by low levels of appropriability and poor institutional quality. In this context, higher competition would be associated with lower incentives to innovate.

Our findings can be related to the idea of self-discovery modeled and documented by Hausmann and Rodrik (2005). For developing countries, they argue that higher *ex-post* competition reduces the incentives to discover new activities because pioneers cannot appropriate the benefits of their investments. Thus, there are ex-ante low investments in new activities, which can be interpreted as innovation.

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Table 1 Descriptive statistics

Variable	Observations	Mean	Std. Dev.	Min.	Max.
Innovation Variables					
Aggregate Index	15,790	1.34	1.03	0.00	3.00
Core Innovation Dummy	19,457	0.52	0.50	0.00	1.00
Innovative Dummy	19,457	0.39	0.49	0.00	1.00
Competition Measure					
Boone Index	19,457	-0.48	0.40	-1.94	-0.01
Lerner Index	19,431	0.36	0.26	0.00	1.00
HH	19,457	0.18	0.23	0.01	0.99
Control Variables					
Log(L)	19,371	4.20	1.64	0.00	10.73
Log(Age)	18,517	2.55	0.89	0.00	5.26
Exporter	19,457	0.31	0.46	0.00	1.00
State-Owned	18,626	0.04	0.20	0.00	1.00
Foreign	18,838	0.09	0.28	0.00	1.00
White-Collar	19,371	0.05	0.07	0.00	0.50
Between 0-50 CU	17,893	0.11	0.32	0.00	1.00
Between 50-80 CU	17,893	0.55	0.50	0.00	1.00
Between >80 CU	17,893	0.34	0.47	0.00	1.00
Emp/Manager Owner	19,457	0.03	0.16	0.00	1.00

Note: This descriptive statics are conditioned to non-missing value of Core Innovation Dummy and non-missing value of competition definition. Without this condition observation grows up to more than 24,000.

Table 2 Pair-wise correlation

	Boone Index	Lerner Index	HH Index	N° of Comp.	N° of Supp.	Foreign Comp.	State Comp.	Inf. For. Comp.	Hyp. Monop.
Boone Index	1.000								
	-								
	-								
Lerner Index	0.520	1.000							
	0.000	-							
HH Index	0.131	-0.020	1.000						
	0.000	0.002	-						
			-						
N° of Comp.	0.267	-0.186	0.018	1.000					
	0.000	0.000	0.061	-					
			-						
N° of Supp.	0.328	-0.220	0.075	0.327	1.000				
	0.000	0.000	0.000	0.000	-				
	-								
Foreign Comp.	0.092	-0.028	0.000	0.226	0.092	1.000			
	0.000	0.087	0.971	0.000	0.000	-			
					-				
State Comp.	0.189	-0.131	0.047	0.157	0.050	-0.609	1.000		
	0.000	0.000	0.003	0.000	0.003	0.000	-		
Inf. For.				-			-		
Competitor	0.052	-0.019	0.081	0.070	0.009	0.108	0.098	1.000	
	0.069	0.468	0.000	0.001	0.656	0.000	0.003	-	
Hyphotetical	-		-		-		-		
Monop.	0.212	0.158	0.003	0.035	0.024	0.066	0.054	0.003	1.000
	0.000	0.000	0.798	0.032	0.132	0.000	0.029	0.871	-

Note: Pairwise correlation between competition definitions and the number of competitors, number of suppliers, if the firm faces a foreign or state competitor, if the firm decisions are influenced by competitor moves and the firm believes about the reaction of customers against an hypothetical increase in 10% of the product prices (hypothetical monopolist test). 5% Confidence *p*-value below pairwise correlation.

Table 3 Boone index ANOVA

	% of Variance
Country	67.10%
Industry	8.29%
Year	10.62%
Residuals	13.99%
Total	**100%**

Table 4 Variable definitions

Variable	Definition
Log (L)	Log of employment
Log(Age)	Log of Age
Exporter	Exporter Dummy
Sate-Owned	Sate Owned Company Dummy
Foreign	Foreign Ownership (More than 52% of the property)
White-Collar	Percentage of employment that is skilled
Capacity Utilization	3-categories: 1[CU<50%], 2[50%<CU<80%] and 3[CU>80%]
Emp/Manager Owner	Principal owner of the firm are employees or the manager

Table 5 Aggregate index: Intensive margin

	(1) Agg. Index	(2) Agg. Index	(3) Agg. Index	(4) Agg. Index
|Boone Index|	-0.763**	-0.361	-0.302	-0.298
	(0.385)	(0.421)	(0.412)	(0.411)
|Boone Index|^2	-0.268***	-0.295***	-0.282***	-0.282***
	(0.0624)	(0.0701)	(0.0688)	(0.0688)
Log(L)		0.235***	0.231***	0.232***
		(0.0354)	(0.0344)	(0.0347)
Log(L)^2		-0.0176***	-0.0173***	-0.0175***
		(0.00455)	(0.00435)	(0.00439)
Log(Age)		0.0149	0.0192	0.0183
		(0.0316)	(0.0310)	(0.0310)
Log(Age)^2		0.000206	0.000542	0.000608
		(0.00629)	(0.00620)	(0.00621)
Exporter		0.140***	0.125***	0.124***
		(0.0249)	(0.0235)	(0.0234)
State-Owned		-0.318***	-0.292***	-0.297***
		(0.0879)	(0.0876)	(0.0890)
Foreign		-0.155***	-0.151***	-0.154***
		(0.0352)	(0.0349)	(0.0352)
Percentage of White Collars		0.00731	0.0447	0.0377
		(0.293)	(0.280)	(0.281)
Between 50-80% of Cap. Utilization			0.190***	0.190***
			(0.0382)	(0.0382)
More than 80% of Cap. Utilization			0.165***	0.165***
			(0.0300)	(0.0300)
Employees/Manager Owner				-0.103**
				(0.0508)
Residuals	1.608***	1.315**	1.215**	1.210**
	(0.379)	(0.411)	(0.399)	(0.398)
Constant	0.345	-0.415	-0.555*	-0.560*
	(0.237)	(0.327)	(0.332)	(0.331)
Observations	15,942	14,994	14,765	14,765
Industry-Year FE	YES	YES	YES	YES

Control Function Estimation. Country-Industry-Year clustered Standard errors in parentheses. * significant at 10 %; ** significant at 5 %; *** significant at 1 %

Table 6 Innovation probabilities: Extensive margin

	Product Innovation			Process Innovation		
	(1)	(2)	(3)	(1)	(2)	(3)
|Boone Index|	-0.424***	-0.443***	-0.443***	-0.521***	-0.535***	-0.535***
	(0.130)	(0.124)	(0.124)	(0.116)	(0.115)	(0.115)
Log(L)	0.019*	0.020*	0.020*	0.029**	0.031**	0.031**
	(0.011)	(0.011)	(0.011)	(0.012)	(0.012)	(0.012)
Log(Age)	0.015**	0.019***	0.019***	-0.001	0.003	0.003
	(0.007)	(0.007)	(0.007)	(0.006)	(0.006)	(0.006)
Exporter	0.069***	0.069***	0.069***	0.048***	0.047***	0.047***
	(0.019)	(0.019)	(0.019)	(0.016)	(0.016)	(0.016)
State-Owned	-0.129***	-0.132***	-0.134***	-0.120***	-0.128***	-0.131***
	(0.047)	(0.047)	(0.048)	(0.043)	(0.043)	(0.043)
Foreign	-0.022	-0.021	-0.022	-0.044**	-0.044**	-0.045**
	(0.020)	(0.021)	(0.021)	(0.018)	(0.018)	(0.019)
White-Collar over L	-0.181	-0.184	-0.187	-0.135	-0.126	-0.129
	(0.173)	(0.169)	(0.169)	(0.177)	(0.178)	(0.178)
Between 50-80% of Cap. Utilization		0.078***	0.078***		0.068***	0.068***
		(0.015)	(0.015)		(0.017)	(0.017)
More than 80% of Cap. Utilization		0.059***	0.059***		0.053***	0.053***
		(0.013)	(0.013)		(0.013)	(0.013)
Employees/Manager Owner			-0.037			-0.042
			(0.035)			(0.034)
Observations	17,539	16,829	16,829	17,539	16,829	16,829
Industry-Year FE	YES	YES	YES	YES	YES	YES
Cragg-Donald	322.5	327.4	328.3	322.5	327.4	328.3
First Stage F-Statistic	27.36	626.4	1447.9	27.36	626.4	1447.9

Marginal Effects Reported. Country-Industry-Year Clustered standard errors in parentheses.
* significant at 10 %; ** significant at 5 %; *** significant at 1 %.

Table 7 Tech-no-tech Results

	Product Innovation		Process Innovation	
	Low-Tech	High-Tech	Low-Tech	High-Tech
|Boone Index|	-0.406*	-0.477***	-0.509**	-0.561***
	(0.175)	(0.119)	(0.167)	(0.0921)
Log(L)	0.0166	0.0226	0.0360**	0.0233
	(0.0124)	(0.0166)	(0.0138)	(0.0153)
Log(Age)	0.0117	0.0306**	-0.00826	0.0191
	(0.0105)	(0.0114)	(0.00732)	(0.0107)
Exporter	0.0495*	0.0927**	0.0276	0.0681**
	(0.0204)	(0.0294)	(0.0174)	(0.0233)
State-Owned	-0.143	-0.134**	-0.149*	-0.119**
	(0.0812)	(0.0511)	(0.0693)	(0.0436)
Foreign	-0.0736*	0.0274	-0.0910**	-0.00218
	(0.0362)	(0.0281)	(0.0306)	(0.0277)
White-Collar over L	-0.338	-0.0669	-0.279	0.00349
	(0.271)	(0.171)	(0.296)	(0.162)
Between 50-80% of Cap. Utilization.	0.0838***	0.0702***	0.0701**	0.0637**
	(0.0241)	(0.0174)	(0.0260)	(0.0210)
More than 80% of Cap. Utilization	0.0725***	0.0435*	0.0570**	0.0489*
	(0.0187)	(0.0187)	(0.0186)	(0.0203)
Employees/Manager Owner	-0.0506	-0.0193	-0.0560	-0.0179
	(0.0485)	(0.0376)	(0.0510)	(0.0343)
Observations	9,404	7,425	9,404	7,425
Industry-Year FE	YES	YES	YES	YES
Cragg-Donald	203.5	134.0	203.5	134.0
First Stage F-Statistic	34.46	62.38	34.46	62.38

Marginal Effects Reported. Country-Industry-Year Clustered standard errors in parentheses. * significant at 10 %; ** significant at 5 %; *** significant at 1 %.

Table 8 PAVITT Taxonomy results

	Product Innovation	Process Innovation

	Labor	Resource	Scale	Labor	Resource	Scale
|Boone Index|	0.767	-0.437**	-0.469***	-0.809**	-0.439**	-0.569***
	(1.245)	(0.166)	(0.132)	(0.310)	(0.138)	(0.0975)
Log(L)	0.0138	0.0435***	0.0256	-0.00973	0.0588***	0.0256
	(0.0365)	(0.00970)	(0.0170)	(0.0443)	(0.00868)	(0.0159)
Log(Age)	0.0225	0.00700	0.0347**	-0.00869	-0.0134	0.0225
	(0.0366)	(0.0100)	(0.0130)	(0.0170)	(0.00769)	(0.0124)
Exporter	0.00569	0.0721*	0.0884*	0.0255	0.0311	0.0728*
	(0.124)	(0.0281)	(0.0361)	(0.0339)	(0.0195)	(0.0286)
State-Owned	0.244	-0.0720	-0.201**	-0.282*	-0.0782	-0.173**
	(0.521)	(0.0901)	(0.0717)	(0.136)	(0.0594)	(0.0589)
Foreign (d)	0.125	0.0235	0.0349	-0.202*	-0.0556*	0.0365
	(0.540)	(0.0331)	(0.0319)	(0.0888)	(0.0241)	(0.0238)
White-Collar over L	0.795	-0.0184	-0.208	-0.951	0.171	-0.0669
	(1.947)	(0.222)	(0.182)	(0.619)	(0.202)	(0.187)
Between 50-80% of Cap. Utilization.	-0.0358	0.0679***	0.0792***	0.0892*	0.0531**	0.0781***
	(0.285)	(0.0189)	(0.0204)	(0.0350)	(0.0197)	(0.0232)
More than 80% of Cap. Utilization.	0.000202	0.0619**	0.0550*	0.0600	0.0430*	0.0654**
	(0.249)	(0.0214)	(0.0228)	(0.0448)	(0.0194)	(0.0237)
Employees/Manager Owner	0.122	-0.0172	-0.0267	-0.187	0.0116	-0.0291
	(0.405)	(0.0353)	(0.0385)	(0.0985)	(0.0388)	(0.0384)
Observations	4,493	5,596	5,647	4,493	5,596	5,647
Industry-Year FE	YES	YES	YES	YES	YES	YES
Cragg-Donald	2.107	258.5	101.3	2.107	258.5	101.3
First Stage F-Statistic	422.7	224.3	180.3	422.7	224.3	180.3

Marginal Effects Reported. Country-Industry-Year Clustered standard errors in parentheses.
* significant at 10 %; ** significant at 5 %; *** significant at 1 %.

Table 9 Neck-and-Neckness results

	Product Innovation		Process Innovation	
	No-Neck	Neck	No-Neck	Neck
|Boone Index|	-0.363***	-0.470**	-0.555***	-0.526***

	(0.103)	(0.173)	(0.100)	(0.156)
Log(L)	0.0294	0.0184	0.0233	0.0349*
	(0.0174)	(0.0127)	(0.0194)	(0.0139)
Log(Age)	0.0120	0.0207*	0.00185	0.00271
	(0.0121)	(0.00848)	(0.0105)	(0.00734)
Exporter	0.109***	0.0484*	0.0734**	0.0332
	(0.0291)	(0.0221)	(0.0255)	(0.0187)
State-Owned	-0.0438	-0.217**	-0.0641	-0.196**
	(0.0344)	(0.0741)	(0.0357)	(0.0642)
Foreign	0.0105	-0.0410	-0.0334	-0.0526*
	(0.0328)	(0.0270)	(0.0333)	(0.0222)
White-Collar over L	0.132	-0.328	0.0000	-0.196
	(0.235)	(0.200)	(0.241)	(0.221)
Between 50-80% of Cap. Utilization	0.0478*	0.0943***	0.0618*	0.0729***
	(0.0241)	(0.0189)	(0.0275)	(0.0213)
More than 80% of Cap. Utilization	0.0209	0.0800***	0.0387	0.0635***
	(0.0222)	(0.0165)	(0.0250)	(0.0158)
Employees/Manager Owner	-0.00574	-0.0513	0.00787	-0.0556
	(0.0498)	(0.0423)	(0.0375)	(0.0419)
Observations	5,696	11,133	5,696	11,133
Industry-Year FE	YES	YES	YES	YES
Cragg-Donald	98.92	234.3	98.92	234.3
First Stage F-Statistic	86.37	59.76	86.37	59.76

Marginal Effects Reported. Country-Industry-Year Clustered standard errors in parentheses. * significant at 10 %; ** significant at 5 %; *** significant at 1 %

Table 10 Robustness analysis and extensions

	1 - Lerner		Any innovation		R&D > 0	
	Product	Process	Boone	1 - Lerner	Boone	1 - Lerner
Competition Measure	-1.152***	-1.174***	-0.519***	-1.161***	-0.179	-1.157***

	(0.0525)	(0.0209)	(0.120)	(0.0359)	(0.201)	(0.161)
Log(L)	-0.000404	-0.00133	0.0239	-0.000849	0.0686***	0.00535
	(0.0104)	(0.00944)	(0.0122)	(0.00992)	(0.0174)	(0.0329)
Log(Age)	0.0169***	0.0147**	0.0107	0.0153***	-0.00565	0.00978
	(0.00510)	(0.00461)	(0.00629)	(0.00457)	(0.0121)	(0.0102)
Exporter	0.0152	0.0102	0.0713***	0.0139	0.0513**	0.0304
	(0.0170)	(0.0125)	(0.0185)	(0.0158)	(0.0167)	(0.0253)
State-Owned	-0.113***	-0.107***	-0.132**	-0.108***	-0.0983	-0.118***
	(0.0246)	(0.0219)	(0.0469)	(0.0225)	(0.0695)	(0.0352)
Foreign	- 0.0453***	- 0.0477***	-0.0179	-0.0448***	-0.0975***	-0.0793*
	(0.0137)	(0.0137)	(0.0201)	(0.0134)	(0.0275)	(0.0353)
White-Collar over L	-0.200*	-0.212*	-0.177	-0.202*	0.300	-0.245
	(0.0986)	(0.0902)	(0.175)	(0.0956)	(0.198)	(0.200)
Between 50-80% of Cap. Utilization	0.0260	0.0211*	0.0773***	0.0241*	0.0534*	0.0365*
	(0.0135)	(0.0104)	(0.0152)	(0.0117)	(0.0239)	(0.0146)
More than 80% of Cap. Utilization	0.00543	0.00199	0.0549***	0.00349	0.0306	0.0107
	(0.0137)	(0.0111)	(0.0129)	(0.0116)	(0.0181)	(0.0126)
Employees/Manager Owner	-0.0263	-0.0274	-0.0426	-0.0268	-0.00858	-0.00730
	(0.0193)	(0.0194)	(0.0342)	(0.0190)	(0.0427)	(0.0326)
Observations	19,746	19,746	16,829	19,734	10,105	11,567
Industry-Year FE	YES	YES	YES	YES	YES	YES
Cragg-Donald	3.716	3.716	328.3	3.716	234.3	8.330
First Stage F-Statistic	1.987	1.416	61.11	1.015	631.6	23.89

Marginal Effects Reported. Country-Industry-Year Clustered standard errors in parentheses.
* significant at 10 %; ** significant at 5 %; *** significant at 1 %

Appendix

Industry taxonomy

Industry	PAVITT	OECD
Textiles	Labor	Low-Tech
Leather	Labor	Low-Tech
Garments	Labor	Low-Tech
Food	Resource	Low-Tech
Beverages	Resource	Low-Tech
Metals and machinery	Scale	High-Tech
Electronics	Specialized	High-Tech
Chemicals and pharmaceutics	Scale	High-Tech
Wood and furniture	Labor	Low-Tech
Non-metallic and plastic materials	Resource	High-Tech
Paper	Resource	Low-Tech
Other manufacturing	Labor	High-Tech
Auto and auto components	Scale	High-Tech

Based on Hatzichronoglou (1997) and Bérubé *et al.* (2012).