“Competition and Innovation in Developing Countries”

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Competition and Innovation in Developing Countries[1]

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Abstract

Using the Climate Investment Survey from the World Bank, we find a negative relationship between competition and innovation in developing countries. This result supports the idea of Schumpeter (1942) that competition can harm innovation. We deal with endogeneity issues using as instrument the interaction between industry turnover and entry regulation in the U.S. The basic idea is that entry regulations have a more pronounced and negative effect on competition in those industries with more natural entry. For this, we find that relevant competition is at the country-level rather than at country-industry level. Finally, we find no evidence of heterogeneity on this relationship across firms and industries.

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1. – Introduction

Competition and innovation are main drivers of productivity, growth, and development (Aghion *et al.* (2006)). This is especially true in developing countries where innovation may help to "catch-up" with developed nations (Cameron (1998), Griliches (1998), and Bravo-Ortega & Garcia (2011)), specifically behind these two drivers is that theory realized that they are continuously connected (Schumpeter (1934, 1942), Arrow (1962), Aghion and Howitt (2006), among others) even when the relationship between them is not yet clear or conclusive.

With the creative destruction concept, Schumpeter (1942) points to a linear and negative effect of competition over innovative activities and hence in firms' performance.[3] He found that stronger incentives for monopolist over competitive firms exist for innovation because these kinds of firms can capture gains of innovation without any probability of free riding by competitors. Later Arrow (1962), Scherer (1980), and Porter (1990) questioned Schumpeter's results, finding a positive net effect of competition over innovation because of fears of being run out the market by potential entrants' innovations. Thus the incumbent firms have to innovate in order to survive against entrants.

Empirical evidence exists supporting both sides, negative effect papers include: Hamberg (1964); Mansfield (1964); Kraft (1989); Aghion and Howitt (1992); Crepon, *et al.* (1998); Campante and Katz (2007); and Gorodnichenko, Svejnar and Terrell (2008). Meanwhile for positive effect papers, there are: Geroski (1990), Blundell *et al.* (1995, 1999), Nickell (1996), Carlin *et al.* (2004), Ayyagari *et al.* (2011), and Correa (2012). Nevertheless, and due to no consensus in literature, Aghion *et al* (2005), following Scherer (1967), produces a non-linear relation between competition and innovation using a theoretical model that captures both trends and comes up with an inverse U relation between competition and innovation where, depending on the initial level of competition, you may find positive or negative effect. So in a very competitive market, profit gains from innovative activities are almost zero. Meanwhile as competition decreases, profit gains from catching-up with the leader increase until there is not any difference in efficiency of competitors. Above this point, gains of innovation start decreasing and the inverted U and the trade-off between competition and innovation appears.

[3] In a preview book, Schumpeter (1934) points out the change in his thoughts over the time.

Since Aghion *et al.* (2005) several empirical studies test this non-linear relationship between competition and innovation, both finding that this relationship holds (Hashmi (2005), Lee (2005), Lee and Sung (2005) and Polder and Veldhuizen (2012)) and doesn't (Aiginger and Falk (2005), Tingvall and Poldahl (2006)). Even the results of Aghion *et al.* (2005) seems to be inconsistent because Correa (2012), using the same data, found the existence of structural break in the middle of the sample and when taking that into account, the inverted U relationship disappears showing that those results are incorrect, the inverted U relationship doesn't necessary exist, and that there is a positive relationship between innovation and competition during the first subsampole and no relationship at all in the second subsample.

In summary,[4] the literature on firm growth, innovation and competition suggests that innovation is likely to be one of the most important channels through which competition affects economic growth, although there lacks a consensus on the relationship between them. Additionally, the evidence of this relationship for developing countries is very scarce and incomplete. Moreover, most of the literature identifies an endogeneity problem which they do not address or used outdated methods to do so (Cohen and Levin (1989) and Cohen (2010)).

This investigation looks to contribute to the literature in competition and innovation using firm-level data for more than 24,000 firms from 70 developing countries. The main research addresses if there is a relationship between competition and innovation for developing countries, if this effect is heterogeneous among different industries and firms, and if it remains for different types of innovation.

Using the same approach of Aghion *et al.* (2005) and then by using a probability model with instrumental variables to deal with endogeneity we find that there exists a negative and robust effect of competition over the level of innovation and the probability to engage in product or process innovation. This is probably in line with Schumpeter (1942) and with modern self-discovery theories developed by Hausmann and Rodrik (2003), empirically proved for export diversification and discovery by Klinder and Lederman (2011), and for competition and innovation by Gorodnichenko, Svejnar and Terrell (2008). These results remain at different industry classifications, and we do not found significant difference between them. In fact, we

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

found that country-specific competition is what matters the most for firm decision, not industry specific competition or even country-industry competition.

The rest of the paper is structured as follows. The next section describes the dataset used in this paper, present some important definitions (innovation, competition, and covariates) and descriptive statistics. The third section presents the methodology and how the endogeneity is addressed, and the fourth section discusses and presents econometrics results for the relationship between competition and innovation. Finally section 5 provides the main conclusions and findings.

2. – Data

To address this paper's objectives, we use the World Bank Investment Climate Survey pooled cross-section database (ICS)[5] that consists of firm survey responses of over 24,000 2-digit sector firms in 70 developing countries between the years of 2002 and 2006.[6] This data comes from a random size-industry-location stratified survey that captures information of the characteristics of the local businesses, and the investment climate facing by the firms and its impact on performance by reporting detailed information on firm employment, age, industry, ownership, legal status, number of establishments, and other information.

Innovation Definition

A great advantage of this survey over other ones available 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 data does not only have R&D expenditure data, but also of different kinds of innovative activities that a firm undertakes three years prior to the survey.[7] This allows us to measure the level of innovation in a broader sense of the word, leveling innovation with three different variables reflecting output measures of innovation that allow us to analyze the

[5] Available previous registration at http://www.enterprisesurveys.org/

[6] Gross version of this database consists for more than 70,000 2-digit sector firms in more than 90 countries. But we restrict it to developing countries, manufactures, and for those not missing data.

[7] The more updated version of the Enterprises Surveys carried by the World Bank lacks information about innovative activities.

intensive (probability to commit innovative activities) and extensive margin (the level of innovation committed by the firm). The intensive margin is addressed using two variables: the first one corresponds to a Product innovation dummy equal to 1 when the firm undertakes activities 1 (“Developed a major new product line”) or 2 (“Upgraded an existing product line”) and zero otherwise, and the second one corresponds to a Process dummy that is 1 when the firm reported undertaking activity 3 (“Introduced new technology that changed the way that the main product is produced”) and zero otherwise. The extensive margins is address using a count index that correspond to the sum of the 3 innovative activities reported to be undertaken during the three years prior the survey following the approach of La Porta *et al.* (1998) and Ayyagari *et al.* (2011).

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 1 presents the descriptive statistics of the sample used, specifically innovation variables and shows that, on average, firms undertake 1.34 innovative activities during the past three years: 52% of the firms perform Product Innovation and 39% of firms perform Process

Innovation. This is proven to be a large number of innovations over the real indicators, but corresponds to a usual output of innovation surveys and remains high in every country-industry in this sample.

Competition Definition

In this paper, the definition of competition plays a very important role; if we have a poor measure then the results would be biased and the interpretation would be wrong. There are a few different methodologies to measure the level of competition inside an industry[8] and the most common are the price cost margin (PCM) approach with the Lerner Index and the market concentration approach with the Herfindahl–Hirschman (HH) Index. These measures suffer from various theoretical and empirical problems; specifically HH Index is not suited for small (open) economies, as it only expresses domestic industrial power, and does not necessarily represent the competition pressure for firms. Meanwhile, the Lerner index has been proven to provide a poor theoretical measure of competition (Boone 2008a), this is especially relevant for empirical studies (Griffith et al. (2005)) because it is found to be particularly poorly correlated with alternative measures of competition (Boone *et al.* (2007), Duhamel and Kelly (2011)).

Boone (2008a) proposed a theoretical new measure based on relative profits-elasticity solving previous measures problems, taking into account the heterogeneity of efficiency of firms in a market. His approach is based on the idea that competition rewards efficiency. More efficient firms will have higher market shares and higher profits than less efficient ones and that effect should be stronger for a more competitive market. Numerous investigators study the empirical application of this measure and their benefits (Gustavsson and Karpaty (2011), Boone *et al*. (2011), Schiersch and Schmidt-Ehmcke (2010), Polder and Veldhuizen (2012), and Peroni and Gomes Ferreira (2012))). Thus we use a standard of the methodologies previously mentioned, estimating the following equation in every industry-country-year to collect the Boone-index:

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

[8] For a complete discussion of different measures and its problems see Boone (2000) and Griffith, Boone and Harrison (2005).

Where $\log(\pi)_i$ correspond to the logarithm of the profits of the firm i in every industry j and country c, TVC_i correspond to Total Variable Cost, and following Bérubé, Duhamel and Ershov (2012) we add $log(Sales/Employment)$ to control for size and efficiency of the firm in order to get a good identification of the index.[9] Total Variable Cost is always negatively related with profits, so the Boone Index is always negative. Nevertheless, and for the purpose of the estimations, we use the absolute value of this index in order to get a more interpretable estimator. So, the Boone index corresponds to the coefficient β_1 from the country-industry-year estimations shown above and represents the profit elasticity of cost over profits where higher absolute value indicates greater sensitivity of firm profits to cost and for higher competition intensity. This measure corresponds to a relative measure of competition and does not allow us to identify the difference between a monopoly markets vs. a perfect competition one. 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 (Boone *et al.* (2007)). Table 2 shows the pairwise correlation matrix between different usual measures of competition or concentration (HH Index, Lerner, and Boone Index) and some competition parameters available in the dataset (number of competitors, suppliers, and customers, existence of State owned or Foreign competitor, and the influence of these competitors over their prices, products, and processes). As this table shows, a significant correlation exists among these competition parameters and the significance is higher and greater than Lerner and HH Index, and unlike the Lerner index, this correlation proves the monotonously relationship between this competition parameters and Boone index.

In order to understand the composition and the distribution of the Boone Index, Table 3 presents an analysis of variance of the Boone Index and shows that country variable explains more than 67.1% of the model variance of the index, while industry variations are almost 8.3%, year 10.62% and residuals of the model represent 13.99%. This is an interesting preview estimation result, telling us that what really matters in the decision to innovate is the

[9] To ensure robust Boone index estimates, industries in the country-year that did not have more than 20 firm observations were omitted from the dataset.

competition at the country-level than the industry or even the country-industry-level. This result directly affects our empirical strategy preventing us to use country fixed effect in order to get a good identification.[10]

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.

Endogeneity: Instrument Definition

As Aghion *et al.* (2005) and others note, there exists a reverse causality effect from innovation on industry structure. So, this structure may change as a result of firm's innovation decisions and the character of competition as well as the pressure to innovate. This issue may produce endogeneity in the competition indicator, and we use instrumental variable (IV) as an approach to solve it. The IV instruments have to fulfill two main conditions to get unbiased

[10] In order to test this result we run Country fixed effects regressions and lose significance on Boone index as predicted. This regressions are reported in the Appendix

estimators of the competition over innovation. First, they must be correlated with the endogenous explanatory variables, conditional on the other covariates, and cannot be correlated with the error term in the explanatory equation. So, 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[11] and U.S. industry turnover data taken from Fisman and Sarria-Allende (2004). Entry regulation for one side negatively affects the number of firms in an industry leading to a less competitive market, while higher industry firm turnover is correlated with a more competitive industry. Using data from the U.S. as a frictionless and baseline measure of industry turnover gives us an exogenous measure of how the industry behaves. The interaction between these two variables gave us an indicator that affects the market structure through firm entry regulation for every country and to relate it with an exogenous measure of industry turnover, without affecting the firm's decision to undertake innovative activities. These factors make this variable a good instrument candidate.

Table 3 Boone Index ANOVA

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

3. – Empirical Strategy

In order to fulfill the aims of this paper, we estimate the next equation.[12]

$$Y_{icjt} = \beta_0 + \beta_1 comp_{cj} + \beta_2 X_{icjt} + \beta_3 \mu_{jt} + \epsilon_{icjt}$$

where Y_{icj} represent the innovation measure of the firm i in country c, industry j and year t, and correspond to a continuous or dichotomic variable depending on the case, $comp_{cj}$ corresponds to the Boone Index from the estimation described in the previous section, X_{icjt}

[11] Doing Business Project from the World Bank takes the data from Djankov *et al.* (2002) and extends the index to more countries and years.
[12] In Poisson model we also control for non-linearity of competition, labor, and age.

corresponds to usual covariates used in literature, μ_{jt} to industry-year fixed effects, and ϵ_{icjt} to country-industry-year clustered standard errors, while allowing for observations within country-industry-year group to be correlated in some unknown way.

We estimate the former equation following two approaches, using instrumental variables to deal with endogeneity. In the first, following Aghion *et al.* (2005), we estimate a Poisson count model with a control function of the aggregated index of innovation over the competition measure, and in second place we estimate a Probit model with instrumental using product and process innovation dummies as dependent variables, while capturing the effect of competition over the probability of innovating.

We are particularly interested in evaluating the effects of competition over the probability of innovation on different industries and firms. So we compute the marginal effects at the sample mean of each regressor and analyze how these marginal effects change with firm and industry characteristics. In addition to these basic results, we re-estimate these marginal effects with different industry classifications subsamples, such as the OECD Classification of technology sectors made by Hatzichronoglou (1997), Pavitt's (1984) Taxonomy update used by Bérubé, Duhamel, and Ershov (2012), and, in the spirit, of Aghion *et al.* (2005) using the distance to the frontier to get neck-and-neckness firms.[13] These estimations allow us to not only understand how the relationship between competition and innovation behaves among different kinds of industries[14] and to test hypotheses about how firms behave along different industry classifications, but also to check for robustness of preview results.

The vector X of firm-specific variables includes characteristics that are expected to affect innovation and that are part of standard covariates used in the literature (Hamberg (1964), Kraft (1989), Ayyagari *et al.* (2010), Gustavsson and Karpaty (2011), Polder and Veldhuizen (2012), among others). For instance, we consider the impacts of size, age, exporter status, firm capacity utilization, white-collar proportion of employment, and employee (or manager) ownership over innovation (both probability and level). White-collar proportion and employee ownership are directly related with innovation decision making. Meanwhile, firm capacity

[13] As Aghion *et al.* (2005) more neck-and-neck firms are those firms below median technological country gap.
[14] In Appendix you can find the correspondence of industries and the PAVITT and OECD classifications.

utilization is more greatly related with the firms' period of production and the effect on innovation.

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

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. Finally, exporter status and state and foreign ownership correspond to dummy variables equal to 1 if the firm sell abroad, belongs to the state, or a foreigner respectively.[15]

As Table 1 shows, 31% of the firms are exporters, while 4% are state owned, 9% are foreign, and 3% are employee (or manager) owned. On average firms are about 19 years old with around 308 employees; 5% of total employment is white-collar and, on average, firms are running at a medium scale, using between 50% and 80% of installed capacity.

4. – Results

This section presents and discusses the results of the estimation of the empirical estimations that test the relationship between competition and innovation. It first presents Aghion *et al.* (2005) approach, and then shows the results using a probability model with instrumental variables. The main result we found is a persistent negative effect of innovation over the level of innovation undertaked by the firm.[16]

[15] Table 4 summarizes variable definitions.

[16] In order to check for robustness (and to control for more developed countries in the sample) we re-estimate by dropping 10th decile of GDP per capita and also compute from more basic to complete specifications ,without significant changes in the main results.

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^2(L)		-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. Use			0.190***	0.190***
			(0.0382)	(0.0382)
More than 80% of Cap. Use			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 %

In addition to what we just mentioned, we also found results support for Shumpeterian ideas that bigger firms tend to innovate more, perhaps because bigger firms may have greater access to innovation scale economies and more stability to undertake these kind of activities. State and Foreign owned firms tend to innovate less while exporters tend to innovate more. Finally manager and employee owned firms innovate less.

Unlike previous estimations that tried to understand innovation levels, the second approach is used to understand the probability in undertaking innovative activities. Table 6 presents the results for a probability model with instrumental variables.[17] In this case, the results remain quite similar with the Poisson case. We found a negative and persistent effect of the level of competition over the probability of innovation in for both product and process innovation. This means that moving from the 10th percentile of competition to the 90th percentile of competition implies an average decrease in undertaking product innovation by 20.39% and, for the case of process innovation, a decrease in the probability by 24.25%.

For the case of product and process innovation we also find support for the Shumpeterian ideas that bigger firms tend to carry on more innovation activities. Meanwhile, in the case of firm age, we did not find any relationships with respect to process innovation, while in the case of product innovation we found a positive and significant effect. As in the preview estimations, exporter status is positively correlated the probability in innovation for both kinds, and state owned firms are less likely to commit any kind of innovation. Results also show that for the case of process innovation, being a foreign-owned firm is negatively associated with undertaking this kind of innovation.

Finally, we found that there exists a kind of non-linear effect of firm capacity utilization over the probability of innovation, where it's more likely to innovate if the firm capacity utilization is more than 50% but less than 80%.

Besides the relationship testing, it's necessary to test the instruments' validity in order to gain a truly better estimator than non-instrumental variable estimations. In all instrumental variable

[17] As in Poisson model approach, we restrict the sample to 9/10 decile and compute from more basic to more complete specifications without remarkable changes in the results.

estimations tables, we present two instruments tests. One is the Cragg-Donald (2009) statistics that test weak instrument null hypothesis against the alternative of strong instruments. This statistic is defined as the lowest *eigenvalue* of the concentration matrix, and when this *eigenvalue* is highest than the Stock and Yogo (2002) critic value at a bias size, number of endogenous repressors, and number of instruments, then we reject the hypothesis of weak instruments. Despite Cragg-Donald (2009) statistic, the literature also uses F-Statistics of first stage as a weak instrument test and, when this statistic is above 10, we can conclude that our instruments are good.

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 (d)	-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. Use		0.078***	0.078***		0.068***	0.068***
		(0.015)	(0.015)		(0.017)	(0.017)
More than 80% of Cap. Use		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 %

As shown in the tables, all Cragg-Donald statistics remain above their critical value at 10% of bias (the lower number)[18] and all F-statistics remain over 10. Thus we can conclude that we have a good and strong instrument.

Looking for heterogeneity among firms and industries

Although we don't address the evidence of heterogeneity through firms and industries in the preview estimations, we do attempt to find this by using different subsample estimations. In this case we restrict the sample and divided it into different groups of industries using standard taxonomies. In Table 7 we shows the results using neck and no-neck firms division[19] where no-necks are those firms that are above the median of sales over employment and necks are those that are below median of sales over employment in the country-industry. In addition, in Table 8 we show the results using OECD taxonomy of technical industry classification. In this case we group the firms in two categories - the Low-Tech firms industries and High-Tech industries[20] - using medium-low to medium-high industries.[21] Finally in Table 9 we show the results using an updated form of PAVITT taxonomy that is an input upstream classification reclassified into five categories. The supplier-dominated category was broken into Resources and Labor; the production intensive was defined as Scale-intensive and Specialized suppliers; and Science-based remained a single category.[22]

For both, neck and no-neck firms, we found that there exists a negative and persistent effect of competition over the probability to innovate. On average moving from a highly uncompetitive industry (10th percentile of competition) to a very competitive industry (90th percentile of competition) means an average decrease in the probability to innovate by about 20.59% in the

[18] Critical values for 1 endogenous regressor and 1 excluded instrument: 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.

[19] As neck firms are defined to be closer to the technological frontier, one may expect that these firms are positively correlated with more competition, while in no-neck firms we can expect the opposite.

[20] In this case, more technological industries are used to face fierce competition, so we expect to find a positive correlation between competition and innovation in this case.

[21] In this sample no very high-tech industries were found.

[22] In this database we found firms belonging to the Resource, Labor and Scale intensive categories. In this case we may expect that Resource and Scale firms are more likely to be related with competition because they have to improve their process in order to reduce cost, depend less of scale or reduce their demand of resources to stay competitive. Labor-intensive firms are less capable of reacting to competition, so one may expect to find little or no relationship with competition in this case.

case of product innovation and 25.03% in the case of process innovation. Now, if we separate this effect for neck and no-neck firms, we find that this movement generally implies an equal decrease in the probability to innovate around 22%.

Table 7 Tech-NoTech 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. Use.	0.0838***	0.0702***	0.0701**	0.0637**
	(0.0241)	(0.0174)	(0.0260)	(0.0210)
More than 80% of Cap. Use	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 %

For technology sector estimations results seems to be very similar to the neck and no neck estimations. There also exists a negative and persistent effect of competition over innovation. Doing the above exercise, moving from an uncompetitive sector to a competitive sector implies an average decrease in probability to innovate for about a 21.49% in the case of low-tech sectors and 14.80% in the case of high-tech sectors.

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. Use.	-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. Use.	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 %

At last, for the Pavitt taxonomy estimations, results show that there also exists a negative and persistent effect of competition over innovation for Resource and Scale intensive industries. Meanwhile, for Labor intensive industries, the results also show a negative relationship but only for process innovation. As to the same exercise above, moving from a noncompetitive industry to a very competitive leads to an average decrease in the probability of innovation for about 19.7 % in the case of Resource intensive industries, 15.8% in the case of Scale intensive industries, and 30.3 % for the case of Labor intensive industries.[23]

Table 9 Neck-and-Neckness Results

	Product Innovation		Process Innovation	
	No-Neck	Neck	No-Neck	Neck
|Boone Index|	-0.461**	-0.418***	-0.525***	-0.556***
	(0.148)	(0.126)	(0.128)	(0.137)
Log(L)	0.0121	0.0242*	0.0273*	0.0316*
	(0.0133)	(0.0113)	(0.0137)	(0.0134)
Log(Age)	0.00707	0.0306***	-0.00516	0.0116
	(0.00820)	(0.00900)	(0.00659)	(0.00988)
Exporter	0.0732**	0.0442*	0.0302	0.0442**
	(0.0235)	(0.0184)	(0.0211)	(0.0157)
State-Owned	-0.195**	-0.0624	-0.182**	-0.0751*
	(0.0672)	(0.0420)	(0.0611)	(0.0367)
Foreign	-0.0649*	-0.0187	-0.0861***	-0.0371
	(0.0299)	(0.0227)	(0.0256)	(0.0206)
White-Collar over L	-0.279	-0.173	-0.221	-0.115
	(0.184)	(0.165)	(0.187)	(0.205)
Between 50-80% of Cap. Use.	0.0941***	0.0548**	0.0860***	0.0414*
	(0.0208)	(0.0176)	(0.0226)	(0.0173)
More than 80% of Cap. Use.	0.0648***	0.0429*	0.0717***	0.0297
	(0.0174)	(0.0195)	(0.0178)	(0.0163)
Employees/Manager Owner	-0.0644	0.00796	-0.0794	0.0127
	(0.0503)	(0.0306)	(0.0487)	(0.0294)
Observations	7800	8499	7789	8328
Industry-Year FE	YES	YES	YES	YES
Cragg-Donald	184.5	205.0	184.5	205.0
First Stage F-Statistic	13.50	197.2	13.50	197.2

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

[23] Labor intensive industry results must be taken with caution because it may be driven by a bad behavior of the instrument for this subsample. Cragg-Donald statistics are below the 10% bias Stock and Yogo critic value, and there is not any significance of the instrument on the first-stage.

Finally, there seems to be no remarkable changes in the relationship between covariates and innovation probability and it seems that instruments are working well, with nearly all having F-statistics over 10 and Cragg-Donald statistics over 10% bias Stock and Yogo critic values.

5. – Conclusions

Using the Climate Investment Survey from the World Bank, we found a negative and persistent relationship between competition and innovation. These results are quite different from the majority of the literature where most findings are a positive or non-linear effect. But, unlike others, we focus on developing countries, use an innovation measure in the broader sense of the word, and use the Boone index competition measure. Thus we prove it to be monotonically related with real competition inside an industry and have better properties than other measures typically used.

Moreover, using the same methodology of Aghion *et al.* (2005), we indeed found a nonlinear relationship but this a negative relationship with slightly non-linearity than an inverted U. This is probably because of the characteristics of our dataset; developing countries are characterized by low levels of appropriability and institutions and thus the higher the competition, the lower the incentives to innovate. Moreover, and related to Rodrik’s (2005) self-discovery discussion, our results are coherent with the theory that predicts a negative relationship between competition and innovation. Higher competition reduces private incentives to invest and discover cost reductions in new activities and therefore creates lower levels of innovation.

There seems to be no relevant heterogeneity in firms’ responds to competition at the industry classification level. A few particularly interesting results are that low-tech industries tend to be more sensitive to competition than high-tech industries, while neck firms do not present any differences with no-neck firms. Moreover, competition does not have any effect in labor-intensive industries

Finally besides preview results, competition in developing countries varies more at cross-country levels than at industry levels and, we try to deal with endogeneity problems providing evidence of a exogenous and good instrument.

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Appendix

Table A1 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, Duhamel and Ershov (2012)

Table A2 First Stage Innovation Probabilities

	(1)	(2)	(3)
RcExpi	0.0724**	0.0731**	0.0732**
	(0.0259)	(0.0259)	(0.0259)
Log(L)	-0.0270**	-0.0256**	-0.0255**
	(0.0115)	(0.0117)	(0.0117)
Log(Age)	0.0104	0.0128	0.0124
	(0.00931)	(0.00934)	(0.00936)
Exporter	0.0418*	0.0365	0.0361
	(0.0228)	(0.0222)	(0.0223)
State-Owned	-0.206***	-0.211***	-0.215***
	(0.0499)	(0.0500)	(0.0501)
Foreign (d)	-0.0407*	-0.0430*	-0.0446*
	(0.0237)	(0.0240)	(0.0244)
White-Collar over L	-0.639***	-0.628***	-0.634***
	(0.178)	(0.176)	(0.175)
Between 50-80% of Cap. Use.		0.0703***	0.0706***
		(0.0179)	(0.0179)
More than 80% of Cap. Use.		0.0288*	0.0289*
		(0.0157)	(0.0157)
Employees/Manager Owner			-0.0635
			(0.0399)
Observations	17,539	16,829	16,829
Industry-Year FE	YES	YES	YES

IVProbit first stages results reported. Country-Industry-Year Clustered standard errors in parentheses.

* significant at 10 %; ** significant at 5 %; *** significant at 1 %

Table A3 First Stages Industries Classifications

	PAVITT			TECH		NECK	
	Labor	Resource	Scale	Low-Tech	High-Tech	No-Neck	Neck
RcExpi	0.0286	0.0794*	0.0659***	0.0727	0.000759***	0.0734**	0.0754**
	(0.166)	(0.0382)	(0.0157)	(0.0394)	(0.000179)	(0.0269)	(0.0273)
Log(L)	-0.0201	-0.00146	-0.0414*	-0.00807	-0.0497**	-0.0284*	-0.0253*
	(0.0282)	(0.00953)	(0.0193)	(0.0148)	(0.0168)	(0.0134)	(0.0118)
Log(Age)	-0.0119	-0.0135	0.0492**	-0.0144	0.0492***	-0.000832	0.0270*
	(0.0169)	(0.0130)	(0.0159)	(0.0114)	(0.0129)	(0.00845)	(0.0120)
Exporter	0.0264	0.00881	0.0550	0.0190	0.0481	0.0256	0.0244
	(0.0324)	(0.0264)	(0.0415)	(0.0226)	(0.0347)	(0.0228)	(0.0214)
State-Owned	-0.345***	-0.0262	-0.250**	-0.222**	-0.195**	-0.269***	-0.157***
	(0.0904)	(0.0394)	(0.0814)	(0.0663)	(0.0586)	(0.0702)	(0.0377)
Foreign (d)	-0.246***	-0.0113	0.0579*	-0.107**	0.0199	-0.0800**	-0.0289
	(0.0697)	(0.0327)	(0.0264)	(0.0407)	(0.0238)	(0.0260)	(0.0250)
White-Collar over L	-1.190*	-0.272	-0.491*	-0.799**	-0.442*	-0.522**	-0.674***
	(0.453)	(0.238)	(0.237)	(0.277)	(0.186)	(0.200)	(0.179)
Between 50-80% of Cap. Use.	0.102*	0.0531*	0.0478	0.0840**	0.0513*	0.0955***	0.0433***
	(0.0463)	(0.0213)	(0.0260)	(0.0262)	(0.0216)	(0.0226)	(0.0130)
More than 80% of Cap. Use.	0.0605	0.0210	0.00646	0.0446*	0.00923	0.0578**	0.00316
	(0.0368)	(0.0213)	(0.0276)	(0.0210)	(0.0215)	(0.0180)	(0.0147)
Employees/Manager Owner	-0.208	-0.0289	-0.0274	-0.0905	-0.00581	-0.0855	-0.0370
	(0.125)	(0.0318)	(0.0389)	(0.0559)	(0.0401)	(0.0580)	(0.0262)
Observations	4493	5759	5647	9,404	7,425	7800	8499
Industry-Year FE	YES	YES	YES	YES	YES	YES	YES

IVProbit first stages results reported. Country-Industry-Year Clustered standard errors in parentheses

* significant at 10 %; ** significant at 5 %; *** significant at 1 %

Table A4 Aggregate Index with industry and country FE.

	(1)	(2)	(3)	(4)
	Agg. Index	Agg. Index	Agg. Index	Agg. Index
|Boone Index|	0.0210	-0.0362	-0.0933	-0.0943
	(0.326)	(0.347)	(0.335)	(0.335)
|Boone Index|^2	0.0363	0.0799**	0.0794**	0.0795**
	(0.0412)	(0.0391)	(0.0388)	(0.0388)
Log(L)		0.192***	0.193***	0.193***
		(0.0271)	(0.0266)	(0.0267)
Log^2(L)		-0.00643**	-0.00719**	-0.00720**
		(0.00299)	(0.00289)	(0.00290)
Log(Age)		0.0595*	0.0574*	0.0573*
		(0.0307)	(0.0298)	(0.0298)
Log(Age)^2		-0.0188**	-0.0177**	-0.0177**
		(0.00587)	(0.00572)	(0.00572)
Exporter		0.0519**	0.0501**	0.0499**
		(0.0180)	(0.0180)	(0.0180)
State-Owned		0.0236	0.0340	0.0314
		(0.0323)	(0.0323)	(0.0331)
Foreign		-0.106***	-0.103***	-0.104***
		(0.0265)	(0.0268)	(0.0268)
Percentage of White Collars		0.882***	0.874***	0.874***
		(0.142)	(0.142)	(0.142)
Between 50-80% of Cap. Use.			0.0907***	0.0907***
			(0.0239)	(0.0239)
More than 80% of Cap. Use.			0.107***	0.107***
			(0.0237)	(0.0237)
Employees/Manager Owner				-0.0241
				(0.0333)
Residuals	-0.200	-0.238	-0.183	-0.182
	(0.321)	(0.339)	(0.328)	(0.328)
Constant	-0.0154	-0.474**	-0.504**	-0.504**
	(0.167)	(0.192)	(0.191)	(0.191)
Observations	15942	14994	14765	14765
Industry-Year FE	YES	YES	YES	YES
Country-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 A5 Innovation Probabilities with industry and country FE.

	Product Innovation			Process Innovation		
	(1)	(2)	(3)	(1)	(2)	(3)
|Boone Index|	-0.161	0.0556	0.0558	-0.0974	0.103	0.103
	(0.184)	(0.120)	(0.120)	(0.221)	(0.156)	(0.156)
Log(L)	0.0626***	0.0652***	0.0651***	0.0708***	0.0736***	0.0738***
	(0.00485)	(0.00426)	(0.00426)	(0.00417)	(0.00365)	(0.00364)
Log(Age)	-0.0112**	-0.0123**	-0.0123**	-0.0164**	-0.0167**	-0.0167**
	(0.00532)	(0.00521)	(0.00521)	(0.00554)	(0.00537)	(0.00537)
Exporter	0.0486***	0.0505***	0.0506***	0.0260**	0.0239*	0.0236*
	(0.0109)	(0.0113)	(0.0113)	(0.0121)	(0.0126)	(0.0127)
State-Owned	-0.00625	-0.000911	-0.000162	-0.0127	-0.0146	-0.0172
	(0.0195)	(0.0194)	(0.0199)	(0.0186)	(0.0187)	(0.0190)
Foreign (d)	-0.0597***	-0.0533***	-0.0530***	-0.0595***	-0.0544**	-0.0551**
	(0.0152)	(0.0154)	(0.0154)	(0.0170)	(0.0183)	(0.0183)
White-Collar over L	0.444***	0.460***	0.460***	0.384***	0.404***	0.405***
	(0.0907)	(0.0884)	(0.0883)	(0.0888)	(0.0879)	(0.0880)
Between 50-80% of Cap. Use.		0.0442***	0.0442***		0.0410**	0.0410**
		(0.0114)	(0.0114)		(0.0154)	(0.0154)
More than 80% of Cap. Use.		0.0563***	0.0563***		0.0549***	0.0547***
		(0.0117)	(0.0117)		(0.0147)	(0.0147)
Employees/Manager Owner			0.00976			-0.0294*
Observations	15,006	14,473	14473	15247	14710	14710
Industry-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Cragg-Donald	437.3	461.9	461.9	437.3	461.9	461.9
First Stage F-Statistic	1,117.5	2,340.5	4.39066e+10	1,117.5	2,340.5	3.05622e+10

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