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How Does Market Competition Affect Firm Innovation Incentives in Emerging Countries?

Evidence from Chile and Colombia

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Abstract[*]

The effect of market competition on firm innovation remains controversial, especially in the context of developing countries. This paper presents new empirical evidence about the causal impact of competition on firm innovation for Chilean and Colombian manufacturing firms. Using instrumental-variable estimation, our results show that market competition increases firm propensity to invest in innovation, but this relationship manifests differently in the two countries. While this relationship is linear in Chilean firms, an inversed-U shaped relation prevails in Colombian firms. In both countries, however, innovation incentives are mostly concentrated in the medium range of the firm productivity distribution. These findings are robust to including past innovation engagement, import competition, and business dynamics. In addition, first- stage estimations show that competition law interventions improved market competition in sanctioned sectors while business entry reforms significantly leveraged competition across industries. These findings stress the importance of pro-competition regulations and competition policy, not only to benefit consumers' welfare but also to support firm innovation.

JEL Codes: O32, D41, O47, D24

Keywords: competition, innovation, productivity, Chilean firms, Colombian firms

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Introduction

Competition is a major engine of productivity growth, and intense empirical research recurrently corroborates this impact. Several mechanisms are at play. First, competition acts as a disciplining device within firms, placing pressure on managers to become more efficient and decreasing 'x-inefficiency' ("within" effect). Second, competition raises average productivity in industries as less productive firms exit markets ("selection") while new firms enter pressing incumbent firms to improve ("between" effect). Thus, competition drives economic efficiency through renewal of industries and firms. Third, competition fosters innovation through technological improvements of production processes and new products and services, which brings welfare improvements in the long run (dynamic effects).

Although competition is widely recognized as a major determinant of firm productivity, how this happens, and the ways competition affect firms' innovation incentives are still subjects of debate. This paper analyzes the impact of market competition on firm innovation decision in two Latin American countries. Following the studies of Scherer (1965; 1967), Aghion et al. (2005) postulated a nonlinear relationship where stronger competition would encourage firm innovation up to a certain level but will discourage such efforts after reaching a threshold point depending on the initial state of competition, the level of technological symmetry among firms, and the distance from the technological frontier (see Acemoglu et al., 2006; Aghion et al., 2009). Accordingly, market competition would enhance incentives to be more productive in firms that are closer to the frontier and in symmetrical sectors where incentives "to escape competition" will dominate over Schumpeterian motivations associated with market power (e.g., Arrow, 1962; Scherer, 1967).

For firms (and industries) in developing countries, the impact of market competition and what types of forces will dominate and for which firms are still unclear empirically. It has been argued that the negative effects from competition could be larger if other policy failures for business innovation prevailed, such as the severity of financial constraints and lack of finance, which are known to be more accentuated in developing countries (Galle, 2020; Yang and Pan, 2018) and if other restrictions for resource allocation persist, such as barriers to entry or exit (e.g., Driffield et al., 2013).

This paper presents new evidence on the role of market competition in firm innovation decisions in the context of emerging countries. Using firm-level data from manufacturing firms from Chile and Colombia, we evaluate the causal impact of market competition on firms' innovation engagement using an instrumental variable approach. We use the analytical framework proposed by Aghion et al. (2005) and extend this approach in several dimensions. We first test whether competition enhances firms' incentives to innovate ("competition-escaping" incentives) and evaluate whether this response is constant across competition levels and firm types, or it is subject to nonlinearities. To establish a causal impact, we instrument market competition with a set of policy variables and measures of competitive pressures that should be associated with innovation but influence it indirectly through the competition channel. As measures of market competition, we use the profit elasticity index, or "Boone index" (Boone, 2008a; 2008b), which is a more reliable indicator than traditional measures of competition (Herfindahl and Profit-Margin indicators or Lerner indexes).

There are several reasons why we should look at these issues in Latin American firms. First, evidence on the links between innovation and market competition is scarce for these countries. Studies on the impact of trade liberalization on firm (and aggregate) productivity provide some insights and tends to indicate positive effects only on a range of firms (i.e., larger, more productive ones) and sectors (i.e., those that already faced import competition) (e.g., Amiti and Konings, 2007; Bustos, 2011; Iacovone et al., 2013). A better understanding of how competition impacts firms' innovation behavior is crucial given the persistent lack of productivity growth in the region (Blyde and Fentanes, 2019; OECD, 2021) and the strong evidence about a positive impact of innovation on firm productivity (e.g., Griffith et al., 2006; Crespi and Zuniga, 2012). In addition, international survey studies indicate that lack of competition and the prevalence of barriers to firm entry remain major impediments to competitiveness in the region. This is reflected, for instance, in the rankings of the Doing Business indicators and the country assessments of competition policy (e.g., the OECD Reviews of Competition for Mexico, Chile, and Costa Rica).

Our contribution to the literature is threefold. First, we provide novel evidence on the impact of market competition on firm innovation efforts in manufacturing industries from two emerging countries. We use a common analytical framework and methodology for the computation of market indicators, which allows us to compare results across countries. Second, by conducting a two-stage estimation, we investigate some of the structural and policy determinants of market competition. Our paper provides new evidence regarding the effectiveness of competition policy, such as sanctions issued to collusive behavior and abuse of market power, and pro-competition policy reforms (i.e., the 2013 business entry reform in Chile) for the promotion of competition. To our knowledge, this is the first time that such aspects are examined and linked to the understanding of business innovation investment in emerging countries. Third, we further extend the analysis on the role of distance to the frontier by looking at the differential impact of market competition across different levels of productivity performance. In doing so, we evaluate whether competition helps firms in the process of catching up (i.e., Bustos, 2011; Andrews, Nicoletti, and Timiolitis, 2018; Alvarez and Gonzalez, 2020).

1. Innovation and Competition: What We Know

The relationship between the intensity of competition and the rate of technical progress has been investigated in both the theoretical and the empirical economic literature (see Gomellini, 2013). The analysis of these questions relates to at least two strands of the literature; the new endogenous growth models (e.g., Romer, 1990; Aghion and Howitt, 1992) and the industrial organization literature (Reinganum, 1989). Traditional arguments date back to Schumpeter (1942; 1947) and Arrow (1962). According to the former, technological progress requires the presence of (some) market power (see also Romer, 1990; Aghion and Howitt, 1992) as ideas are costly to produce and knowledge is non-rival and can be appropriated by others. A negative linear relationship is predicted: by reducing monopoly profits that reward innovation, competition slows down innovation by leaders, and economic growth contracts.

In contrast to these perspectives, Arrow (1962) sustained that firms in monopolistic situations would only innovate to replace a rent ("replacement" effect) that they already have while firms under a regime of competition would gain the full return on innovation as they would not lose any monopoly profit. Thus, competition promotes innovation especially if it allows entry of more innovative and efficient firms (e.g., Aghion et al., 2005; 2009). Research by Aghion, Bloom, Howitt, and Griffith (2005) conciliated these two opposing views and acknowledged the existence of both scenarios depending on the initial level of competition, firms' (and industries') technological distance to the frontier and level of technological rivalry (or symmetry), which would make the competition-innovation relation non-monotonic. This shape arises due to the heterogeneity of different industry contexts distributed across the curve, which is endogenously defined. In this theoretical setting, innovation incentives for incumbents are driven by the difference between post-innovation and pre-innovation profits and their position to the technology frontier.

Accordingly, innovation incentives are stronger when technology rivalry is strong (disparity is low) because competition reduces firms' pre-innovation rents by more than it reduces post-innovation rents. In leveled industries or neck-and-neck sectors, increased product market competition, by making life more difficult for neck-and-neck firms, will encourage them to innovate in order to acquire a lead over their rivals in the sector and escape competition. In contrast, in asymmetrical sectors, increased competition will tend to discourage innovation by laggard firms as it decreases the short-run extra profit from catching up with the leader (Schumpeterian effect), driving down the average industry innovation effort.[1] The farther firms are from the technology frontier (and the larger their share in industries), the more negative effects would dominate

[1] For laggards, ex-post rents from innovation are eroded by new entrants, as in Schumpeter's appropriability argument, as these firms mostly have low profits. Therefore, competition mainly affects ex-post profits from innovating.

because ex-post rents are eroded by competition. These predictions were corroborated empirically in a panel of British industries and a follow up study (Aghion et al., 2009); and more recently, in an experimental study (Aghion et al., 2014). It should be noted, however, that economic theory does not offer an exact indication regarding the empirical threshold at which we should expect nonlinear effects.

The concept of distance to the technology frontier ("technology gap") is central to the analysis of the competition-innovation nexus. As confirmed in neo-Schumpeterian growth theories (Howitt and Mayer-Foulkes, 2002; Acemoglu, Aghion and Zilibotti, 2006) and new trade theories of the firm (e.g., Melitz, 2003), a greater heterogeneity in the technical efficiency of firms reduces the marginal positive impact of market competition on firms' innovation efforts. Firms (industries/countries) farther from the productivity frontier would find it difficult to invest in innovation (especially in R&D) given the costs of entry in technology as opposed to investing in factor accumulation (Acemoglu et al., 2006), that is, capital and labor, while the selection effects (entrepreneurs) may not be substantial. As countries approach the frontier, the marginal effects of investing in innovation increase and the selection process accelerates. The dominance of negative effects (e.g., Alvarez and Campusano, 2014; Elejalde et al., 2019) could also be driven by the severity of financial constraints and the lack of funding for innovation in these country contexts (i.e., Hall, 2002; Hall and Lerner, 2009), which may neutralize innovation incentives from competition. Yet recent research tends to reinforce the arguments about the predominance of "escape-competition" effects encouraging firm innovation (Ackdigit et al., 2018; Aghion et al., 2019). Accordingly, innovation incentives from competition can be more substantial in the context of global markets due to the additional effects raised by (expanded) market size and spillovers; and with contestability of markets, that is, free firm entry and exit (e.g., Federico, Scott, and Shapiro Gall, 2019).

1.1. The Empirical Evidence

Empirically, academic research tends to confirm a positive relationship between competition and innovation, contradicting the Schumpeterian argument.[2] The works of Kamien and Swartz (1982), Blundell et al. (1999), Griffith et al., (2010), and many others confirmed a positive linear relationship. For British companies, Blundell et al. (1999) find that companies that innovate the least are those highly concentrated with less competition. Griffith et al. (2010) showed that pro-competition reforms carried out under the European Union's Single Market Program (SMP) led to

[2] See also Shapiro (2012) and De Bondt and Vandekerckhove (2012) for a review of the literature.

an increase in R&D investment in industries.[3] These studies conceived the relationship between competition and innovation as linear.

Initial reflections on the potential nonlinearity of this relationship were provided empirically by Levin et al., (1985) with data from U.S. firms. Since the seminal paper of Aghion et al., (2005), many studies have evaluated whether this nonlinear relation prevails in different industry and country contexts, accounting for the endogeneity of competition. Although estimation techniques and theoretical modelling have improved to consider more complex settings, findings often diverge.[4] Aghion et al., (2009) tested their hypothesis on British companies and confirmed an inverted U-shaped relationship using semi-parametric methods and instrumental variables to correct for endogeneity. This relationship was found steeper for neck-to-neck industries. Similar findings have been reported for Dutch firms (Polder and Veldhuizen, 2012). In a follow-up work, Aghion et al., (2009) also find that the threat of technologically advanced entry (i.e., foreign entry greenfield) spurs innovation in sectors close to the technology frontier but discourages it in the rest (Aghion et al., 2009).

Overall, recent empirical studies tend to confirm that the impact of competition is generally positive. In fact, more recent studies report results different than those preconized by Aghion et al. (2005). Empirical examinations of American firms (e.g., Hashmi, 2013; Correa, 2012; Correa and Ornaghi, 2014), for French manufacturing firms (Askenazy et al., 2013), Canadian firms (Berube et al., 2012), and Portuguese companies (Santos et al., 2018) report a positive linear connection. Some recent studies for firms in developing countries find a negative relationship (e.g., Elejalde et al., 2019 for Uruguay; see Alvarez and Campusano, 2014). In some cases, significance relationships only prevail for certain types of firms and industries. For French firms, Askenazy et al. (2013) report the same results as Aghion's et al. (2005), but they find that the inverse U-shaped relation was only significant for the largest French companies and not for small enterprises.

For firms in developing countries, recent cross-country studies suggest a positive impact of competition on firm innovation efforts, including technology acquisition. Studies by Alvarez, Benavente, and Crespi (2019) for Latin American firms and by Crowley and Jordan (2017) for Central European firms show empirically that stronger competition encourages firm innovation. The former found that import competition positively affects firms' probability of engaging in R&D and product innovation (and other innovation activities) and this relation is predominantly linear. For Central European firms, Crowley and Jordan (2017) find a positive impact of competition on

[3] Other studies that support this intuition are Nickell (1996); Carlin et al. (2004), and Correa and Ornaghi (2014).
[4] This divergence across results might depend on the functional form that is assumed, the type of market structure, or how competition is measured, the type of indicators (product vs. process innovation, R&D vs. patents).

firm R&D engagement, but this impact decreases with the number of competitors. In a cross-country analysis, Bloom and Van Reenen (2007) find an overall positive effect of competition on the adoption of better managerial practices; these effects appear less robust, however, for firms in developing countries (e.g., Alvarez and Campuzano, 2014; Elejalde et al., 2019).

Studies evaluating the impact of trade liberalization on productivity and technology upgrading report more consistent findings. These often indicate a positive (mostly linear) impact of trade shocks on firm productivity and technology-upgrading activities, especially on the most productive firms and firms (and sectors) that were already globally integrated. Reallocation effects leading to aggregate productivity gains have also been documented for several emerging countries (e.g., Pavcnik (2002) for Chile; Eslava et al., 2004) for Colombia). Accordingly, reinforcing trade competition helps mitigate principal-agent frictions (reducing managerial slack) which can lead to important productivity gains especially in industries that were already competing with global markets (Pavcnik, 2002).[5] However, the literature recurrently confirms important heterogenous effects across firms with negative impact on firm productivity and innovation efforts in lagging firms and sectors (e.g., Aghion et al., 2005; Bustos, 2011; Amiti and Khandelwal, 2013). Accordingly, a negative effect of market competition on productivity and innovation could be explained by the technological conditions of these type of firms. That is, laggards may be less able to absorb R&D and unable to scale up and benefit from synergies (Haskel and Westlake, 2017); they could also be more financially dependent, which countervails innovation incentives from competition (ibid).

For Latin American firms, there is evidence of a large heterogeneity response to trade integration and competition. For instance, for Mexican companies, empirical research suggests that manufacturing firms have responded positively to Chinese import competition with a variety of innovation and technology adoption activities (e.g., Iacovone et al., 2013; Blyde and Fentanes, 2019). However, according to the study of Iacovone et al. (2013) for manufacturing, this impact is mostly confined to the largest and most efficient firms, whereas negative effects prevailed in small companies and lagging sectors, leading to increasing within-sector disparity (see also Blyde and Fentanes, 2019). For Argentinian firms, Bustos (2011) finds that the tariff reduction in Brazil induced entry in the export market but only for firms in the middle range of the total factor productivity (TFP) distribution. In contrast, for Chilean firms, Alvarez and Gonzalez (2017) report that competition may spur productivity in lagging companies, while Cusolito, Garcia, and Maloney (2017) find that innovation incentives from market competition (proxied by profit margins) are mostly associated to oligopolistic industries and high productivity firms, that is, those in the first

[5] See also the work of Álvarez and Robertson (2007) for Chile and Fernandes (2003) for Colombia.

two quartiles. Accordingly, market power would compensate for market failures in the financing of innovation by providing additional (internal) sources of finance.

2. Data

We use firm-level data from national industrial censuses to compute market competition indicators and match these measures at the sector level to firm-level data from innovation surveys to evaluate our research questions. For Colombia, industry and firm-level indicators are from the National Economic Census (EAM) for Manufacturing, which includes all the manufacturing firms in the country with more than 10 workers and more than US$180,000 of production value (at 2016 prices). An additional advantage of using this dataset is that the EAM mirrors the national innovation survey. Since 2003 the National Statistics Institute (Departamento Administrativo Nacional de Estadísticas, or DANE) has conducted the national innovation survey (Encuesta de Desarrollo e Innovación Technológica, or EDIT) using EAM's business directory. The completed database is an unbalanced panel made up of 11,941 firms for a total of 14 years (from 2003 to 2016) and 95,046 observations. For Colombia, once the dataset is merged with competition data and outliers are excluded, we ended up with around 60,000 observations, for an average of 6,300 firms per year. For Chile, we use two firm-level surveys. First, we use the National Industry Survey (Encuesta Nacional de Industria Annual, or ENIA), which is a census of the manufacturing industry. We use the panel dataset available for the years 2003–2015. Given its coverage, we compute our competition productivity indicators (average industry gap and productivity dispersion) with this dataset (which is available at the 3-digit levels of ISIC. Rev.3 and 4). Innovation investment activities are only available in the national innovation survey. Thus, for regression analysis, we are constrained to use the Enterprise Innovation Survey (Encuesta Innovación de Empresas), which is a nationally representative survey of Chilean establishments conducted by the Chilean National Statistical Agency. As distinct from ENIA, the Chilean innovation surveys do not have a panel dimension, as each edition has a different sample design. Only a very small component of firms is surveyed in every wave (212 firms).[6]

We use the last three innovation survey waves: the 8th Innovation Survey (2011–2012), the 9th Innovation Survey (2013–2014) and the 10th Enterprise Innovation Survey (2015–2016). Only firms with annual sales above 2,400 UFs (unidades de fomento) for 2017 prices were included in these three surveys. According to the nomenclature, these firms are considered small enterprises (i.e., firms with sales between UF2.400 and UF25.000 annually). It must be noted that the firms in

[6] We conducted analysis on this subset of firms, but given the similarity of firms and the reduced number of sectors, the evaluation of competition was not statistically robust.

the Chilean samples are, on average, much larger than the Colombian firms. The average number of employees in the former is 210 (with a large standard deviation of 549.42) while in Colombian firms, the equivalent average is 95.57 (with a standard deviation equal to 200.97). To have more comparable samples, we restricted the data to firms with more than 10 employees in both samples. Since each wave includes questions (i.e., R&D investment, innovation activities, personnel, and sales) asking activities or investment undertaken over the last two years, it is possible for some sub-samples to run panel analysis for 2–4 years and 6 years (for the small group of panel firms).

For the Chilean data, we harmonized the industry classifications across the three innovation survey data to the ISIC. Rev. 4 (OECD) Classification (the 8th survey reported data at the ISIC. Rev. 3-3 digits, whereas the 9th and the 10th surveys use the ISIC Rev. 4 at 2-digits). By merging the different innovation surveys, and merging them with the market competition dataset resulting from the Industrial Survey (ENIA) (at the two-digit level), we ended up with 1,150 enterprises at least for every year in the pooled dataset (2011–2016); resulting in a total of 6941 firm-year observations. Monetary values are in constant 2009 pesos (IPC industry deflator). In the two country datasets, we trimmed our data and excluded firm-level outliers based on productivity distributions (bottom 1 percent and top 1 percent in the productivity distribution).

3. The Empirical Model and Estimation Strategy

Following Aghion et al. (2005) and Schumpeter (1943), the main idea of this research is to measure the impact of competition on firm innovation. The dependent variable is a dichotomous variable that takes the value of one if the company spends any amount on innovation activities and takes zero otherwise. We define a reduced innovation equation (firm decision) as follows:

$$IN_{ijt} = \beta_0 + \beta_1 C_{jt-1} + \beta_2 C_{jt-1}^2 + \quad \beta_4 X_{ijt-1} + u_{ijt} \qquad (1)$$
$$where\ u_{ijt} = f_{jt} + v_i + \varepsilon_{ijt}$$

where C_{jt-1} is the competition variable (Boone index) at the three-digit sector level (ISIC- Rev. 4 Classification) for Colombian firms and at the two-digit level for Chilean enterprises. u_{it} is the idiosyncratic error composed by three terms: f_{jt} which is the interaction of the vector containing time effects (t) with a vector containing sector-specific effects (2-digit level dummies); v_i which is a firm-specific component, and $\varepsilon_{\mathrm{ijt}}$ is the residual error term. The time-varying industry intercepts allow us to control for industry-specific changes and shocks (technological or economic) over time that may affect firms' innovation decisions. The use of these dummies also helps us deal with the risk of endogeneity of competition since it allow us to control for time-idiosyncratic changes such as import competition or industry price changes which may affect rivalry among firms over time.

Under the inverted-U hypothesis, β_1 is expected to be positive and β_2 negative (prediction 1). Standard errors are clustered at the firm level to control for within-firm cluster correlation in residuals.

We then extend this equation to evaluate whether competition effects are mediated by firms' technology distance to the frontier (GAP) and industries' level of technological dispersion (DISP). We interact our measure of competition with these indicators and use different measures of intra-sectoral disparity for robustness purposes (see Sub-section 3.2). These equations are expressed as:

$$IN_{ijt} = \beta_0 + \beta_1 C_{jt-1} + \beta_2 C_{jt-1}^2 + \beta_3 C_{jt-1}.GAP_{jt-1} + \beta_4 C_{jt-1}^2.GAP_{jt-1} + \beta_x X_{ijt-1} + u_{ijt} \qquad (2)$$

$$u_{ijt} = f_{jt} + v_i + \varepsilon_{it}$$

When squared terms are non-significantly different from zero ($\beta_2 = 0;\ \beta_4 = 0$), equation (2) simply reduces to:

$$IN_{ijt} = \beta_0 + \beta_1 C_{jt-1} + \beta_3 C_{jt-1}.GAP_{jt-1} + \beta_4 GAP_{jt-1} + \beta_x X_{ijt-1} + u_{ijt} \qquad (3)$$

where GAP_{ijt} corresponds to firm productivity gap vis-à-vis the leaders (median in frontier firms) in each sub-sector or alternatively the average industry gap. If the inverted-U relationship in more technologically rival industries is steeper, as implied by Prediction 3 (Aghion et al., 2005), then we would expect coefficients β_3 and β_4 to be smaller than those for the total sample. These are the same expressions as in Berube et al., (2012) and Ding et al. (2016), which will allow us to compare our results with theirs. The vector X_{ijt-1} contains a set of control variables suggested by the literature (Crepon et al., 1998; Gorodinchenko et al., 2008; Cohen 2010).

We include export intensity of the firm (EI_{ijt-1}) which is the proportion of income corresponding to sales in foreign markets in the previous period. As an alternative measure and to avoid endogeneity issues, we also use a dummy indicating whether the firm was engaged in exporting during the previous three years. We control for the size of the firm (L_{jt-1}) proxied by the natural logarithm of the total employees of the company and firm age (Age_{jt-1}) which is the logarithm of the number of years since the firm was founded. In the Chilean regressions, we also include a dummy form multinational firms for firms reporting foreign capital ownership of at least 10 percent and a dummy for firms belonging to a group. In the Colombian data, our proxy for foreign ownership is the proportion of foreign labor in total employment; although this is an imperfect measure, we can assume that those firms with employees of foreign origin (white collar) are multinational corporations.

Our analysis differs from those of Aghion et al. (2005), Hashmi (2013), and other studies for developed countries that used patents or R&D investment as the main explained variables. We use a broader definition of innovation activity. For Chilean firms, the innovation surveys use the definition of innovation activities provided by the OECD Oslo Manual (OECD and EU, 2015) and consider innovation activity as any expenditure incurred in terms of internal or external R&D services, expenditures related to acquisition of machinery and equipment associated to innovation activities, payments and royalties related to the acquisition of licensing, intellectual property, software licensing plus expenses in labor training related to the use of new technologies or R&D. Our explained variable is a categorical variable equal to one if the firm declared expenditures in these items.

Estimations of equations such as (1) and (2) cannot be consistently estimated by probit regression (incidental parameters problem). Thus, we estimate our equations using linear probability models, where we allow for firm fixed effects to deal with (time unvarying) unobservable firm attributes.[7] Further, we correct for endogeneity with a set of policy changes and industry-level indicators of market pressures for panel data (fixed effects). The main objection to the use of linear probability models is that heteroscedasticity is almost invariably present, and that the model can potentially predict probabilities that are not between 0 and 1 if sufficiently extreme values of the predictor variables are used. We deal with this heteroscedasticity problem in two ways. We implement fixed effects estimation with instrumental variables and panel regression (fixed effects) for some equations.

3.1. The Measurement of Market Competition

As indicators of market competition, we use the Boone index as in Boone (2008a; 2008b) and the more traditional profit cost margin ratio or PCM (Lerner index). The Boone index is a profit-elasticity measure (at the market/industry level) developed in Boone (2008a) and Boone et al. (2005). It has been proven to be a more reliable measure compared to traditional indicators such as the Lerner or the Herfindahl-Hirschman index. Lerner or profit-margin indicators (PCM) indicators suffer from several imitations (see e.g., Stiglitz, 1989; Roberts, 2014, among others), such as misleading trends in small markets and poorly capturing geographical market power.[8] The superiority of the Boone indicator is based on the fact that it incorporates heterogeneity in firm efficiency to measure profit-cost elasticity through econometric estimation. The main idea is that competition rewards

[7] Using the LPM has three main drawbacks: The effect $\Delta P(y=1|X=x0+\Delta x)\Delta P(y=1|X=x0+\Delta x)$ is always constant; the error term is by definition heteroscedastic by definition, and OLS does not bound the predicted probability in the unit interval.
[8] Traditional indicators of competition such as market share or markup indicators have known important limitations. For instance, they mostly capture domestic market competition, neglecting the influence of open markets, and they are also subject to some theoretical and empirical weaknesses (Boone, 2008a).

efficiency. More efficient firms (that is, firms with lower marginal costs) obtain higher market shares and profits compared to less efficient rivals, and this effect is stronger with fiercer competition.

As competition intensifies, output is reallocated from less efficient to more efficient firms (Aghion and Schankerman, 2004). It has been also proven that the Boone index is monotonously related to various competition parameters, unlike other used measures such as the Lerner or the HHI (Boone, 2008a; 2008b). Empirically, the Boone index (the profit-costs elasticity) can be recovered by coefficient β_1 for each sector *j* and year *t* in the following regression:

$$log\pi_{ijt} = \alpha_{ijt} + \beta_1 \log\left(\frac{TVC_{ijt}}{sales_{ijt}}\right) + \beta_2 \log\left(size_{ijt}\right) + \epsilon_{ijt} \tag{4}$$

where, $log\pi_{ijt}$ corresponds to the natural logarithm of operating profits of the firm *i* in sector *j* at year *t*, TVC_{ijt} to total variable cost relative to sales, a measure of firm size (number of firm employees) and ϵ_{ijt} to a robust standard error. The econometric strategy consists of estimating the logarithm of the operating profits as a function of the logarithm of variable costs over total sales. We estimate equation (4) for each sector-year combination at the three-digit level in the ISIC (4) classification for Colombian firms and at the two-digit level for Chilean firms. Profits on the left-hand side of the equation are computed as sales—total costs (administration expenditures + labor cost + raw materials + depreciation + opportunity cost). Each of these variables is individually observed in the industrial survey, except for the opportunity cost, which is calculated as asset book value times the interbank interest rate. To the extent that the measurement errors are time invariant, they will be picked up by the firm fixed effects. To have more robust and reliable indicators that are less influenced by outliers, we excluded industries with fewer than 20 firms. In addition, in the industrial surveys we also excluded outliers based on the productivity distribution, dropping the top 99 percent and bottom 1 percent of the TFP distribution (sector-year).

As total variable cost is negatively related to profits, the Boone Index is always negative, although positive values can appear (e.g., perfect collusion). For this analysis, we will 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.[9] To ensure robust Boone index estimates less influenced by outliers and small industry sizes, industries with fewer than 20 firms are dropped.

In our robustness tests, we also control for the rate of business dynamics. We follow the definition of the OECD (SDBS) Business Demography Indicators for birth enterprise creation and

[9] The Boone does not allow for the perfect identification of extreme cases such as monopoly and perfect competition. Nevertheless, in theory, Boone indicator near infinity could be related to perfect competition and near zero to more uncompetitive conditions.

business entry rate. This is the number of enterprise births in the reference period (*t*) divided by the number of enterprises active in the same period. If we consider the exit rate (number of enterprises that disappear every year) we can compute the *net entry rate (NER) as*: $NER = \left(\frac{Births_{jt} - Exits_{jt}}{Total\ of\ Active\ Firms_{jt}}\right) * 100$. For Chile, we compute firm creation and exit rates with data from the ENIA (Industrial Census) at the three-digit ISIC Rev. 3 level. According to Pavcnik (2002), it is important to incorporate dynamics like firm exit in the productivity (innovation) analysis to correct for the selection problem induced by existing firms (see also Amiti and Konings, 2007).

3.2. Endogeneity and Identification Strategy

Competition might be weakly exogenous to innovation at both the firm and the industry levels. Endogeneity might arise due to measurement errors in covariates (competition), unobserved heterogeneity (i.e., through omitted variables affecting both equations), and /or simultaneity (i.e., random shocks trigger the change in covariates). The problem of simultaneity can be more severe as causality can run both ways in the case of market competition and innovation. Innovation can reinforce firms' market power (leading to market concentration) or totally displace competitors through new products or process innovation, product differentiation, and other forms of competitive strategies. If innovation increases market power and hence reduces competition, the estimates will be biased toward finding a more negative (or less positive) relationship between competition and innovation.

For all these problems, we can apply instrumental variables (IV) estimation because IVs can help cut correlations between the error term and independent variables. By addressing firm unobserved heterogeneity, panel data can help deal with these problems but cannot fix the problem. For IVs estimation to be valid, we need to have IVs that are uncorrelated with the error term but partially and sufficiently strongly correlated with the weakly exogenous variable (competition) once the other independent covariates are controlled for. Suitable IVs are exogenous changes to the system such as global competition shocks (supply trends, e.g., Autor et al., 2016). Several authors have used structural policy changes and regulatory reforms altering competition conditions in markets/industries (i.e., Aghion et al., 2005; Bloom. Draca, and Van Reenen, 2016).

We need exogenous variation in our measure of market competition with respect to innovation decision to identify the causal effect we are interested in. The identification strategy rests upon the premise that IVs are related to the intensity of market competition but do not enter directly into the innovation equation. We use two types of IVs which are assumed exogenous to the system and strongly explanatory factors of market competition. For Colombia and Mexico, we use: *(i) official competition enforcement decisions,* which take the form of sanctions for firms issued by the national Competition Authorities (NCC in Colombia) (see Aghion et al., 2009; Griffith et al., 2010); and (ii) a measure of *entry barriers or "sunk costs"* in each sector. The former refers to competition law decisions to sanction firms found to exercise collusive or other anti-competitive practices such as market segmentation practices or monopolistic abuses. We assign a dummy equal to one for industries (at the three-digit level of ISIC Rev. 4 for Colombian industries) where such policy decisions occurred and another categorical variable equal to one since the year these decisions were emitted (difference-in-differences estimation). It must be noted that this identification strategy allows us to test the effectiveness of competition policy interventions in improving competition conditions.

Entry barriers is a measure of setup costs following Sutton (1991) (see also Vives, 2008; Beneito et al., 2015). This variable is defined as the output share of an industry's mid-size firm multiplied by the average capital-output ratio in each of the sectors (two-digit level in Chile). The former part of this product is considered by Sutton (1991) as a measure for the firm's minimum efficient scale. Firms' output is measured as sales plus variation in inventories, whereas the stock of net physical capital is obtained using the perpetual inventory method. The measure for setup costs is a proxy for capital requirements required in each sector to establish a new firm. In the three country datasets, we also include an indicator of market size (logarithm of production in the previous period) and average sector growth in the previous three years.

We can assume that our measure of "entry costs" is exogenous with respect to firm decision to invest in innovation while being a strong determinant of competition. First, this measure is a one-year lagged variable and second, being an industry-level indicator, it reflects differences across sectors in the capital intensity required to compete, which determines the conditions for new firm entry. Previous research has shown that "sunkness" of capital (i.e., intensity of the rent or resale markets and the rate of depreciation, see Kessides, 1990) is a good indicator of market contestability and strongly correlates with inter-industry differences in market concentration (i.e., Kessides, 1990; Sutton, 1991).[10]

The use of competition policy decisions as IVs is motivated by the fact that such interventions affect the intensity of market competition, namely by re-defining competition conditions through law enforcement and punishment of market dominance abuses and monopolistic practices (see Voigt, 2009). We argue that the policy instruments have no additional impact on innovation, after we condition for these covariates. We test the overidentification

[10] Kessides (1990) notes that the extent of sunk capital outlays incurred by a potential entrant will be determined by the durability, specificity, and mobility of capital. The latter relates to resource allocation and financial constraints.

assumptions and experiment with using only subsets of these instruments. Table 3 (in the Annex) reports a summary of the competition policy decisions included in our samples for Colombian industries.

Policy interventions (and business reforms) have been used previously as instruments for competition to evaluate effects of competition on productivity growth (Aghion et al., 2005; 2009; Griffith et al., 2010). These authors also used trade and privatization reforms in Europe as instruments for competition. A cross-country study by Buccirossi et al. (2013) found strong evidence of policy complementarities between competition policy and law enforcement to explain productivity growth in European industries. The empirical study of Dutz and Hayri (2000) of a large sample of countries showed that domestic competition is strongly correlated with long-run growth and effective enforcement of antitrust policies.[11] Moreover, some research suggests that the benefits of competition laws for productivity growth could be stronger for developing countries. Benetatou et al. (2020) found that the impact of competition policy quality (composite index that includes enforcement measures) on labor productivity growth in laggard (developing) economies is about three times as large as the effect estimated for the whole sample. Thus, enforcement of competition law seems critical for promoting competitive markets in developing countries.

In the Chilean sample, in addition to entry costs and size of the sector, we exploit the variation in competition that arises from a major policy reform. In 2013, Chile introduced and implemented a new process (contained in Law 20,659*)* for the creation of new firms in a single day. By using this reform as instrument, we account for such structural policy changes in the business environment, which directly affects competition conditions by facilitating firm entry. Under this reform, a company can be fully incorporated online, and new members or shareholders can create a limited liability company, a company by shares, a corporation, or an individual company with limited liability. Although registration costs and time of procedures might not be as critical for business creation in services, this reform reflects an overall improvement of the doing business framework, which should influence market competition by promoting and facilitating entry. We test these overidentifying restrictions and experiment with some interactions among them.[12]

Competition laws and their enforcement have substantially improved during the last two decades in these countries. During the 2010s, several reforms strengthened the legal and

[11] The authors used several indicators of competition policy based on the questions in the World Competitiveness Report, which asked managers their perceptions about the effectiveness of anti-trust or anti-monopoly policy in their countries in promoting competition.

[12] As alternative instrument, we also tested the average growth of Chinese imports experienced in other Latin American economies with similar trade openness. We tested the four-year average growth of Chinese imports (see Bernard, Jensen, and Scott, 2006). Although this instrument was expected to influence market competition and often used as instrument, it was found non-significant in explaining the Boone indicator.

institutional capacity of the competition authority in Colombia. In 2009 the Colombian Competition Authority (Superintendencia de Industria y Comercio, or SIC) underwent a radical change. Its budget increased, it was granted the right to carry out surprise visits and precautionary measures, it formed an elite group against collusion, and it created a program to grant benefits to informants in a cartel. Most importantly, the number of fines for violations of free competition increased substantially, rising from a maximum of US$500 thousand to US$25 million. These reforms led to a significant increase in the number of sanctioned firms and the amount of penalties (SIC, 2018). Several cartels were unmasked. They have been found in large economic sectors such as printing and paper industries, cement, sugar, and livestock (See Table 3 in Annex).[13]

4. Results and Discussion

Tables 1–3 in the Annex report summary statistics for the three country samples. Figures 1 and 2 in the Annex display the evolution in market competition, proxied by the Boone index as well as the evolution in the proportion of firms reporting investment in innovation activities. According to the average profit elasticity index (Boone Index), competition has deteriorated substantially in Chilean and Colombian manufacturing industries. The percentage of Colombian firms involved in innovation activities has also decreased over time. Between 2003 and 2006, about half of the firm population in manufacturing claimed to have invested in some type of innovation activity related to expenditures in science, technology services, or other forms of innovation. In 2015–2016, this figure was 20 percent (Figure 1). According to the Boone index, market competition in Colombian sectors was cut by half during this period.[14] In Chile, innovation measured on the Boone Index fell from an average of 1.7 to an average of 1.35 between 2009 and 2016. According to the OECD (2021), competitive pressures remain low and entry restrictions still prevail. The regulatory environment inhibits competition and the scaling up of firms, and restrictions on firm entry and formalization prevail. In terms of innovation engagement, the proportion of firms investing in innovation activities remains the same between 2011 and 2016, rising briefly in the middle of the period.

Aggregate figures regarding firm innovation engagement provide mixed messages, while productivity indicators consistently indicate the existence of large asymmetries within sector gaps, large gaps vis-à-vis the leaders (within sectors), and a deterioration in average firm productivity. Much of this productivity weakness is driven by business polarization, that is, long tail of micro and

[13] From 120 in the period 2003-2010 to 536 in the period 2011-2018) and the total amount of fines (from 21 million dollars in the period 2002-2010 to 450 million dollars in the period 2011-2018, in constant prices).

[14] Recall that the Boone indicator (negative definition) here reported, is the (negative) coefficient from the marginal cost to profit regression multiplied by -1; larger numbers reflect more efficient markets and competitive prices.

small firms with weak productivity performance. In Colombian sectors, the average firm gap has remained largely the same (65–68 percent) over the last decade, whereas in Chile it increased substantially, reaching an average of 75 percent (with respect to leaders or top 5 percent) in 2016, according to data for the manufacturing industry. According to data from the economic census, the average firm-level gap in Colombian manufacturing is 67 percent. Several studies have documented these dramatic levels of asymmetry (e.g., OECD, 2021). These figures are largely above the average firm gap reported for firms in OECD countries: in Canadian firms: 0.47 (Bérubé et al., 2012), American firms, 0.49 (Hashmi, 2013), and British firms, 0.49 (Aghion et al., 2005).

Table 4 in the Annex reports our results with OLS and a two-stage least squares IV regression for pooled and panel data with fixed effects. In both techniques, standard errors are clustered at the firm level, which helps us deal with heterogeneity and intra-firm serial correlation. Regressions include time and industry effects (pooled IV-2SLS and OLS). The results indicate a positive linear causal relationship for Chilean companies and a nonlinear relationship for Colombian firms. Instrumenting competition pulls out the significance and impact of market competition, effects that were not captured with OLS regression in the case of Colombian companies. For Chilean firms, correcting the endogeneity of market competition makes the impact of market competition on innovation much larger than the estimates produced by OLS regression, reflecting the bias revealed by the correlation of residuals with our variable of interest. This result stresses the importance of correcting for endogeneity when evaluating the impact of market competition.

We briefly discuss the adequacy of instrumentation and the validity of instruments. The implementation of two-stage least squares with instrumental variables is largely justified by the different statistical tests on the orthogonality of IVs and significance of excluded instruments. The Chi-squared tests to evaluate the endogeneity of competition (and squared terms) confirm that competition is weakly exogenous and should therefore be instrumented. The Ho (Chi-squared) tests on the lack of significance of firsts stage residuals (for competition variables) is rejected at 1 percent level probability in the different samples.[15] The F-test of first stage regressions confirm that our set of instrumental variables (IVs) are jointly significant and strongly correlated with competition whereas the Hansen-J test, which is robust to heteroscedasticity, indicates that orthogonality conditions are accomplished, confirming the validity of our instruments in both settings (pooled and panel 2SLS-FE). In addition, our F-statistics from the first-stage regressions are in line with Staiger and Stock's rule of thumb that requires that these Fisher values should be larger than 10,

[15] The Chi2 tests (2) is equal to 12.87 with a p-value of 0.001 in the pooled regressions and remains significant in the panel regression (Chi2(2) tests of 15.89 with a p-value of 0.04), which means that competition should be instrumented.

and the weak-identification tests further confirm the validity of instruments. The Stock-Yogo test for weak identification ($H0$: Instruments are weak) corroborates that our set of instruments is valid; our F-test values from this test are very close to the 5 percent accepted IV bias, which allows for robust inference with instrumented competition coefficients.[16]

Figures 3 and 4 (see Annex) display graphically the predicted linear probability of innovation engagement vis-à-vis competition intensity resulting from the 2SLS panel estimations for Colombian and Chilean manufacturing firms, respectively. For Colombian companies, the influence of market competition shows a nonlinear (inverse U-shaped) relationship in both pooled IV regression (column (3)) and panel IV-2SLS with firm fixed effects (column (4). According to estimated marginal effects, the inflection point is at Boone index with a value of 1.85 (with)a standard error of 0.08), which is larger than the mean (0.96) reported for the whole period. Before the threshold, innovation ("escaping competition") incentives predominate over Schumpeterian effects, and the opposite prevails beyond that point. Thus, there is wide room to encourage firm innovation participation by reinforcing market competition. Considering that the average Boone index in Colombian sectors for the years 2015–2016 is 0.75, that would mean that competition needs to increase 2.5 times to reach its maximum positive impact on firm innovation participation.

For Chilean firms, the correction by 2SLS-IV reveals a linear and statistically significant relationship between competition and innovation, when we consider the whole sample matched with industry data. For Chilean firms (column (4)), one standard deviation increases in the Boone index (0.598) is associated with a 14.5 percent increase in the probability of investing in innovation activities by companies (0.237 X0.60=0.14; (t= 1.65 and P>|t|= 0.10), according to the panel (firm fixed effect) estimation with 2SLS-IV; whereas in the pooled 2SLS-IV this effect is 12 percent (t-stat=1.49 and p-val=0.10). With fixed-effects estimation the number of firms drops substantially, moving from 2,330 in pooled regressions to 734 firms.[17]

The sign of coefficients in the control variables are largely in line with previous research. Innovation investment decisions by firms are influenced by the intensity of skills in employment (the percentage of white-collar employees in total labor); the level of technology sophistication as reflected in capital intensity of the firm and is negatively associated with firms' technology distance to the frontier. The propensity to invest in innovation raises with, firm size, reflecting economies of scale and scope in innovation as firm grows (e.g., Crespi and Zuniga, 2012). In contrast, the farther

[16] In pooled (panel) regression, this test has a value of 12.56 (15.62 in the panel regression), which is close to the critical value accepted for a maximal IV relative bias of 5 percent (Stock-You test critical values), of 14.56 (15.72 in panel).
[17] The panel estimation is found to be slightly superior to the pooled IV-2SLS estimation (with a F-test of panel vs. pooled of 3.5 significant at 1% confidence level).

from the frontier, the less likely a firm will invest in innovation; a one standard deviation in firms' technology distance from leaders decreases innovation investment probability in Colombian and Chilean firms by 6.5 percent and 4 percent, respectively.

In the sample of Chilean firms, the propensity for innovation engagement decreases with firm age (and this relationship is significant only with fixed effects estimation, but no significant impact is attributed to foreign ownership (percent in capital). Another interesting finding is the different innovation behavior between exporters and non-exporting firms. According to estimates reported by IV-2SLS in column (3), a Colombian firm that has been an exporter over the last two years has a 6 percent greater probability to invest in innovation than firms that have not been involved in such activity over the same period. A Chilean firm that has been exporting in the last two years has a 10 percent higher probability of investing in innovation than those who have not been exporters in the recent past, according to fixed effects 2SLS regression (column 8). However, when we use 2SLS-FE panel regression, the significance of several coefficients fades away.

4.1 Differences in Results: Are Chilean and Colombian Firms Different?

What could explain the differences between Chilean and Colombian firms in their response (shape) to competition? A first explanation relates to the level of asymmetry within sectors, or how close firms are in terms of technological rivalry. According to data, sector asymmetry in Colombian firms is greater than their peers in Chile. The kurtosis index is larger in the first group of firms (36.61 vs. 24.5) and the average firm gap (within sector disparity) is about 70 percent, that is, average productivity distance from the leaders (top 5 percent in the productivity distribution) while in the Chilean companies the average gap is 23 percent. At least, according to data from the innovation surveys, Chilean sectors are more symmetrical which could explain the predominance of "escape-competition" incentives (i.e., more neck-and-neck industries), and therefore a linear relationship.

There are important differences in the two countries' datasets (and sample designs) that may play a role in driving such differences. On average, the Chilean samples are composed of much larger firms compared to the Colombian dataset; even after restricting the two samples to firms with at least 10 employees to improve comparability in our results. While the average firm size in the combined Colombian sample is 95 employees, in the Chilean dataset this number is 210 employees.

We must also note that the quality of data is superior for Colombian firms as this survey is part of the Economic Census; we have population data covering all firms (above 10 employees), and a richer panel/time dimension. In contrast, the Chilean innovation survey is limited in its time dimension and industry coverage. The industry structure (sample design) has changed over time, which hinders our capacity to evaluate causality and competition effects over time. We believe, however, that these differences do not compromise the validity of our results as a large segment of the Colombian firms respond positively to competition. An additional analysis considering interactions of market competition with productivity quartiles—as will be seen in Section 4.4—shows that even for the lowest-performing firms (Colombian enterprises), the impact is positive. Effects are even larger in the middle range of the productivity distribution and decrease in impact for the highest performers, which would explain the concavity of the relationship.

4.2 First-stage Regressions: The Importance of Competition Policy Enforcement

Table 5 reports our estimations concerning the first-stage regressions for market competition—only the first-stage equation for the linear terms is reported—and the interaction term with firm gap. These regressions further illustrate the validity of our estimation strategy. The coefficients on entry costs all display the expected sign and significance. The coefficient on our proxy for "entry costs" is negative and highly significant (at 1 percent probability level) and confirm theoretical predictions and previous research on the role of sunk entry costs in determining the intensity of market competition (Sutton, 1984; Vives, 2008). Sectors where the ratio of fixed capital assets to production (weighted by firm median size in each sector) in industries is larger are more likely to experience less firm entry (and weaker resource mobility), which translates into lower levels of the Boone index (see also Beneito et al., 2015). The largest impact is in Colombian industries.

Industries in which a competition policy sanction was issued saw their level of market competition improve after policy intervention (columns (1) and (2) for Colombian firms). For Colombian firms, such decisions increased the Boone index by a magnitude of 0.12–0.23 in absolute terms after intervention; that means a rise of about 12.6 percent if we consider that the pre-intervention value in the competition index in these sectors was 0.95, on average. An alternative way to measure such change is including pre-trend dummies denoting treated sectors one and two years before interventions. These coefficients suggest that one year before intervention treated sectors reported on average a Boone index 12 percent smaller (more oligopolistic industries) than non-intervened industries. These results validate the effectiveness of competition policy enforcement in reestablishing competition conditions.

In contrast, market size and sector growth influence market competition in different ways across countries. While market size and sector growth are associated negatively with market competition in Colombian sectors, meaning that industries with larger output participation are associated with concentrated markets, the opposite is true in Chilean industries. In the latter, sectors that grow and larger market size are positively associated with intensified market competition.

In the case of Chilean industries, in addition to the instruments previously mentioned, we also take into consideration an important structural change in business environment policy, expected to play a significant role in shaping market competition conditions. We include a dummy equal to one starting the year the new business entry reform was introduced (2013). Since this coefficient is dropped with fixed effects regression, we interact the reform dummy with our measure of entry costs, which is a weighted measure of the capital requirements in each industry-year combination.

This interaction term is positive and significant in the two specifications; the estimates in column (5) indicate that entry costs led to reduction in the Boone index (by restraining firm entry). In other words, sectors with higher entry costs experienced less market competition before the reform. After the reform, the negative impact of entry costs decreased, leading to an intensification of market competition. This would mean that more capital-intensive companies entered after the reform that had probably hesitated to open a plant or create a new company before the reform due to weaknesses in the business regulatory framework.[18] As previously discussed, the Hansen-J tests confirm the validity of over-identification restrictions while the partial F-statistics also provide evidence of strong instruments.[19]

4.3 Firm and Sector Heterogeneity: Do firm gap and sector asymmetry matter?

According to theory and previous empirical research, we should expect firm distance to the frontier to strongly mediate the impact of competition on firm innovation. A negative impact is expected as firms' (and sectors') technology distance from leaders (global leaders) increases. According to Aghion et al. (2005), stronger innovation incentives are expected in industries where productivity differences across firms are small: a steeper inverse-U shaped relation is expected in symmetrical sectors (neck-to-neck). This type of industry, however, barely exists in Latin America; most industries exhibit a persistent division between a small number of large and productive firms, and a long tail of micro, small, and medium size companies with considerably weaker productivity performance (e.g., Blyde and Fentanes, 2019; Pelaez and Hurtado, 2021).

[18] Gains in profit elasticity after the reform may not only come from increased entry in manufacturing, but also from a potential increase in firm entry and competition in services -which contributes to cost reduction in manufacturing.

[19] For the Anderson-Rubin (AR) Wald test, the null hypothesis of coefficients (competition) equal to zero is rejected at 5 percent p-level; while the Kleibergen-Paap (Wald) statistic for weak instruments is above the required critical values (5 and 10 percent).

In line with Aghion et al. (2005), we evaluate whether the impact of competition is subject to nonlinearities related to firms' technology gap and the level of technological asymmetry within sectors. We estimate TFP at the firm level following the methodology of Levinsohn and Petrin (2003), which assumes a Cobb-Douglas production function. Once we have individual TFP indicators, we compute the difference in productivity with respect to the leaders in each sector. We define leaders as those firms being in the top 5 percent of the TFP distribution in each sector-year combination. To avoid the effects of outliers in the group of frontier firms, we compute the gap in TFP values for each non-frontier firm with respect to the median of leaders, and this difference is expressed as a percentage respect to the median value of frontier firms. The technology distance (GAP_{ijt}) measure then takes values between 0 percent (for leaders) and 99.99 percent, with higher values reflecting proximity to the frontier.

In the case of Chile, we use indicators computed directly from the Industrial Survey. However, for the computation of firm-level gap we are restricted to using labor productivity (sales over employees) since no information on fixed assets and variables costs is available in the national innovation surveys and there is no identifier available to link the industry survey with the innovation surveys.[20]

We use three alternative measures of technological asymmetry of sectors. We use the average firm gap in industries, the standard deviation in firm total factor productivity (TFP), and the kurtosis index, each calculated for every sector-year combination.[21] We interact these indicators with the competition measures to evaluate whether negative responses predominate with productivity dispersion. A similar exercise consists of interacting competition with a dummy denoting symmetrical sectors (neck-to-neck). We define these industries as those where the average gap is at least three standard deviations smaller than the average gap in the whole industry. In line with Aghion et al. (2005), we expect "technologically symmetrical" sectors to display stronger responses to competition; a steeper nonlinear curve.

Table 6 next reports regressions from the estimation with 2SLS-FE for both Chilean and Colombian firms, including interaction terms with technology distance and sectoral asymmetry indicators. Following Wooldridge (2013), we instrument these variables with the same baseline set of instruments plus their interactions with each of these dispersion indicators. In principle, the farther a firm is from the frontier (sector leaders), the larger the discouraging effect from

[20] It is not possible to compute TFP indicators with data from national innovation surveys (no information on capital assets or variable costs is provided) as there is no information on variable costs and capital in national innovation surveys. Our indicators on productivity dispersion and average gaps were built with the Industrial Surveys.

[21] We also tested three-year averages to alleviate business cycle effects and reduce potential measurement errors; results were only significant with the first definition.

competition. We confirm the predictions about the predominance of discouragement effects in firm innovation when technology distance from leaders increases for Colombian firms (columns (1) and (2)), but not for Chilean enterprises (column (7)). In the Colombian sample, once we include interactions linking the square terms (competition) with the firm gap indicator, the significance of the square term disappears which indicates that the nonlinearity detected previously was basically driven by firm heterogeneity (column (2)).

The negative impact of firm distance in Colombian firms reflects the predominance of Schumpeterian (discouraging) effects in laggard firms, while innovation-enhancing effects prevail for firms at the frontier. This combination of firms (and industries) may explain the inversed U-shaped relation that appears for Colombia. In contrast, the presence of a monotonic relationship in Chilean firms would suggest that Chilean industries are more "symmetrical," following the arguments of Aghion et al. (2005). This symmetry is also reflected in the significance of competition effects only emerging for firms in the medium range of the productivity distribution.

For Colombian companies, if we take the value of competition at the mean, the coefficient in column (2) implies that one standard deviation increase in firm gap reduces the probability of firm innovation investment by 21.2 percent. However, when looking at the marginal effects from different values of firm technology gap, we find that significant effects only exist for certain groups of firms. Negative and significant (marginal) effects from competition only exist at very large values of firm gap, starting at a firm gap value of 0.74, but only becomes significant at a firm gap value of 0.85, that is, starting at the 80th percentile of the firm gap distribution and beyond.[22] The negative marginal impact further amplifies with larger firm gaps.

This result has important policy implications that should be considered when embarking on reforms designed to enhance competition. It highlights the need for productivity-supporting policies, especially for firms lagging farthest behind. Strengthening competition makes innovation investment in these firms less likely, which will eventually worsen productivity performance, widening gaps vis-à-vis the leaders. In contrast, the marginal effect of competition for firms closer to the frontier firms is positive and significant-as predicted in Aghion et al. (2005). For firms at the top 25 percent of the firm gap distribution or with the shortest gaps (at the top p-25 percent, the marginal effect is 7 percent -with a standard error of 0.018 and it is significant at 1 percent (z-test=3.68).[23]

[22] At this point, estimates coefficients indicate that at this gap level, the marginal effect of competition is -0.5 (-5 percent), with a standard error of 0.04 and significant at the 10 percent p-value level (z = -1.63).
[23] For firms between the 50th percentile and the 75th percentiles in the productivity gap distribution, the marginal effect is quite small (0.2) and not significantly different from zero.

Finally, in columns (5) and (10), we include the interaction of market competition with two groups of firms: leaders (those at top 25 percent of the productivity distribution) and followers (all the rest of the firms,). We also include the dummy identifying the leaders group. While the latter is not significant in any of the regressions—when competition is equal to zero, leaders are not distinctive from followers in terms of innovation behavior—only the interaction term referring to the group of followers is significant (at the 1 percent level). Increasing market competition, enhances firm innovation engagement in the group of follower firms in both countries. We acknowledge that this is quite a heterogenous group of firms, which may hide different responses within it.

The lack of significance of the coefficient on the group of leaders can be explained by structural features of Latin American industries. Since leaders (best productivity performers) mostly compete in international markets, these types of firms may be less sensitive to changes in domestic competition.[24] This leaves domestic competition basically taking place within firms positioned in the mid-range of the productivity distribution.

4.4 Productivity Groups

To deepen our analysis of the role of firm heterogeneity, we test whether the way competition impacts innovation is nonlinear with respect to firms' productivity performance. Following Bustos (2011) and Alvarez et al. (2019), in Table 7 we include dummies reflecting firms' position in the productivity distribution (productivity quartiles) and interact them with competition. Given that endogeneity of competition disappears once we introduce these three quartile dummies and their interaction with competition, we implement random and fixed-effect regressions. For Colombian firms, our productivity measure is the logarithm of the TFP whereas for Chilean firms we use labor productivity. All quartiles' dummies (and interactions) refer to productivity levels from the previous period.

Following Bustos (2011), we expect that competition may induce innovation efforts in firms at the top and in the middle of the productivity distribution, but not in the least productive firms. Furthermore, for the most productive firms, escape competition may dominate, especially if they compete in industries close to the frontier and in highly symmetrical sectors (Aghion et al., 2005; Aghion et al., 2009). Negative effects are expected for the bottom quartile, especially if these firms are already below the innovation investment threshold (i.e., the technology adoption threshold in the model of Bustos, 2011).

[24] According to data from the ENIA survey, 67 percent of large firms (with more than 250 employees) export, while only 14 percent of SMEs do so according to data for the period 2005-2015 (Zaclicever, 2020). In some sectors such as chemicals and chemical products, the proportion of large firms engaged in exporting is much larger—over 80 percent of large firms export.

The estimates indicate important differences in competition responses across firms within the two country samples. Interestingly, the four interaction terms are significant at the 1 percent probability level in the Colombian sample, with the largest coefficient being reported in the third quartile, in both random (column (1)) and fixed effects estimation (column (2)). In contrast, in the Chilean sample, only the interaction terms for the third and fourth quartile are significant, with no difference in coefficient between these two categories under fixed-effects estimation. No negative effects are found for the lowest productivity quartile either in the Colombia sample or in the Chilean sample, where positive coefficients emerge but are not significant. Given these results, we can conclude that market competition positively influences innovation behavior mostly at the medium and top range of the productivity distribution, and there is weak evidence of Schumpeterian (negative impact) effects dominating in lagging firms.

Figures 5 and 6 in the Annex report the estimated predicted linear probability per group. We can now better understand the linearity in the relationship competition-innovation previously reported for Chilean firms. This linearity is driven by medium- and high-productivity firms, as no there is no significant role of competition for the bottom 50 percent (lagging firms). According to theory, these industries (top 50 percent) could be considered as "strongly even" or "leveled" industries, in the sense of Aghion et al. (2005), where escape-competition incentives arise from stronger market competition.

5. Robustness

We perform several robustness tests, adding covariates and considering a series of extensions for the Chilean and Colombian samples. First, as competition indicators may capture the degree of foreign competition (trade effects), we include and indicator of import penetration to test whether our results are not mainly driven by trade competition. Further, the policy interventions and reforms that we use for instrumenting competition may also affect innovation incentives through other channels, such as changing trade relations. Second, we also control for business dynamics, which allows us to discriminate effects related to competitive pressures stemming from new firm entry, which may also be related to innovation incentives in incumbent firms (e.g., Aghion et al., 2009).

Third, we include firm persistence in innovation activities (e.g., Peters, 2009; Mulkay, 2019). As discussed in the literature, firm innovation is path dependent (Mansfield, 1962; Romer, 1990; Malerba and Orsenigo, 1995); firms develop dynamic capabilities, which drives firm persistence to innovate and invest in innovation. Firm persistence to innovate is associated with "success-breeds-success" effects; in other words, past innovation performance breeds new opportunities to innovate because firms already know how to address consumers demands

(Peters, 2009). Further, firms with past innovation experience are more likely to invest in innovation since entry costs have already been incurred.

In the Colombian regressions, we use import penetration from China (3-digit level of ISIC rev. 4) in t-1 as a measure of trade competition (from low-skilled countries); this competition indicator is expected to directly influence productivity and firm employment evolution, especially in low-skilled sectors (Iacovone et al., 2013; Blyde and Fontanes, 2019). This indicator is two years lagged to avoid any spurious correlation with our dependent variable and market competition. This data come from the United Nations COMTRADE Database HS-6-digit, which was transformed into ISIC. Rev. 3-digit level of ISIC-4. 4.[25] For Chile, we could not use these data and match them to our innovation surveys since the classification is only compatible with Chile's last Innovation Survey (10th) (2015–2016).

Table 8 (Annex) reports these regressions for Colombian and Chilean firms. We only report estimations with IV-2SLS and firm fixed effects. Time effects are included in all regressions. Our findings remain quite close to the previous estimations, with some nuances. These tests corroborate our previous findings and shed further light on how the competition effects influence firm innovation. We find that competition still displays a causal nonlinear relationship as before, but this nonlinearity fades away when we control for past innovation engagement (column (3)). In column (1) (Table 8), we include the new firm entry rate and in column (2) we add the import penetration ratio, both at the same level of industry classification as our competition indicators. With the inclusion of these controls, we still find an inverse-U shaped relationship for Colombian firms, although the coefficients on competition are smaller in size compared to our first regressions.

Interestingly, the dynamism of sectors (entry rate discounted of exits) has a positive incidence on firm´s innovation investment decisions, which is also an indicator of competition-encouraging effects from new firm entry. The coefficient on the import penetration indicator is positive and significant (at 1 percent probability level); firms in industries facing a stronger import penetration show a larger propensity to engage in innovation investment. Column (3) includes both types of competitive pressures—entry and import penetration—plus a dummy referring to innovation investment engagement in the previous period.

Not surprisingly, past innovation investment (engagement dummy) has a strong impact on current firm innovation engagement decisions. Firms who were engaged in innovation in the previous year have 30 percent (average in columns (4)-(6)) higher probability of engaging in

[25] Import penetration ratios are sometimes interpreted as indicators of trade protection policy: low import penetration ratios sometimes reflect restrictive trade policies, that is, that a country is using high import duties or non-tariff barriers to protect domestic producers (see OECD, 2005).

innovation investment activities than firms that were not involved in (such activities in the previous year. Columns (4)-(6) report regressions including the interaction terms with firm gap and industry gap, and we keep the lagged dependent variable as additional explanatory variable. These regressions use the same set of IVs plus past innovation activity in period t-2.

We confirm previous results on the negative coefficient for the interaction term linking competition and firm gap, and the negative effect of sector asymmetry in discouraging innovation effects from competition. For these estimations, we run two-step GMM estimations to deal with the auto-correlation in residuals imposed by the lagged dependent variable. As before, standard errors are robust and clustered at the firm level. Columns (5) and (6) corroborate our previous findings about a decreasing impact of competition as firm technology distance increases, and within sector asymmetry raises.

For Chilean firms, the significance of competition and its linear causal effect on firm innovation investment propensity is further confirmed, although its impact is reduced as we add entry rate and lagged dependent variable. The effect remains positive (linear) and significant (columns (8) and (9)). As in the case of Colombian firms, new firm entry in sectors—which increases market competition—is associated with increased investment in firm innovation. Entry by new competitors raises firm innovation incentives through escape-competition effects (Aghion et al., 2009). Furthermore, the effect of market competition remains significant when we control for past innovation engagement (column (9)). We instrument past innovation engagement (lagged dependent variable) with the share of firms that received public financial support for innovation activities in the previous period and the same sector.

The impact of market competition decreases when we control for recent past (previous year) innovation engagement, although the coefficient on new firm entry (entry rate) loses significance; it is now significant at 15 percent probability level and remains at this level across the rest of regressions (columns (9)-(11)). The impact of past innovation engagement is quite large in size, reflecting firm persistence in innovation engagement over time (e.g., Peters, 2009; Mulkay, 2019). Firms that were engaged in innovation investment activities in the previous period report an 18 percent higher probability of investing in innovation in the current period. The role of sector asymmetry in moderating competition effects (negatively) remains significant with the two additional controls (column (11)) while the interaction term linking market competition and firm gap again appears non-significant, as in the previous analysis.

6. Conclusions

This paper provided new empirical evidence on the role of market competition in fostering innovation efforts in firms from emerging countries. Several new contributions were presented. By implementing a common analytical framework and methodology (i.e., market competition and estimation strategies), we were able to present new evidence regarding (i) the role of market competition in fostering firm innovation in emerging countries from Latin America and (ii) the importance and effectiveness of competition policy enforcement and pro-competition reforms to support innovation indirectly through the promotion of more competitive markets (and business entry, as in Chile) and regulating anti-competitive conduct by companies.

Our research confirms that market competition can increase innovation engagement in Latin American firms, but this response differs across firms and manifests in different ways across the two countries. These differences in response could be explained by differences in industry heterogeneity (i.e., larger asymmetry within sector in Colombia; "more unleveled industries") and methodological differences in surveys. Our analysis shows that firm heterogeneity matters; stronger innovation incentives predominate mostly in the middle range of the productivity distribution, while for laggards (first two quartiles) in Chile, no significant responses exist in terms of innovation investment engagement. For these firms at the left extreme of the productivity distribution, complementary policy actions (i.e., access to finance and skill development) are probably required to induce innovation efforts. Competition changes might not be sufficient if other fundamental market or system failures (i.e., funding of innovation or human capital) prevail.

We also showed that competition law enforcement has been effective (Colombian firms) in restoring and promoting competition conditions, which in turn encourage firm innovation. Easing business entry (Entry Law reform in Chile) was also found a very strong catalyzer of competition. Thus, this evidence combined suggests that pro-competition policies and their enforcement are critical, not only in terms of protecting consumers' welfare, but also to foster innovation efforts in firms (dynamic gains).

Our analysis has some caveats. An important limitation is the limited panel coverage in most innovation surveys in the region. This shortcoming hinders the evaluation of market competition effects over time on firm innovation and productivity. Second, we are aware that most innovation investment takes mostly the form of technology acquisition (i.e., machinery and equipment, and ICT technologies). This represents more than 85 percent of firm innovation investments in Latin American firms (see Navarro et al., 2011). It is likely that competition may affect R&D investment (a sophisticated form of innovation investment) differently. It may be restricted to a segment of firms, since this type of investment is more costly, less certain in terms of returns compared to purchasing technology externally, and requires more specialized human capital.

Finally, the analysis of firm heterogeneity could be extended by looking at other ways in which firms compete, such as by distinguishing global competitors from local market-oriented firms and the interplay of competition and firm access to finance (credit constrains). Another avenue for further research is whether effects of competition differ when firms are less constrained financially.

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ANNEX

Table 1: Summary Statistics, Colombian Manufacturing Firms (2003–2016)

Variable	Obs	Mean	Std. Dev.	Min	Max
Innovation investment dummy (expenditures STI>0)	71,650	0.352	0.478	0	1
Boone Index (Sector Level 3-digit)	71,650	0.959	0.641	-0.01	4.36
Lerner Index (Sector Level 3-digit)	71,650	0.450	0.099	0.21	1.38
Boone Standardized Index	71,650	0.002	1.001	-1.51	5.31
Skills (White Collar % in Total)	63,005	0.282	0.187	0.00	1.00
Foreign Labor (%)	63,005	0.001	0.009	0.00	0.85
Exporting Firm (% of firms)	71,650	0.244	0.429	0.00	1.00
Firm Size	63,012	95.57	200.97	0.00	5598
Firm Gap (TFP)	62,148	0.679	0.224	0.000	1.00
Capital Intensity	62,978	11.674	1.773	0.00	18.76
Sanctioned Sectors	71,650	0.045	0.206	0.00	1.00
Sector Size (Output)	63,012	21.638	1.136	15.54	23.39
Sanctioned Sectors	71,650	0.061	0.239	0.00	1.00
Entry Costs	60,418	0.011	0.032	0.00	0.73
Import Penetration (Standardized)	54,891	-0.082	0.859	-0.80	4.98
Average Growth (four years)	71,650	0.001	0.012	-0.03	0.30

Table 2: Summary Statistics, Chilean Manufacturing Firms (2011–2016)

Variable	Obs	Mean	Std. Dev.	Min	Max
Innovation Investment (dummy)	3773	0.21	0.40	0.00	1.00
R&D engagement (dummy)	4,312	0.12	0.32	0.00	1.00
R&D intensity	4,305	0.12	1.41	0.00	40.00
Technology Purchasing Intensity	4,305	0.03	0.60	0.00	25.06
Competition (Boone)$_{t-1}$	4,312	1.22	0.60	0.12	3.67
Lerner Index	4,312	0.70	0.05	0.51	0.80
R&D per employee (thousands 2009 CH$)	4,292	6518.73	80197.43	0.00	2148910
Skills (% of with univ. & post-graduates)	4,312	0.24	0.28	0.00	1.88
Innovation Expenditures per employee (thousands 2009 CH$)	4,292	1847.44	43688.47	0.00	2119790
Age	4,312	2.97	0.66	0.00	5.60
Export Intensity	4,312	0.35	8.66	0.00	367.30
Firm Size EMP	3,608	210.21	549.42	2	7917
Young firm (with< 10 years)	4,312	0.15	0.36	0.00	1.00
Firm Gap (TFP)	4,312	0.23	0.60	-3.97	0.96
Multinational (Capital>=10%)	4,312	0.31	0.46	0.00	1.00
Group Affiliation (Dummy=1)	4,312	0.24	0.43	0.00	1.00
Exporting (Dummy=1)$_{t-1}$	4,312	0.29	0.45	0.00	1.00

Table 3: Competition Decisions, Sanctioned Cartels

Cartel	Firm	ISIC-4	ISIC-4 description	Date of statement of objections	Date of sanctions	Amount of the sanction
		1709	Manufacturing of other paper			
	Grupo Familia		and cardboard articles	August	June	22,981,833 USD
				4 of 2014	28 of 2016	
	Kimberly-Clark					
Diapers	Tecnoquimicas	1709				
		5811 and	Book publishing and printing			
	Carvajal Educacion	1811	activities	February	August	
						4,941,000 USD
			Other manufacturing	27 of 2015	18 of 2016	
	Kimberly Colpapel	3290	activities			9,881,667 USD
						3,906,667 USD
Notebooks	Scribe					
			Manufacturing of other			
	Riopaila	1790	paper and cardboard articles			
			Sugar processing and	February	December	
Refined	Manuelita	1071	refining	13 of 2012	20 of 2015	86,666,667 USD
sugar	Sugar guilds					
	Argos		Cement, lime and plaster			24,590,567 USD
			manufacturing	August	December	
	Holcim	2394				24,590,567 USD
Cement	Cemex			21 of 2013	11 of 2017	18,024,885 USD

Figure 1: Competition Evolution and Innovation Engagement

(% of firms involved), Colombian Manufacturing

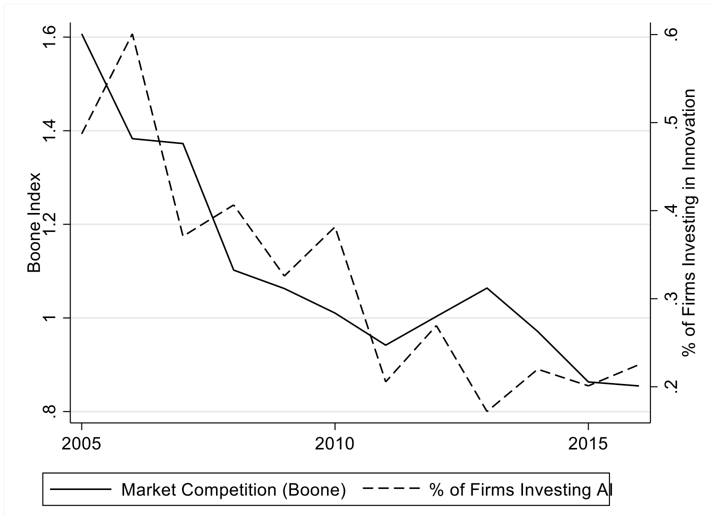
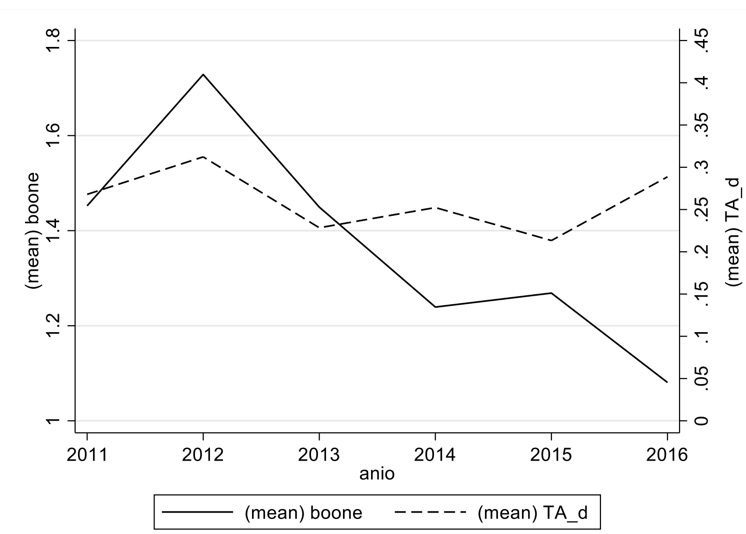


Figure 2: Competition Evolution and Innovation Engagement

(% of firms involved), Chilean Manufacturing



Notes: The Boone index was built with the EAIM (Colombia) and ENIA (Chile) data after trimming outliers and excluding industries with less than 20 employees; the yearly average index is the sector-weigthed indicator based on sales-based economic structure.

Figure 3: Market Competition and Innovation Engagement, Colombian Firms

(predicted linear probability of investment, panel IV-2SLS with FE)

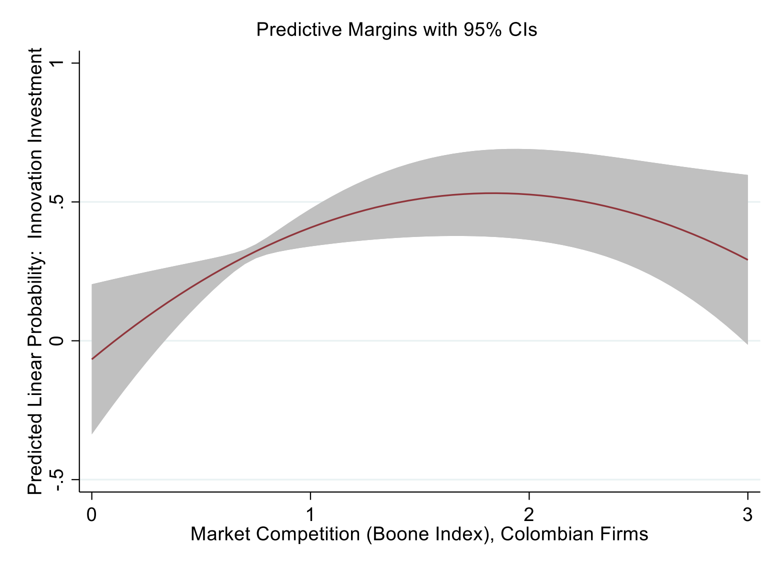


Figure 4: Market Competition and Innovation Engagement, Chilean Firms

(predicted linear probability of innovation investment, panel IV-2SLS with RE)

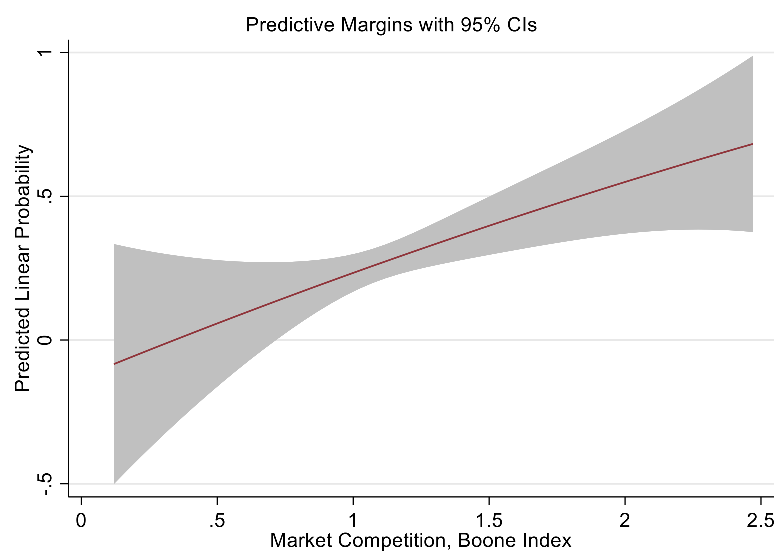
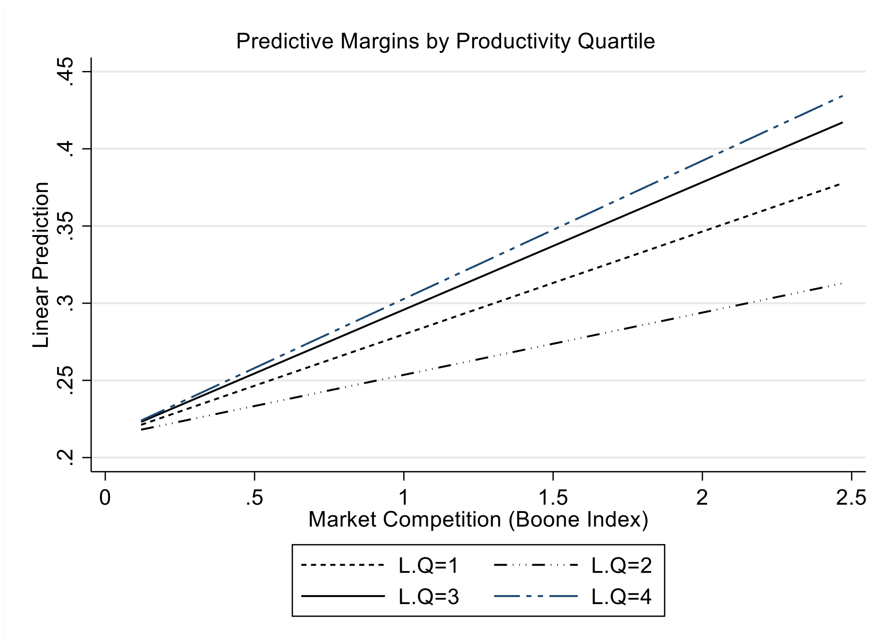


Figure 5: Innovation Investment Propensity per Productivity Quartile, Predictive Margins

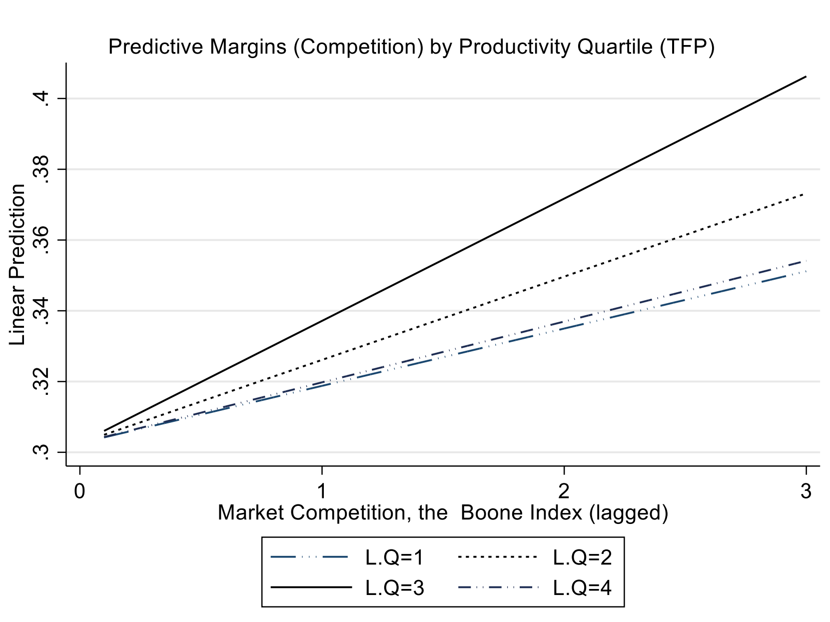
Chilean Manufacturing Firms



Notes: Predicted linear probability from base on panel probability linear model with fixed effects on the set of firms reporting at least four consecutive years of data. Market Competition lagged one period.

Figure 6: Innovation Investment Propensity per Productivity Quartile, Predictive Margins

Colombian Manufacturing Firms



Notes: Predicted linear probability from base on panel probability linear model with fixed effects on the set of firms reporting at least four consecutive years of data. Market Competition lagged one period.

Table 4: Second Stage Regressions: The Causal Effect of Competition on Innovation

Explained Variable: Innovation Investment Decision

	COLOMBIAN ENTERPRISES				CHILEAN ENTERPRISES			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	OLS	IV-2SLS	2SLS-FE	OLS	OLS	IV-2SLS	2SLS-FE
Market Competition	0.002	0.013	0.651***	0.419***	0.035**	0.114**	0.214*	0.237*
	(0.004)	(0.010)	(0.241)	(0.111)	(0.016)	(0.057)	(0.143)	(0.155)
Market Competition^2		-0.003	-0.177**	-0.108**		-0.03	-0.034	-0.074
		(0.003)	(0.073)	(0.044)		(0.021)	(0.050)	(0.053)
$Skills_{t-1}$	0.128***	0.128***	0.134***	0.029	0.045**	0.044**	0.043*	0.007
	(0.015)	(0.015)	(0.016)	(0.023)	(0.022)	(0.022)	(0.022)	(0.025)
Firm $Size_{t-1}$	0.102***	0.102***	0.107***	0.002	0.068**	0.068***	0.068***	0.002
	(0.003)	(0.003)	(0.003)	(0.007)	(0.01)	(0.01)	(0.01)	(0.03)
Exporting Firm	0.059***	0.059***	0.051***	0.005	0.064**	0.064***	0.063***	0.104**
	(0.006)	(0.006)	(0.007)	(0.007)	(0.022)	(0.022)	(0.022)	(0.042)
Firm Gap_{t-1}	-0.095***	-	-	-0.019	-	-	-0.059***	0.01
	(0.011)	(0.011)	(0.013)	(0.015)	(0.013)	(0.013)	(0.013)	(0.021)
$Multinational_{t-1}$	-0.226	-0.225	-0.208	0.236	0.036	0.035	0.04	0.026
	(0.169)	(0.170)	(0.200)	(0.229)	(0.038)	(0.038)	(0.065)	(0.113)
Firm Age					0.01	0.009	0.009	-0.043**
					(0.011)	(0.011)	(0.011)	(0.018)
Capital $Intensity_{t-1}$	0.010***	0.010***	0.013***	-0.015**				
	(0.002)	(0.002)	(0.002)	(0.006)				
Constant	0.379***	-	-		-0.238**	-0.165**	-0.311**	
	(0.069)	(0.028)	(0.137)		(0.119)	(0.066)	(0.141)	
Observations	62,121	62,121	52,183	51,836	4,139	4,139	4,139	2,543
R-squared	0.23	0.23	0.09	0.045	0.24	0.24	0.23	0.065
No. clusters (firms)	7,370	7,370	7,370	7,023	2,330	2,330	2,330	734
F Statistics 2nd			114.4***	145.1***			23.11***	22.617**
F Test of excluded			27.66	14.86			135.67	44.38
Stock-Yoho Weak IV			16.88	15.72			13.43	13.46
F-test first stage			37.01***	25.28***			154.38**	93.87***
F-test first stage			33.60***	16.26***			218.68**	335.15**
Hansen J Statistic			7.476	1.261			13.57	0.133
Endogeneity Chi-2			8.864**	15.03***			1.801**	8.17**

Notes: Robust standard errors clustered at the firm level (Colombia and Chile) and at the sector-level (Mexico). Regressions include sector (OLS and RE) and time dummies. Sector dummies and competition indicators are computed at the 3-digit level of the ISIC-4 classification for Colombia and Mexico; for Chile: at the 2-digit level of ISIC-4. p<0.1. The Hausman (FE vs. RE) Wald test for Colombian firms is: 415.5***, and for Chilean enterprises: 316.19.***. The regressions for Chilean enterprises also include three dummies indicating the level of severity of lack of finance for conducting innovation activities.
*** p<0.01, ** p<0.05, * p<0.10.

Table 5: First Stage Regressions: Competition-Enhancing Regulations

Explained Variable: Market Competition (Boone Profit Elasticity Index)

	COLOMBIAN FIRMS			CHILEAN ENTERPRISES		
	Competition		Comp.*Firm	Competitio	Competition*Firm	
	IV-2SLS (1)	IV-2SLS (2)	IV-2SLS FE (3)	IV-2SLS (4)	IV-2SLS (5)	IV-2SLS (6)
Competition Law	0.116***	0.230***	0.241***	---	----	----
	(0.022)	(0.035)	(0.045)	---	----	----
Sanctioned Sectors	-0.022**	----	----	---	----	----
	(0.012)					
Entry Costs$_{t-1}$	-	-	-0.926***	-0.639***	-0.085*	-0.226
	(0.141)	0.176	(0.198)	(0.135)	(0.336)	(0.256)
Market Size$_{t-1}$	-	-0.009	-0.017*	0.058***	0.059***	-0.056***
	(0.006)	(0.008)	(0.009)	(0.011)	(0.017)	(0.016)
Market Growth	-	-	-2.430**	---	----	----
	(0.665)	(0.807)	(0.982)			
2013 Entry Law	---	----	----	-0.281***	---	----
				(0.032)		
2013 Entry	---	----	----	9.641***	9.657***	0.220
				(0.622)	(0.843)	(0.830)
Constant	1.120			0.873***		
	(0.145)			(0.211)		
Observations	52,183	51,836	51,836	4139	2360	2543
R-squared	0.610	0.190	0.170	0.74	0.31	0.72
No of Clusters (Firms)	7,370	7,023	7,023	2330	705	734
Weak identification (F-	27.66	14.86	15.72	95.38	40.83	4.125
Hansen J Statistic	7.476	1.261	1.075	21.510	2.380	3.396
Anderson-Rubin Wald test	20.98***	20.11***	9.831*	22.49***	14.91*	5.65*
F-first stage	37.01***	25.28***	16.03***	95.38***	95.38***	9.67***
Endogeneity Chi2 Test	8.864**	15.03***	7.096**	8.063**	4.313*	1.343

Note: Robust standard errors clustered at the firm level (Colombia and Chile) and at the sector-level (Mexico). Regressions include sector and time dummies. Sector dummies and competition indicators are computed at the 3-digit level of the ISIC-4 classification for Colombia and Mexico; for Chile: at the 2-digit level of ISIC-4.
*** p<0.01, ** p<0.05, * p<0.1.

Table 6: Competition Effects: Heterogeneous Effects Across Firms and Within Industries

Explained Variable: Innovation Investment Decision

	COLOMBIAN ENTERPRISES (IV-2SLS FE)					CHILEAN ENTERPRISES (IV-2SLS FE)			
	(1)	(2)	(3)	(4)	(5)	(7)	(8)	(9)	(10)
Firm Gap $_{t-1}$	-0.006	-0.031	-0.020	-0.030**	-0.027*	-0.055	0.015	0.015	0.016
	(0.017)	(0.097)	(0.013)	(0.014)	(0.014)	(0.088)	(0.024)	(0.024)	-0.023
Competition	0.299***	0.239**	0.257***	0.323**		0.141*	-0.225	0.087	0.148**
	(0.088)	(0.115)	(0.083)	(0.134)		(0.074)	(0.219)	(0.159)	-0.073
Competition x Firm Gap$_{t-1}$	-0.397***	**-0.290***				0.050			
	(0.134)	**(0.172)**				(0.065)			
Competition^2*Firm Gap$_{t-1}$		0.024							
		(0.095)							
Sectoral Asymmetry (average gap)			0.134***				2.478		
			(0.051)				(1.394)		
Competition x Asymmetry (av. Gap)			-0.364***				-1.757*		
			(0.131)				(0.382)		
Sectoral Asymetry (std. Dev.)				-0.005				-0.020	
				(0.016)				(0.043)	
Competition x Asymmetry (std. Dev.)				-1.282**				0.011	
				(0.572)				(0.033)	
Competition x Leader (top 25%)					0.008				0.025
					(0.028)				(0.036)
Competition x Follower					0.049***				0.118**
					(0.017)				(0.068)
Leader (top 25%)					-0.002				0.087

					(0.006)				(0.082)
Observations	58,909	58,909	58,909	58,909	51,836	2,343	2,343	2,343	2343
R-squared	0.15	0.15	0.17	0.17	0.10	0.00	0.03	0.01	0.03
Number of firms	7,306	7,306	7,306	7,306	7,023	700	700	700	700
Weak Identification F-Test	4.445	3.956	81.68	70.67	7.281	28.19	11.27	28.75	40.23
Hansen J Test (Validity of IVs)	48.39	45.45	49.20	48.52	35.40	2.617	1.322	4.300	3.94
Endogeneity Chi2 Test	6.498**	9.295***	5.985**	7.264**	0.788*	7.082**	4.516*	4.597*	5.33*
Anderson-Rubin Wald test (Chi-2)	69.11**	70.17**	69.53**	69.30***	9.484***	8.18	4.61	8.61	8.13
F Statistics 2dn Stage	353.8**	324.6***	349.9***	350.21***	94.12***	3.457***	3.439***	3.207***	5.35***
F-stat. First stage (comp.)	154.07***	149.11***	131.3***	116.81***	125.52***	38.16**	11.23***	48.70***	21.35***
Fstat. First Stage (gap/asymmetry*comp.)	66.48***	66.37***	54.32***	118.13***	85.35***	17.64***	14.87***	35.72***	---

Note: Robust standard errors clustered at the firm level (Colombia and Chile) and at the sector-level (Mexico). *** p<0.01, ** p<0.05, * p<0.1

Table 7: Competition Effects by Productivity Quartile

Explained Variable: Innovation Investment Decision

	COLOMBIAN FIRMS		CHILEAN FIRMS	
	RE	FE	RE	FE
	(1)	(2)	(3)	(4)
Q1*Competition $_{t-1}$	0.040***	0.016**	0.040	0.067
	(0.006)	(0.007)	(0.033)	(0.039)
Q2*Competition $_{t-1}$	0.054***	0.024***	0.036	0.040
	(0.007)	(0.007)	(0.028)	(0.032)
Q3*Competition $_{t-1}$	0.069***	0.035***	0.056*	0.083**
	(0.007)	(0.007)	(0.033)	(0.034)
Q4*Competition $_{t-1}$	0.050***	0.017**	0.100***	0.090**
	(0.007)	(0.007)	(0.032)	(0.037)
Q1	-0.028**	-0.026*	-0.025	0.068
	(0.012)	(0.013)	(0.061)	(0.078)
Q2	-0.030***	-0.025**	0.015	0.089
	(0.012)	(0.012)	(0.060)	(0.072)
Q3	-0.030***	-0.027**	0.043	0.083
	(0.010)	(0.011)	(0.059)	(0.064)
Constant	0.529***	2.035***	-0.109	0.508***
	(0.029)	(0.045)	(0.120)	(0.183)
Observations	60,448	60,448	2,147	2,147
R-squared		0.15		0.09
Number of Firms	7,420	7,420	627	627

Table 8: Robustness Tests, Iv-2sls Regressions with Firm Fixed Effects

	COLOMBIAN FIRMS						CHILEAN FIRMS				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Firm Gap $_{t-1}$	-0.037***	-0.030**	-0.032**	-0.023**	-0.013	-0.009	-0.061***	-0.064***	-0.044***	-0.042***	-0.040***
	(0.011)	(0.014)	(0.014)	(0.012)	(0.015)	(0.014)	(0.016)	(0.016)	(0.011)	(0.015)	(0.012)
Competition	0.220***	0.181***	0.184***	0.135***	0.140***	0.209**	0.241*	0.154**	0.135*	0.126*	0.187
	(0.013)	(0.015)	(0.015)	(0.013)	(0.050)	(0.085)	(0.078)	(0.078)	(0.074)	(0.083)	(0.139)
Competition^2	-0.018***	-0.038***	-0.039***	-0.027***	-0.003	-0.011	-0.036	-0.039*	-0.037*	-0.034	-0.025
	(0.006)	(0.007)	(0.007)	(0.006)	(0.007)	(0.008)	(0.023)	(0.023)	(0.021)	(0.022)	(0.026)
Entry Rate $_{t-1}$		0.103***	0.101***	0.073***				0.299*	0.271[a]	0.278[a]	0.280 [a]
		(0.007)	(0.007)	(0.006)				(0.183)	(0.192)	(0.194)	(0.195)
Import Penetration $_{t-1}$			0.093***	0.082***	0.053**	0.059**	---	---	---	---	---
			(0.031)	(0.026)	(0.025)	(0.026)	---	---	---	---	---
Innovation Dummy $_{t-1}$				0.296***	0.513***	0.557***		---	0.176***	0.175***	0.176***
				(0.005)	(0.077)	(0.081)			(0.029)	(0.029)	(0.030)
Firm Gap $_{t-1}$*Competition					-0.179**					0.036	
					(0.074)					(0.075)	
Sector Gap $_{t-1}$*Competition						-0.277**					-0.269*
						(0.122)					(0.597)
Sector Gap $_{t-1}$						-0.008					0.296
						(0.061)					(0.905)
Observations	60,852	60,852	60,283	60,283	43,964	43,964	2,368	2,201	2,201	2,201	2,201
R-squared	0.05	0.09	0.09	0.18	0.01	0.05	0.08	0.08	0.11	0.11	0.11
No. of Companies	7,584	7,584	7,545	7,545	6,439	6,439	681	652	652	652	652
F Test -excluded instrum.	46.29	45.07	39.62	39.60	36.86	6.097	191.8	176.5	149.8	15.849	159.5
Stock-Yogo ID test values (5%)[b]	21.03	21.05	21.03	21.05	----	---	20.48	20.48	20.65	19.94	19.77
Hansen-J Test	430.22	483.5	471.1	348.5	44.29	42.95	25.46	20.18	23.10	24.29	22.55

Endogeneity Chi2 Test	58.26***	58.62***	59.60***	32.43***	13.03***	16.08***	5.327**	5.044**	5.026**	4.257	3.463
F Statistics 2dn Stage	322.4***	260.8***	244.2***	538.2***	236.8***	212.5***	8.781	6.886	9.722	9.114	9.103
F-first stage (Competition)	96.52***	107.57***	104.50***	106.90***	114.31***	125.06***	223.52***	204.71***	186.85***	188.58***	203.61***
F-first stage (Competition^2)	57.47***	55.63***	59.97***	45.78***	50.79***	52.48***	419.61**	332.42***	378.46***	352.22***	384.35***

Notes: All regressions include the same set of control variables as in Table 4. b: We report the critical values of the SY test considering a 5% maximal IV relative bias; the F-statistics (excluded instruments) should be larger than critical value. Robust standard errors in parentheses clustered at the firm level. In the regressions for Colombia firms, we use the following instrumental variables: Regressions (1)-(2) and ((7)-(8) include a dummy for sectors where a sanction was issued for anti-competitive behavior (=1 after the year of sanction), the size of the sector (total sales in each 3-digit industry) in t-1, the average growth of production (3-digit) over the last four years, plus entry cost in t-1. In the regressions (3)-(6) which include the lagged dependent variable we use 2SLS with GMM estimation. The lagged dependent variable is instrumented with the same set of excluded instruments plus the dependent variable in t-2. For the Chilean firms, the regressions in columns (7)-(8) use the same set of instruments as previously (see Table 4). In columns -11, we instrument the lagged innovation variable with the average proportion of firms engaged in any innovation activity in the same sector (t-1) plus the proportion of firms that received any public funding for innovation activities (t-1), in addition to the baseline set of instruments. Interaction terms are instrumented with the baseline set of instruments interacted with firm gap, and sector asymmetry (Wooldridge, 2013). *** p<0.01, ** p<0.05, * p<0.1. Superscript a: p< 0.15.