INNOVATIONS

Size, Concentration and Innovative Activities: A Developing World Perspective

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Abstract:

Issues: The impact of firm size and market concentrationon firm-level innovative activities have received considerable attention in developed countries, but still lacksfocus in developing world, despite theimportance of innovation for growth of developing world in today's knowledge intensive era. This scarcity leads to the lack of innovation policy guidelines by keeping in view two very important contributors towards innovation. **Methods:** The impacts of firm size and market concentration on firm's innovative activities are investigated by using Heckman selection two-step procedureand Probit model. The data used for this study was taken from the Enterprise Survey data of the World Bank administered on fourteen Latin American countries. **Findings:** Our analysis reveals that firm size increases the likelihood of R&D and product innovation, and influence R&D expenditure positively but at a less than proportionate rate. **Conclusions:** The size-innovation relationship in developing region of our study is almost same as the relationship of developed countries. The effect of market concentration has some interesting discrepancies. JEL Classification: L11; L12; L13; O3

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1. Introduction

Innovation is pervasive in every aspect of life, but its importance becomes more apparent when observed within the context of economic growth. It is considered an influential determinant of business growth (Castaño, Méndez, & Galindo, 2016) and economic development (Bernier & Plouffe, 2019; Cinnirella & Streb, 2017), which in turn beneficial to society (Ahsltrom, 2010). Innovative activities have been widely studied at the firm level, and a plethora of research is available investigating the factorswhich influence firms'innovativeness (Feng and Ma, 2020; Freitas et al., 2011; Werner, Schröde, & Chlosta, 2018). Two factors contributing to innovative activities are firm size and market concentration. Whether Schumpeter's view regarding these two characteristics could be corroborated or not is still contentious. This view can be explained as: (1) innovation and firm size are positively associated (and more strictly innovative activities increase more than proportionately with firm size); (2) innovation thrives in monopolistic markets.

The notion of innovation can be divided into inputs to the innovation process and innovation outputs. If we consider stricter version of the Schumpeter's hypothesis on firm size, the literature commonly championed a less than proportionate increase (Santarelli and Sterlacchini, 1990; Lee and Sung, 2005). For innovation output, nevertheless, we can also find a negative(Stock et al., 2002) and insignificant (Pla-Barber and Alegre, 2007) firm size effect. Regarding market concentration, the most-established phenomenon – for both input and output innovation – is the inverted-U relationship (Aghion et al., 2005; Peneder and Wörter, 2014), implying that neither monopoly nor perfect competition is conducive to innovative activities, but the suitable market structure is the moderately concentratedmarket.

One common feature of the outcomes stated above is their provenance from the studies on developed countries. So far, a limited amount of research has been carried out with particular reference to developing countries. This paper is an attempt to step forward to this direction. We compare the findings of studies of developing countries – particularly of Latin America – with those that are well-established from research on developed countries. The motivation is to observe whether any differences at the input and output stages of innovative activities exist, both within our dataset and for our data compared with developed countries' outcomes.

Developing countries tend to have a less formalized R&D structure, a less knowledgeable workforce, and greater bureaucratic hurdles. These shortcomings inhibit optimal results of firms' R&D activities in these countries. We try to capture this phenomenon empirically by investigating the role of R&D as a determinant of product innovation. To our knowledge, size-innovation and concentration-innovation studies have hardly been done for such a large number of countries. Our analysis includes 14 countries, which also gives us the opportunity to inquire whether country-specific factors contribute to input and output innovative activities.

Regarding concentration, we refute the Schumpeter hypothesis (and also find no indication of an inverted-U relationship), because our analysis reveals that increase in number of competitors increases the likelihood of both positive R&D decisions and product innovation, and we find no relationship between number of competitors and R&D intensity.

2. Firm Size and Concentration as Determinants of Innovative Activities

2.1. Firm Size and Innovative Activities

The advantage of economies of scale in R&D activities is perhaps the most striking argument in favor of large-sized firms. Large research departments can provide an environment to engage with more colleagues, facilitate division of labor according to expertise and, consequently, improve the individual's productive performance. Large-sized firms are more able to diversify their R&D activities to increase the probability of beneficial results. In large firms, R&D activities may be more productive due to the complementarities with non-manufacturing processes.

Contrary arguments can also be found in the literature. Bureaucratic hurdles created by the innovation-hostile culture of the red tape are considered one of the drawbacks of large-sized firms. In large firms, the rewards of innovative activities are less likely to reach the individuals responsible for these activities.Hence, the motivation of these individuals may be lower in large firms than in small ones. The large, established firms are arrested in growth trap and not usually willing to take innovation-related risk.

On empirical grounds, there seems to be consent that firm size and innovative activities have a positive association (Laforet, 2008). The studies rely on both input and output measures of innovation. Looking at innovation input,Choi and Lee (2018) analyzed Korean manufacturing firms and found a positive and significant relationship between firm size and R&D expenditure.Fritsch and Meschede's (2001) analysis on German manufacturing firms concluded a positive and significant relationship between firm size and R&D expenditure. More specifically, they concluded a less than proportional firm size effect on total R&D expenditure, product R&D expenditure and process R&D expenditure. The general conclusion of Lee & Sung (2005) is that the size-R&D relationship is conditioned on technology-driven industrial orientation: the effect of firm size on R&D expenditure is more than proportional for high-tech industries, and this more than proportional relationship disappears for low-tech industries and produce a less than proportional relationship.
Looking at developing countries, Kumar and Saqib (1996) concluded that the likelihood of R&D activities has an inverted-U relationship with firm size; however, R&D intensity and firm size have a linear, positive relationship. In the Latin American context, (Morris, 2018)showed that firms' size

increases the odds of R&D activities, but that the effect is rather small, although significant. For Chile, Benavente (2006) concluded that firm size is a significant and positive determinant of the probability to engage in R&D activities; he did not find any link between firm size and the amount of R&D expenditure relative to employees.

Focusing on output measures, Santarelli and Sterlacchini (1990) concluded that innovation activities increase with firm size, albeit less than proportionally. After analyzing 125 large firms in Europe and the USA, Chesbrough and Brunswicker (2014) concluded that these firms largely embrace the notion of open innovation. According to Hewitt-Dundas (2006),the most important barrier for innovation in small plants is the lack of external partners, while for large plants it is related to internal expertise and risk of development. One of the conclusions of the study of Chandy and Tellis (2000) is that large, incumbent firms are the main source of radical innovation, especially after World War II. Some studies found innovation output is negatively related to firm size (e.g., Stock et al., 2002), and it is also argued that R&D productivity decreases with firm size (Acs and Audretsch, 1991). Looking at developing economies, the literature generally describes a positive relationship between firm size and innovation output (see, for example, de Mel et al., 2009, for Sri Lankan firms; Benavente, 2006, for Latin American context, particularly Chilean firms).

2.2. Concentration and Innovative Activities

There is an ongoing debate whether innovation thrives in monopolies or not, and we can find both favorable and unfavorable accounts. A firm realizing extraordinary profits by exploiting a monopoly is in a better position to finance research internally to protect itself against the disclosure of its technological secrets, thereby hire more R&D personnel and strengthen its R&D department. It has also been argued that the introduction of a new product to the market, patents, and trademarks give firms an advantage over their rivals by creating a temporary monopoly. A monopolistic firm's reaction against innovation by a new entrant is nimble, and it endeavors to control the market again by improving its old product or by introducing new products. Although the industrial organization literature provides arguments in favor of increased market concentration, we can also find the opposite. If a monopolistic firm earns enough profits (especially through innovation), it may develop a sluggish attitude towards innovation, and may not be as eager to promote innovation as new entrants. This sluggishness decreases the chances of technological development especially if the monopolist firm is able to establish non-technological entry barriers (such as advertisement and capital, for example) to retain the status quo. If this situation persists the market will stagnate in a low technology equilibrium.

Similar to the size-innovation relationship, the impact of monopoly power on innovation has been studied empirically with the help of both input and output indicators. The relationship between concentration and innovation is not as simpler as perceived usually. Vives(2008) argued that we should be careful to establish the link between concentration and innovation empirically, since it depends on the varying definitions and proxies used to measure both concentration and innovation. He established the relationship which does not depend upon functional forms and quantitative indicators. Analyzing innovation input,Griffith, Harrison and Simpson (2010) found a positive relationship between increased product market competition (measured by decreased profitability) and innovation efforts (measured by R&D expenditure and intensity), for manufacturing sector of the EU countries. Peroni and Gomes Ferreira (2012) analyzed the relationship between competition intensity (measured by Boone index) and R&D expenditure of Luxembourgish firms. The results showed a significant, positive relationship, conditioned on the firm's position at technological efficient frontier, however. Subodh (2002) concluded that market concentration has no influence on the decision to perform R&D and on R&D intensity in the pharmaceutical and electronics industries in India. Looking at output measures Acs and Audretsch (1988) used a more direct measure of innovative activity obtained from the data gathered by the U.S. Small Business Administration, and concluded that the number of innovations in 1982 decreased with the four-firm concentration ratio. However, Tang (2006) found a positive relationship between competition and innovation. Similar to the findings of studies focusing on innovative inputs, an inverted-U relationship is found to be the general pattern between market concentration and innovative outputs (Aghion et al., 2005 for example).

3. Data Description and Summary Statistics

The dataset used in this paper is obtained from the Enterprise Survey (ES), which is an outcome of the World Bank's efforts to understand business environment of the country.[1]The survey is conducted using the stratified random sampling based on three criteria: size, geographical location of the firm, and industrial sector (primarily classified on two-digits. This richness of the survey allows researchers to investigate the innovation characteristics of the firm in a broader context.

Table 1: Percentages of product innovators and R&D performers, and average annual R&D expenditure (in $1000), for different size classifications and concentration environments

Innovation activities	Firm size		Concentration environments			
	Small firms	Large firms	Monopoly	Duopoly	Medium concentration	Low concentration
Product innovation (%)	0.98	30.39	49.65	3.41	65.41	23
R&D performers (%)	2.55	66.20	27.56	3.11	38.81	97
Av. R&D Exp.(in $1000)	5.02	39.31	74.7	3.97	67.92	.66

In this paper we focus on manufacturing companies of fourteen Latin American countries (see appendix A.1 for country detail) over eight two-digit (ISIC Rev. 3.1) industrial sectors[2]. The survey data needed to be cleaned for missing observations, outliers, and non-responses, after which we are left with the data of 6917 firms. The largest fraction is Mexican firms (16.78%), while Panama contributes the smallest share with a representation of only 0.03%. All pecuniary information in the survey is gathered in local currency. To achieve homogeneity, we convert these into USD using the corresponding annual average exchange rates.

Table 1 shows the summary statistics of product innovation and R&D activities by firm size and product market concentration. It should be emphasized that, due to the unavailability of information, we do not use traditional measures such as concentration ratio and Lerner index to measure market concentration, but follow Tang (2006) and use firms' perception of market structure. We consider firms with more than 200 employees as large firms.Table 1 reveals that large firms are more often product innovators than small firms. In terms of annual average R&D expenditure (for R&D performers only), large firms on average spend $439,310, which is significantly higher than the expenditure of small-sized establishments with an average of$35,020. This large difference between large and small firms illustrates the fact that large firms spend relatively large amounts on R&D activities. Large firms are also 19.55% more likely to be product innovators than small ones, and the difference is 34.24% for R&D performance. Firms facing between 2 and 5 competitors present the biggest share of product innovators, followed by firms facing more than 5 competitors. Medium concentration environments produce the highest proportion of R&D performers, followed by low concentration environments, while monopolies produce the lowest share of R&D activists.

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[1] More detailed information on the Enterprise Survey can be found at http:// www.enterprisesurveys.org.

[2] Those industrial sectors are: Food, Chemicals, Garments, Non-Metallic Minerals, Machinery and Equipment, Textiles, Electronics and Other Manufacturing.

4. Regression Analysis

Table 2 provides the detailed information (labels and descriptions) of the variables used in our regression analysis. To capture the heterogeneity attributable to the country-specific and industry-specific differences, we include their respective intercepts in our regression models. The reference categories are Mexico and "other manufacturing" for countries and industries respectively. The introduction of dummies allows us to probe inter-country and inter-industry differences of R&D activities and product innovation. Our regression equations also include dummies for market concentration levels taking low concentration as the reference category. Several control variables are also included in the analysis. The control variables used are export intensity, import intensity, foreign ownership (i.e., foreign owners owning more than 10% of the company's shares), the age of the firm, the share of unionized and skilled workers of the workforce, and the average education level of production workers.

Only 35.61% of all firms in our sample are R&D performers, implying that the R&D intensity variable is zero for the majority of firms in the sample, and we have continuous data for only 35.61% of firms. This means that the OLS regression of R&D intensity would provide misleading conclusions because it only takes firms with a positive amount of R&D expenditure into account, and ignores the majority of firms as incomplete samples. Subsequently it is unrealistic to extend the empirical finding of a selected portion of a sample to the whole population (selectivity bias). Hence, we use the Heckman selection two-step procedure to avoid the erroneous conclusions attributable to a sample selection bias.

Table 2: Variables and their description

Variable	Description
LEMP	Logarithm of number of full- time employees. It includes both permanent and temporary employment.
LRDI	Log of Ratio of R&D expenditures to employment.
EXP	Ratio of export sales to total annual sales.
IMP	Ratio of imports in total annual purchase of material inputs and/or supplies.
AGE	Age of the firm in years
UNION	Ratio of unionized workforce to total workforce.
SKILL	Ratio of skilled production workers to total production workers
MONO	Dummy if a firm faces no competitor in the main market in which it sold its main product.
DUOP	Dummy if a firm faces one competitor in the main market in which it sold its main product.
MEDCON	Dummy if a firm faces between 2 to 5, inclusive, competitors in the main market in which it sold its main product.
LOWCON	Dummy if a firm faces more than 5 competitors in the main market in which it sold its main product.
FOR	Dummy if the ownership of private foreign individuals and/or companies is more than 10%.
ASSET	Dummy if a firm purchases fixed assets (machinery, vehicles, equipment, land, or buildings).
EDU	Dummy if the average education of a typical production worker is 13 years and above.
LARGE	Dummy if a firm has more than 200 employees.
MODU	Dummy if product market is monopoly or duopoly.
PDINN	Dummy if a firm introduces into the market any new or significantly improved product.
RD	Dummy if a firm spends on R&D activities.

4.1. The Heckman Selection Model

The Heckman selection model rectifies the selectivity bias by introducing two equations, which are commonly known as the selection equation and the outcome equation. Firstly, the selection equation estimates the relationship of a firm's R&D choice and its determinants by probit regression. In the second step, the outcome equation describes the influences of the explanatory variables on R&D intensity, after incorporating the selectivity problem.
More specifically, suppose RD_i^* is the unobserved utility difference between the i^{th} firm's R&D and non-R&D, and x_{1i} is a vector of determinants influencing the i^{th} firm's R&D decision, then:

$$RD_i^* = x_{1i}'\beta_1 + \varepsilon_{1i} \quad (1)$$

All we know (i.e. 0 & 1 for R&D decision variable) follows the decision rule:

$$\begin{aligned} RD_i &= 1 \qquad if \quad RD_i^* > 0 \\ RD_i &= 0 \qquad if \quad RD_i^* \leq 0 \end{aligned} \quad (2)$$

where RD_i is (a dummy of) the R&D decision for the i^{th} firm. Moreover,

$$RDI_i^* = x_{2i}'\beta_2 + \varepsilon_{2i} \quad (3)$$

where RDI_i^* is the observed value of R&D intensity for the i^{th} firm, which is a positive amount if the i^{th} firm is a R&D performer, and zero otherwise, i.e.

$$\begin{aligned} RDI_i &= RDI_i^* \qquad && if \quad RD_i = 1 \\ RDI_i &= 0 (assumed) \qquad && if \quad RD_i = 0 \end{aligned} \quad (4)$$

where x_{2i} is a vector of all determinants that influence the i^{th} firm's R&D intensity. Note that equations 1 and 3 also include random error terms, which jointly follow the distributional assumptions (where $\text{var}(\varepsilon_{2i}) = \sigma_2^2$, $\text{cov}(\varepsilon_{1i}, \varepsilon_{2i}) = \sigma_{12}$):

$$\begin{pmatrix} \varepsilon_{1i} \\ \varepsilon_{2i} \end{pmatrix} \overset{NID}{\sim} \left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix} \right)$$

The Heckman selection model corrects the selectivity bias and estimates the conditional expectation of R&D intensity as:

$$E(RDI_i / RD_i = 1) = x_{2i}'\beta_2 + \sigma_{12}\lambda(x_{2i}'\beta_2) \quad (5)$$

Where λ, the inverse mills ratio, is obtained as $\phi(x_{2i}'\beta_2)/\Phi(x_{2i}'\ \beta_2)$, $\phi(.)$ and $\Phi(.)$ are the density function and the cumulative distribution function of a standard normal distribution respectively.

Recall that we consider both innovation input and output. Innovation output is presented as a binary response variable which calls for the probit model.

4.2. The Probit Model

Since the only observable information for product innovation is whether the firm innovates or not, we define the i^{th} firm's unobserved utility difference of carrying out product innovation and of not carrying out it as:

$$PDINN_i^* = x_i'\beta + \varepsilon_i \,,\ \varepsilon_i \sim NID(0,1) \quad (6)$$

where x_i is a vector of all predictors which can explain this utility difference. A firm carries out product innovation, if its utility difference exceeds a certain threshold, and we assume this threshold level is zero. Hence, the probit model can be written as:

$$PDINN_i = 1(\text{firm is a product innovator}) \qquad \text{if} \quad PDINN_i^* > 0$$
$$PDINN_i = 0(\text{firm is not a product innovator}) \qquad \text{if} \quad PDINN_i^* \leq 0 \quad (7)$$

4.3 Empirical Results

The results of the Heckman selection two-step procedure using LRDI as a dependent variable are depicted in Table 3.

Table 3: Results of the Heckman selection model. Standard errors are in parentheses

Independent Variables/Tests	pendent Variables	
	LRDI (outcome equation)	RD (selection equation)
Intercept	7.462*(0.647)	*(0.119)
LEMP	-0.364*(0.066)	(0.020)
MONO	0.102 (0.199)	(0.099)
DUOP	0.157 (0.201)	†(0.103)
MEDCON	-0.011 (0.079)	0.044)
EXP	0.461†(0.279)	(0.151)
IMP	0.279#(0.128)	(0.066)
AGE	0.004†(0.002)	0.001)
UNION	-0.114(0.156)	0.085)
SKILL	-0.060(0.112)	0.060)
FOR	0.307#0.124)	0.080)
EDU	0.169†(0.098)	(0.052)
ASSET	-	(0.044)
Country Dummies	yes	es
Industry Dummies	yes	es
Test-stat. to test		
Significance of countries	156.90*	106.76*
Significance of industries	30.51*	116.52*
No. of obs.	5102	
censored obs.	3510	
λ	-0.619#(0.265)	
* Significance at 1% level # Significance at 5% level † Significance at 10% level		

The variable selection for the vectors x_{1i} and x_{2i} is a critical aspect of application of the Heckman selection model. One of the important assumptions of the Heckman selection model is that the

vector x_{2i} (the outcome equation) should exclude at least one variable of the vector x_{1i}(the selection equation).[3] Our likely explanation to exclude ASSET from the outcome equation is that this variable shows the improvement of a firm's infrastructure (machinery, equipment, etc.), which is one of the basic necessities before a firm decides on R&D activities. Secondly, R&D in developing countries is not a firm's first priority, but often left until it perceives that it has sufficient infrastructure to start a R&D project successfully to ascertain optimal results. Hence, we anticipate a positive influence of ASSET on positive R&D decisions, but it seems less likely to influence the R&D budget allocation.
In addition to control for selectivity problem, the Heckman selection model provides the framework to analyze the determinants of the R&D decision (column 2 of Table 3) and the influence of these determinants on the subsequent R&D expenditure (column 1 of Table 3). The significance of λ provides empirical support to use of the Heckman selection model. Our results are in line with the well-established notion of R&D in developed countries: size has a significant, positive impact on firms' decision to perform R&D, and increases R&D expenditure but at a less than proportional rate[4]. We find that firms' R&D expenditure per employee are not influenced by any form of market concentration (all concentration-related dummies are insignificant). However, our results give the impression that competitive pressure has an influence on the firms' R&D decision (although the negative coefficient of DUOP is significant only at the 10% level, the coefficient of MONO, albeit insignificant, also has a negative sign). Hence, although we have the concentration-related variables in discrete forms, our results hint the absence of an inverted-U relationship between R&D and concentration, a well-established phenomenon in the developed world. Trade orientation (both exports and imports) increases both the likelihood of positive R&D decisions and the intensity of R&D expenditure, with the former being more important. Firm age has no influence on R&D decisions but has a significant, positive effect on R&D intensity, though significance is only achieved at the 10% level. Our results reveal that shares of unionized workers and skilled production workers have no influence on R&D-related variables. At first glance this could contend that skill has a positive influence on R&D activities, but the intuition on the insignificance of the coefficient is that in our dataset skill denotes production workers' professional skill level, which is quite different from the scientific and technological knowledge of workers. Of course, the advantage of professional skills is the ability to implement production processes efficiently, but it does not imply that the workforce is also sufficiently equipped with the technological expertise necessary for innovativeness. We observe that foreign ownership has no influence on firms' R&D decisions but increases R&D intensity, and that education increases the probability of and the expenditure on R&D activities; similar to trade orientation education is more vital for R&D decisions. Finally, firms that purchased fixed assets have a significantly higher likelihood to perform R&D. The Wald tests of the overall significance of the country and industry dummies show that country- and industry-specific characteristics are significant determinants to explain both types of R&D activities (R&D decisions and expenditure).

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[3] In the literature, this is often called the exclusion restriction. This crucial restriction is also used to avoid the collinearity between the mills ratio and other explanatory variables used in the outcome equation (Wooldridge, 2009).

[4] Note that the coefficient of employment in Table 3 is negative, but it does not mean thatthe relationship between employment and R&D expenditure is negative since the dependent variable is R&D expenditure to employment. More precisely, suppose an R&D expenditure model for the i^{th} firm is $r_i=a_1+a_2emp_i+a_3z_i+\varepsilon_i$, where r_i and emp_i, in logarithm form, are the firm's R&D expenditure and number of employees, and z_i is a vector of other explanatory variables with a_3 is a coefficient vector. We can then measure the proportionate change of R&D expenditure with respect to empployment as the departure of coefficient $a_2$from unity. We can rewrite the model as $r_i-emp_i=a_1+(a_2-1)emp_i+cz_i+\varepsilon_i$. The coefficient of emp_i, i.e., a_2-1, now measures the proportionate change by its departure from zero

Table 4: Results of the Probit regression. Standard errors (robust for column 1 and bootstrapped for column 2) are in parentheses

Independent Variables/Tests	Dependent Variable: PDINN	
Intercept	-.386*(0.108)	-0.271(1.549)
LRDI		-0.143(0.209)
LEMP	0.234*(0.019)	0.180#(0.072)
EXP	0.390# (0.175)	0.460#(0.185)
IMP	0.391*(0.063)	0.431*(0.081)
MONO	-0.150†(0.087)	-0.137(0.088)
DUOP	-0.315*(0.090)	-0.290*(0.087)
MEDCON	0.045(0.041)	0.043(0.042)
AGE	-0.001(0.001)	
UNION	0.363*(0.080)	0.347*(0.083)
SKILL	0.063(0.056)	
FOR	-0.016(0.082)	
EDU	0.143*(0.051)	0.173*(0.060)
Country Dummies	yes	yes
Industry Dummies	yes	yes
Test-stat. to test		
Significance of countries	238.01*	244.39*
Significance of industries	33.67*	15.62#
No. of obs.	5420	5420
McFadden R^2	0.127	0.127

* Significance at 1% level # Significance at 5% level †Significance at 10% level
Note: For LRDI, the predicted values obtained in Table (3) are used.

Table 4 shows the results of the probit regression of product innovation. We run two probit regressions: excluding and including LRDI as a determinant of PDINN, and the results are shown in column 1 and 2 respectively. The objective of including R&D intensity as an explanatory factor is to observe the effect of R&D on firms' innovation output. To control for endogenous nature of R&D intensity in the PDINN equation, we use the instrumental variablefor LRDI. To serve as an instrument, we use the predicted values of LRDI obtained from the Heckman selection model in Table3. Since we use predicted values as explanatory variables, we correct our standard errors by bootstrapping (100 replications). Note that column 1 of Table 4 (PDINN equation without R&D intensity) is simply a reduced form equation for PDINN. Note that most of the results in column 1 and 2 are same. Firm size and low market concentration increase the likelihood of product innovation. The comparison of the relationship between concentration and innovation output with the relationship between concentration and R&D intensity in Table 3 reveals that firms rely more on product innovation than the R&D expenditure, to succeed over product market competitors. The reason might be that the firms' perception of their competitors' control of the market requires a prompt response such as product innovation, which can be carried out with less R&D-intensive activities like the slight modification of an existing product or the imitation of an innovation available in developed countries.

Our results reveal that R&D intensity does not influence product innovation. Similar to R&D, trade orientation (both exports and imports) increases the probability of innovation output. These findings are in line with the general concept that trade orientation induces firms to innovate. We show that firm age has no influence on the likelihood of product innovation. This means that while firms' maturity has a positive impact on their R&D intensity, it might be offset by higher innovative efforts (in the innovation output phase) of the younger firms which have to perform to withstand being drivenout of the market by their mature rivals. Foreign ownership and workers' skill levels also have no effect on the likelihood of product innovation.

As expected, education is a significant, positive determinant of firms' chances of product innovation. Our results show that the probability of product innovation increases with the share of unionized workers. Similar to R&D activities, the country and industry dummies have a significant impact on product innovation, implying that inter-country and inter-industry differences play important roles in firms' attitude to and aptitude for product innovation.

Conclusions

The firm size-innovation and the market concentration-innovation relationships have been studied intensively in developed countries, but the research body evaluating the developing world is still scarce. This paper contributes to this research field by analyzing both innovation input and output.

According to our analysis, the impact of firm size on innovation is similar to developed countries. We find that employment has a significant, positive impact on the likelihood of R&D and product innovation, and employment increases R&D expenditure at a less than proportional rate. We observe that low concentrated market is a positive stimulus for product innovation, but has no influence on R&D expenditure per employee. The reason for these findings could be that the pressure from the competitors in the product market triggers an immediate response in terms of final products. Since R&D is a longterm process, firms may prefer to fight competitive pressures through slight modification of existing products and/or the imitation of developed countries' innovations, which may be achieved quicker and without costly R&D expenditure. Country-specific and industry-specific characteristics are observed to be significant factors for both innovation input and output.

We fail to find a significant relationship between R&D intensity (R&D expenditure per employee) and the likelihood of product innovation. Our two interpretations of this finding are that firms, especially in developing countries, may not have a formal R&D structure and underestimate their actual expenditure, which in turn leads to an underestimation of the significance of their R&D expenditure. Secondly, developing countries are more prone to imitate (of developed countries products) than to engage in radical product innovation, which entails lower R&D expenditure.

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Appendix

Table A.1. List of Countries

Countries
Argentina
Bolivia
Chile
Colombia
Ecuador
El Salvador
Guatemala
Honduras
Mexico
Nicaragua
Panama
Paraguay
Peru
Uruguay