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How does market competition affect firm innovation incentives in emerging countries? Evidence from Latin American firms

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Abstract

The role of market competition on firm innovation remains a controversial policy question, especially in the context of developing countries. This paper presents new empirical evidence about the impact of market competition on firm innovation engagement in Colombian and Chilean manufacturing industries. We correct for the endogeneity of market competition using instruments proxying entry costs and policy interventions (i.e. competition decisions and entry law reforms), our results are like those of developed countries. Market competition increases firm propensity to invest in innovation in manufacturing enterprises and this relationship is linear in Chilean while in Colombian industries it takes the form of an inversed-U shape relation. The impact of competition is decreasing with the level of sector asymmetry -as preconised in the literature, while the impact of firm distance to the frontier affects firm innovation engagement differently in the two countries. In Chile, competition raises innovation incentives for the third and fourth productivity quartiles while no impact is found for firms in the first (bottom) two quartiles. In contrast, in Colombia market competition raises innovation engagement across regardless their firm productivity position but effects are stronger in the medium range (second and third quartiles). Our main results are robust to controlling for past innovation engagement, import competition and business dynamics.

Key words: Market Competition, Innovation, Technology Purchasing, Productivity, Latin American Firms

JEL: O32, D41, O47, D24

INTRODUCTION

Competition is a major engine of productivity growth and an intense empirical research recurrently corroborates this impact (see reviews by Holmes and Schmidt, 2010; Van Reenen, 2011). Several mechanisms are at play. Firstly, competition acts as a disciplining device within firms, placing pressure on the managers of firms to become more efficient, 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. And thirdly, 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 recognised as a major determinant of firm productivity, how this happens, and the ways competition affect firms' innovation incentives are still subject to debate. In this paper we analyse the impact of market competition on firm innovation. Following the studies of Scherer (1965; 1967) and Kamien and Swartz (1982), research by Aghion et al., (2005) postulated a non-linear 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, technological symmetry among firms, and the distance from the technological frontier (see also Acemoglu et al., 2006; Aghion et al., 2009). Accordingly, more intense competition enhances innovation incentives in "frontier" and symmetrical firms -where "escape competition" incentives will prevail (e.g., Arrow, 1960; Scherer, 1967)- but may discourage it in "non-frontier" firms and lagging sectors (Schumpeter, 1942).

For firms and industries in developing countries, the impact of market competition and what type of forces will dominate and for which firms, are still unclear empirically. For developing countries, economic theory mostly predicts that negative effects ("Schumpeterian "discouraging" innovation effects plus "business stealing") would overcome innovation motivations given the very large disparity within industries (i.e., Klinder and Lederman, 2011); their large share in the economy and the distance of industrial from the global frontier (i.e. Hausman and Rodrick, 2005). These "discouraging effects" could be exacerbated if other policy failures for business innovation prevail such as the lack of finance and the severity of financial constraints (Galle, 2020; Yang and Pan, 2018) and other restrictions for resource allocation persist (e.g., Driffield *et al.,* 2013; Andrews *et al.,* 2018). Yet recent research reinforces the arguments about the dominance of "escape-competition" effects -encouraging firm innovation. Innovation incentives from competition increase in the context of global markets due to the additional effects raised by (expanded) market size and spillovers (Aghion *et al.,* 2019; Ackdigit *et al.,* 2018); and in contestable markets -with free firm entry and exit (e.g. Federico *et al*., 2019).

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 effects 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 evaluate the hypothesis of a non-linear relationship and test whether "competition-escaping" incentives or the incentives to innovate to preserve market leadership predominate over "Schumpeterian" reactions which relate to discouraging (negative) incentives to innovate because it becomes more costly to engage in innovation (ibid). According to theory, the negative incentives to innovate will increase with firm distance to the technology frontier and will decrease in industries where technology rivalry among firms is strong (similar productivity competences). As measures of market competition, we use the profit elasticity index or "Boone Index" (Boone, 2006; Boone *et al.,* 2008), which is a more reliable indicator than traditional measures of competition (Herfindahl and Profit-Margin indicators or Lerner indexes). We implement instrumental variables with two-stage estimation and use measures of sector entry costs (e.g. Sutton, 1991; Vives, 2008), and competition policy interventions as instruments to correct for the endogeneity of market competition (i.e., Aghion et al., 2005; Griffith et al., 2010). The latter are assumed to introduce structural changes in market conditions and correct for anti-competitive behaviour.

There are several reasons why we should look at these questions in Latin American firms. First, the evidence on the links between innovation and market competition is quite scarce for these countries. A better understanding of how competition impacts firms´ innovation behaviour is crucial given the persistent lack of productivity growth in the region (Blyde and Fentanes, 2019; OECD, 2021). In addition, international benchmarking studies and surveys indicate that lack of competition and the prevalence of entry barriers remains a major issue for competitiveness in the region. This is reflected, for instance, in the rankings of the Doing Business indicators and the country reviews assessment of competition policy (e.g. the OECD Review of Competition for Mexico (2018) and Costa Rica (2017)). Accordingly, competition restrictions (e.g. sectoral regulations) and anti-competitive practices remain substantial in several industries whereas entry barriers (and exit) barriers persist (e.g. tax systems, entry regulations, bankruptcy laws, etc.). There are other additional reasons why it is timely and necessary to conduct this research. The rise of new technological paradigms such as digital technologies and the fourth industrial revolution risks to further widen the technological gaps among firms and between countries (see Calligaris *et al.,* 2018). If market concentration slows-down innovation and technology diffusion towards laggard firms and sectors (e.g. Andrews *et al.,* 2018), productivity gaps risk to increase, pulling down aggregate productivity.

Our results show that market competition increase firm propensity to invest in innovation activities in Chilean and Colombian enterprise; while this relationship is linear in Chile, an inversed U-shaped relation emerges in the case of Colombian firms. In line with the literature, the impact of competition is decreasing with the level of sector asymmetry while the impact of firm distance to the frontier affects firm innovation engagement differently in the two countries. We find heterogeneous effects across the firm productivity distribution with stronger and more significant responses found in the medium range of the productivity distribution. Thus, we partially confirmed the postulates advanced from the literature (i.e., Aghion *et al.,* (2005) and Acemoglu et al., (2016) regarding firm distance to the technological frontier and we found distinctive responses across these two countries. In Chile, competition raises innovation incentives for the third and fourth productivity quartiles while no impact is found for firms in the first (bottom) two quartiles. In contrast, in Colombia market competition raises innovation engagement across regardless their firm productivity position but effects are stronger in the medium range -i.e., second and third quartiles. Our results are robust to controlling for past innovation engagement, import competition and business dynamics.

This paper is structured as follows. In the first section, we briefly review the literature and summarise the key messages from past research on the links between competition and innovation and identifies main findings from Latin American countries. The second section present our models and empirical strategy. Section 3 first describes the evolution of competition in manufacturing industries and reports our results. Section 4 reports our robustness tests. The final section summarises our main findings and concludes.

I. INNOVATION AND COMPETITION: WHAT WE KNOW

The relationship between the intensity of competition and the rate of technical progress has been investigated in both 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, 1986; 1990; Aghion and Howitt, 1992) and the industrial organisation literature (Reinganum, 1989). Traditional arguments date back to Schumpeter (1942) and Arrow (1962). According to the former (Schumpeter,1942; 1943), 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 already have while firms under a regime of competition would gain the full return of innovation as they would not lose any monopoly profit. Thus, competition promotes innovation especially if 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) technology 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.[3]

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-to-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.[4] The farther firms are from the technology frontier (and the larger their share in industries), the more negative effects would dominate 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).

[3]Technological progress by leaders and followers takes place step-by-step and not through automatic leap-frogging -as defined in previous research.

[4] 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 affect ex-post profits from innovating.

The concept of distance to the technology distance to the frontier ("technology gap") is central to the analysis of the competition-innovation nexus. As confirmed in neo-Schumpeterian growth theories (Howitt and Mayer-Foulkes, 2005; Acemoglu, Aghion and Zilibotti, 2006) and new trade theories of the firm (e.g. Metz, 2003), a greater heterogeneity in the technical efficiency of firms reduces the marginal positive impact of market competition on firms´ innovation efforts. Accordingly, firms (industries/countries) farther from the productivity frontier would find difficult to invest in innovation (especially in R&D) given the costs of entry in technology as opposed to investing in factor accumulation; selection effects from competition would be rather weak. As countries approach to the frontier, the marginal effects of investing in innovation increase and more important is the selection process. Hausman and Rodrick (2005) also stressed the potential negative effects that could arise from competition given the higher costs for resources, which are exacerbated by the weak appropriability regime that often prevails in developing countries; this in turn means low returns to investing in innovation (see also Klinder and Lederman, 2011). 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 neutralise potential innovation incentives from competition.

The theoretical postulates by Aghion et al., (2005) has encountered limitations both theoretically and empirically. According to Federico, Morton and Shapiro (2019) the notion of an inverse U-shaped relationship between competition and innovation is not only empirically, but also theoretically invalid. First, their model is solved in closed economy with steady state. If we consider market contestability -free entry and exit-, stronger competition in the sense of stronger contestability in future sales, unambiguously leads to more innovation (ibid). This is because in contestable markets, future sales will be won by the most innovative firm regardless of their market position.

The Empirical Evidence

Empirically, academic research tends to confirm a positive relationship between competition and innovation contradicting the Schumpeterian argument.[5] The works of Blundell *et al*. (1999), Van Reenen *et al.* (2000) or Griffith *et al.,* (2010), and many others confirmed a positive linear relationship. For UK companies, Blundell *et al.* (1999) find that companies that innovate the less

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

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 an increase in R&D investment in industries.[6] These studies conceived the relationship between competition and innovation as linear.

Initial reflections on the potential non-linearity of this relationship were provided empirically by Scherer (1984) and Levin et al., (1985) with data from US firms. Since the seminal paper of Aghion *et al.,* (2005), many studies have evaluated whether this non-linear 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.[7] 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 (e.g. accession to the European Union market and deregulatory changes). This relationship was found steeper for neck-to-neck industries. In a follow-up work, Aghion *et al.,* (2009), find that the threat of technologically advanced entry (proxied by foreign entry greenfield) spurs innovation in sectors close to the technology frontier but discourses it in laggard sectors (Aguion *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 preconised by Aghion et al., (2005). Empirical examinations on American firms (e.g. Hashmi, 2013; Correa, 2012; Correa and Ornagui, 2014), for French manufacturing firms (Askenazy et al., 2013), Canadien firms (Berube et al., 2012), and Portuguese companies (Santos et al., 2018) report a positive linear positive connection; whereas 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; not for small enterprises. They also found that the curve flattens when the relative cost of R&D increases. For the US, Correa (2012) finds that a positive relation prevails during the period 1973-1982 but this relation turns non-significant after the introduction of the US Court of Appeals (CAFC) in 1982,

[6] Other studies that support this intuition are Nickell (1996); Carlin et al. (2004), and Correa and Ornaghi (2014).

[7] 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).

which significantly change patent protection. Furthermore, results may diverge depending on the type of competition indicator used (i.e., Polder and Veldhuizen, 2012) and timeframes (Correa, 2012).

Until a few years ago, most of the empirical research on market competition and innovation has focused on developed countries. Recent cross-country studies tend to suggest a positive impact of market competition on firm innovation. 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 affects positively 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) finds a positive impact of competition on firm R&D engagement but this impact decreases with the number of competitors. In a cross-country analysis, Bloom and Reenen (2010); Van Reenen (2013) find overall positive effect of competition on the adoption of better managerial technologies, although this result appears somewhat less robust for firms from lagging countries (Maloney and Sarrias, 2014; Campuzano and Alvarez, 2017).

More consistent findings are reported by studies evaluating the impact of trade on productivity and technology upgrading. These recurrently report a positive (mostly linear) impact of trade shocks or import competition on firm productivity and technology-upgrading activities and aggregate productivity gains. Several studies have found important reallocation effects experienced after liberalisation in the medium run (see Pavnick (2002) for Chile and 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, i.e. with high import competition exposure, and where initial competition is low. See for instance the work of Bustos (2011) for Argentina; Pavnick (2002); Álvarez and Robertson (2004) and Bergoing et al., (2010) for Chile; Fernandes (2003) for Colombia and by Amiti and Konings (2007) for Indonesia. Yet the negative predictions for lagging firms/countries is well supported by the microeconomic evidence on market (regulatory) reforms and trade studies (e.g. Bustos, 2011; Amiti and Khandelwal, 2013; Ding et al., 2016) and growth studies (i.e. Acemoglou *et al.,* 2006). The negative effect could be explained by firm technological conditions, e.g. laggards may be less able to absorb R&D, not able to scale-up and benefit from synergies (Haskel and Westlake, 2017); they could also be more financially dependent. which countervails innovation incentives from competition.

For Mexican firms, the empirical evidence suggests that manufacturing firms responded positively to Chinese import competition in a variety of innovation and technology adoption activities (e.g. Iacavone et al., 2013; Blyde and Fentanes, 2019). Meza-Gonzalez and Sepulveda (2019) found a U-curved shape influence of foreign competition on innovation in Mexican manufacturing firms during the 2012- 2013 period. However, they concluded that the Schumpeterian "escaping-competition effect" predominates in Mexico as much of the estimate points were in the positive side of the curve. Iacovone *et al.,* (2013) find that import penetration from China has a positive impact on firm innovation and productivity; but this response is mostly driven by large and more efficient firms whereas negative effects prevailed in small ones and lagging sectors. These have been in fact the observed trends in manufacturing in Mexico and Chile over the last two decades; with rising import penetration firm employment has decreased while exists have multiplied.[8] 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 TFP distribution; no significant responses were detected in the rest of firms.

II. THE DATA

We use firm-level data from national industrial Census 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 and it includes all the manufacturing firms in the country with more than 10 workers and more than 180,000 USD of production value (at 2016 prices). An additional advantage of using this data is that the EAM is mirrored with the national innovation survey. Since 2003 the National Statistics Institute (DANE) has conducted the national innovation survey (EDIT) using the same EAM´s business directory. The completed database is an unbalanced panel made of 11,941 firms for a total of 14 years (from 2003 to 2016) and 95,046 observations. For Colombia, once data is merged with competition data and outliers excluded, we ended with around 60,000 observations, for an average of 6300 enterprises per year.

For Chile, we use two firm-level surveys. First, we use the National Industry Survey (ENIA from its acronyms in Spanish), which is pretty much a census of the manufacturing industry. We use the panel dataset available for the years 2003-2015. Given its coverage, we compute our

[8] See empirical studies by Blyde and Fentanes (2019) and Hale and Torres Ruiz (2013) for Mexico; Bergoing et al., (2010) for Chilean firms.

competition productivity indicators (average industry gap and productivity dispersion) with this data (which is available at the 3-digit levels of ISIC. Rev.3 and 4). Innovation investment activities is only available in the national innovation survey. Thus, for regression analysis, we are constrained to use the Enterprise Innovation Survey (*Encuesta Innovacion de Empresas*), which is a nationally representative survey of Chilean establishments, conducted by the Chilean National Statistical Agency. As opposed to ENIA, the 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 wage (212 firms).[9] We use the last three survey waves: the 8th Innovation Survey (2011-2012), the 9th Innovation Survey (2013-14) and the 10th Enterprise Innovation Survey (2015-2016).

Given that each of the waves include questions (i.e. R&D investment, innovation activities, personal 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). We have at least two points in time for each firm. We have harmonised the industry classifications across the three innovation surveys 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). For Chile, from the merging of the different innovation surveys, and the merging with market competition indicators from the Industrial Survey (ENIA) (at the two-digit level), we ended with 1150 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). Given that the industry structure (sample design) somewhat changes across waves our panels for Chile are not nested in terms of industry clusters. In the two country datasets, we trimmed our data and excluded firm-level outliers based on productivity distributions (bottom 1% and top-1% in the productivity distribution).

III. THE 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:

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

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

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

where C_{jt-1} is the competition variable (Boone index) at the 3-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 specific industry-specific changes and shocks (technological or economical) 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 this 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 hypothesis of inverted-U, 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. 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 the 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; Cohen 2010; Gorodinchenko et al., 2011).

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; 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% and a dummy for firms belonging to a group. In the Colombian data, our proxy for foreign ownership refers to the proportion of foreign labor in total employment; although is an imperfect measure, we can assume that those firms with employees from foreign origin (white collar) are multinational corporations.

Our analysis differs from the one of Aghion *et al.* (2005) and Hashmi (2013), and other studies for developed countries who used patents or R&D investment as main explained variables. We use a broader definition of innovation activity. For Chilean firms, the innovation surveys uses 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 like (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) firm unobservable firm attributes.[10] 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 the linear probability models is that heteroscedasticity is almost invariably present, and the fact 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

[10] Using the LPM has three main drawbacks: The effect ΔP(y=1|X=x0+Δx)ΔP(y=1|X=x0+Δx) is always constant; the error term is by definition heteroscedastic by definition, and OLS does not bound the predicted probability in the unit interval.

ways. We exclude outliers in key variables of interest (bottom 1% and 99% percentile in productivity and sales in the innovation survey dataset). We implement fixed effects estimation with instrumental variables and panel regression (fixed effects) for some equations (i.e. interactions per quartile).

3.1 The measurement of market competition

As indicators of market computation, we use the Boone index as in Boone (2008; 2010) 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 (2000; 2001) and Boone *et al.* (2007) and it has been proven to be a more reliable measure compared to traditional indicators such as the Lerner or the Herfindahl-Hirschman index. The superiority of the Boone indicator relies in the fact that it incorporates heterogeneity in firm efficiency to measure profit-cost elasticity through econometric estimation.[11] The main idea is that competition rewards 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, there is a reallocation of output from less efficient to more efficient firms (i.e. 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) and can be recovered by coefficient β_1 for each sector *j* and year *t* in the following regression:

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

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 in estimation 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 3 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

[11] Traditional indicators of competition such as market share or markups 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, 2008).

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 assets 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 which are less influenced by outliers, we excluded industries with less than 20 firms. In addition, in the industrial surveys we exclude outliers based on the productivity distribution dropping the top 99% and bottom 1% of the TFP distribution.

As total variable cost is negatively related to with 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 amore interpretable estimator. Thus, a higher value for the Boone index indicates a greater sensitivity of firm profits to cost and therefore higher competition intensity.[12] To ensure robust Boone index estimates less influenced by outliers and small industry sizes, industries with less than 20 firms are dropped.

For comparison purposes, we also use the Lerner Index (price-cost margin) and the Herfindahl-Hirschman Index (HHI) as alternative market competition indictors, for purposes of comparison. For Mexico and Chile, we calculate the Lerner Profitability Index (Lerner, 1934) as follows:

$$Li_{it} = \frac{(OP_{it} - FC_{it})}{sales_{it}} \quad (5)$$

where Li_{it} is the profit costs margin index in firm *i* in time *t*, and operating profit corresponds to the total income which is the sum of national and international income minus total cost of production. The Lerner index ranges from 0 in situation of perfect competition to the inverse of the price elasticity of demand in situation of monopoly or collusion. FC are financial costs and is calculated as $FC = (FAC_{it} * 0.085) - AD_{it}$, where FAC_{it} corresponds to fixed asset cost, 0.085 which is assumed to be the cost of capital as in Aghion *et al* (2005) and AD_{it} correspond to asset depreciation. The competition index is the average of the li_{it} across firms for each subsector: $C_{jt} = 1 - \frac{1}{N_{jt}} \sum_{i \in J} Li_{it}$ where N_{jt} corresponds to the number of firms in each subsector *j.* It must be noted that PCM indicators suffer from several imitations (see Stiglitz, 1989; Amir, 2003, among others), such as misleading trends in small markets; poorly capturing geographical market power, etc. The

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

competition index at industry level is defined as the inverse of the Lerner index (1-PCM); so that values approaching zero indicate some degree of market power.

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 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 Pavcnick (2002), it is important to incorporate dynamics like firm exit in the productivity (innovation) analysis in order to correct for the selection problem induced by existing firms (see also Amiti and Konings, 2007).

3.1. Endogeneity and Identification Strategy

Competition might be weakly exogenous to innovation at both the firm and 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 reduce competition, the estimates will be biased towards finding a more negative (or less positive) relationship between competition and innovation.

For all these problems, we can apply instrumental variables (IV) estimations 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. Author et al., 2016). Several authors have used structural policy changes and regulatory reforms altering competition conditions in markets/industries (i.e., Aguion et al., 2005; Bloom et al., 2016).

We use two types of IVs which are assumed exogenous to the system but correlated to innovation. 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 designate a dummy equal to one for industries (at the 3-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. We are thus conducting a differences-in-differences (DIF) estimation.

Entry barriers is a measure of set-up costs following Sutton (1991) (see also Vives, 2008; Beneito *et al.,* 2015). This variable is defined as the output share of an industry's median-size firm multiplied by the average capital-output ratio in each of the sectors (2-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 set-up 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 last 3 years.

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 the *Law 20,659)* for the creation of new firms in one single day. By using this reform as instrument, we account for such structural policy change in the business environment. 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 much 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.[13]

[13] As alternative instrument, we also used 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; Autor et al., (2013; 2016). Although this instrument was expected to influence

The use of policy interventions has been already tested in previous studies (i.e, Griffith et al., 2010; Aghion et al., 2005; 2009). Grifitt et al., (2010) and Aghion et al., (2009) used (UK) Competition Authority decisions that culminated in competition policy interventions in sectors to instrument the Lerner index. They also used trade reforms (sector-level) introduced by the market integration to the European Union and privatisation reforms. Further, in a cross-country study, Buccirossi *et al.,* (2013) provide strong evidence of policy complementarities between competition policy and law enforcement to foster productivity growth in industries. This exercise allows us to test the effectiveness of such policy interventions in improving competition conditions.

Competition law and its enforcement have substantially improved during the last two decades in these countries. During the 2010s, several reforms strengthened the legal and institutional capacity of the competition authority in Colombia. In 2009 the Colombian Competition Authority (SIC, for its acronym in Spanish) suffered a radical change. Its budget increased, it was conceded 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 to free competition increased substantially, moving from a maximum of 500 thousand dollars to 25 million dollars. All these reforms led to a significant increase in the number of sanctioned firms and amounts in penalties (SIC, 2018). Several cartels have been unmasked. They have been found in large economic sectors such as printing and paper industries, cement, sugar, and cattle.[14]

3.2 Technology Distance and the role of Asymmetry

In line with Aghion *et al.* (2005), we evaluate whether the impact of competition is subject to non-linearities related to firms´ technology gap and the level of technological asymmetry within sectors. As in Aghion *et al*., this is proxied by the "average technological gap" in industries and its interaction with competition. For the three countries (Colombia, Mexico, and Chile), we estimate total factor productivity (TFP) at the firm level following the methodology of Levinson 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 as leaders as those firms being at the top 5% of the TFP distribution in each sector-

market competition and a good instrument (given its orthogonality), it was found non-significant in explaining the Boone index.

[14] 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).

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% (for leaders) and 99.99% percent, with higher values reflecting closeness to the frontier. In the case of Chile, we use sector-level dispersion indicators computed directly from the Industrial Survey; however, for the computation of firm-level productivity measures we are constrained to use labor productivity (sales over employees) since no information on fixed assets and variables costs are available in the national innovation surveys and there is no identifier available to link the industry survey with the innovation surveys.[15] We also tested three-year averages to alleviate business cycle effects and reduce potential measurement errors; results were only significant with the first definition.

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; calculated each for every sector-year combinations. We interact these indicators with the competition measures to evaluate whether negative responses predominate with productivity dispersion. A similar exercise consists in interacting competition with a dummy denoting symmetrical sector (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 non-linear curve.

IV. THE RESULTS

Tables 1-3 report summary statistics for the three country samples. **Figures 1 and 2 d**isplay 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. During the years 2003-2006, about half of the firm population in manufacture declared to have invested in some type of innovation activity -i.e.,

[15] Please notice that we cannot 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: case of Chile and Mexico). Our indicators on productivity dispersion and average gaps were built with the Industry Surveys.

related to expenditures on science, technology services or other forms of innovation- whereas in 2015-16 this figure was 20% (**Figure 1**). According to the Boone index, market competition in Colombian sectors has been cut by half during this period.[16] In Chile, the Boone index decreased 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 formalisation prevail. In terms of innovation engagement, the proportion of firms investing in innovation activities remains pretty much the same between 2011 and 2016 -with a temporary increase in the middle of the period.

Figure 1: Competition Evolution and Innovation Engagement
(% of firms involved), Colombian Manufacturing

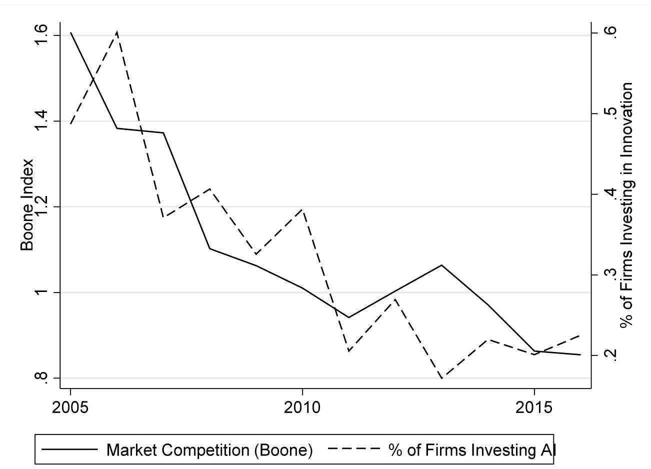
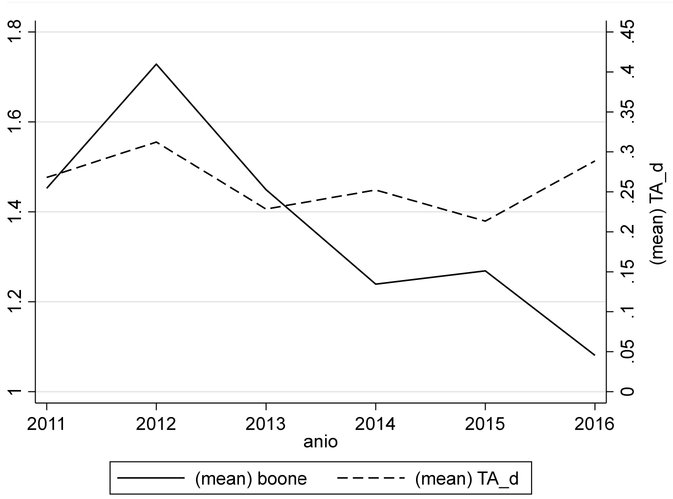


Figure 2: Competition Evolution and Innovation Engagement
(% of firms involved), Chilean Manufacturing



Note: 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.

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 a vis the leaders (within sectors), and a deterioration of average firm productivity. It has been emphasised that much of this productivity weakness is driven by busines polarisation - i.e. long tail of micro and small firms with considerably weak productivity performance. In

[16] Recall that the Boone index (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.

Colombian sectors, the average firm gap has remained pretty much the same (65-68%) over the last decade whereas in Chile it has increased substantially, reaching an average of 75% (with respect to leaders or top 5%) by 2016.[17] The average firm-level gap in Colombian manufacture is 67% (with respect to the median in the group of leaders). These dramatic levels of asymmetry have been previously documented by several studies (i.e., OECD (2021).

Table 1 here below reports our results with OLS and 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 non-linear relationship in the case of 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 enterprises, 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 raised 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-sage least squares with instrumental variables is largely justified by the different statistical tests on the orthogonality of IVs and significance of excluded instruments. The Chi2 tests to evaluate the endogeneity of competition (and squared terms) confirm that competition is weakly exogenous and should therefore be instrumented. The Ho (Chi2) tests on the lack of significance of firsts stage residuals (for competition variables) is rejected at 1% level probability in the different samples.[18] The F-test of first stage regressions confirm that our set of instrumental variables (IVs) are jointly significant and strongly correlated to competition whereas the Hansen-J tests -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).

[17] The 0.73 Colombian technological spread surpasses the average firm gap reported for firms in OECD countries: e.g. in Canadian firms: 0.47 (Bérubé et al., 2012), American: 0.49 (Hashmi, 2013) and British: 0.49 (Aghion et al., 2005).

[18] 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.

Table 1: SECOND STAGE REGRESSIONS: THE CAUSAL EFFECT OF COMPETITION ON FIRM 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***	-0.095***	-0.096***	-0.019	-0.058***	-0.058***	-0.059***	0.01
	(0.011)	(0.011)	(0.013)	(0.015)	(0.013)	(0.013)	(0.013)	(0.021)
Multinational intensity$_{t-1}$	-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***	-0.271***	-0.675***		-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 2dn Stage			114.4***	145.1***			23.11***	22.617***
F Test of excluded			27.66	14.86			135.67	44.38
Stock-Yoho Weak IV (5-			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 Chi2 Test			8.864**	15.03***			1.801**	8.17**

Note: 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.

In addition, our F-statistics from the first-stage regressions are in line with the Staiger and Stock's rule of thumb that require that these Fisher-values should be larger than 10 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% accepted IV bias; which allows for robust inference with instrumented competition coefficients.[19]

Figures 3 and 4 display graphically the predicted linear probability of innovation engagement vis-a-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 point of inflexion 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 2015-16 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 uncovers 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% 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% (t-stat=1.49 and p-val=0.10). It should be noticed that with fixed-effects estimation the number of firms drops substantially, moving from 2,330 in pooled regressions to 734 firms.[20]

The sign of coefficients in the control variables are largely in line with previous research. Innovation investment decisions by firms is influenced by the intensity of skills in employment (the

[19] 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% (Stock-You test critical values), of 14.56 (15.72 in panel).

[20] 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).

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; Arza et al., 2011; Crespi et al., 2015). In contrast, the farther 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 by 6.5% and 4%, in Colombian ad Chilean firms, respectively.

Figure 3: Market Competition and Innovation Engagement, Colombian Firms

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

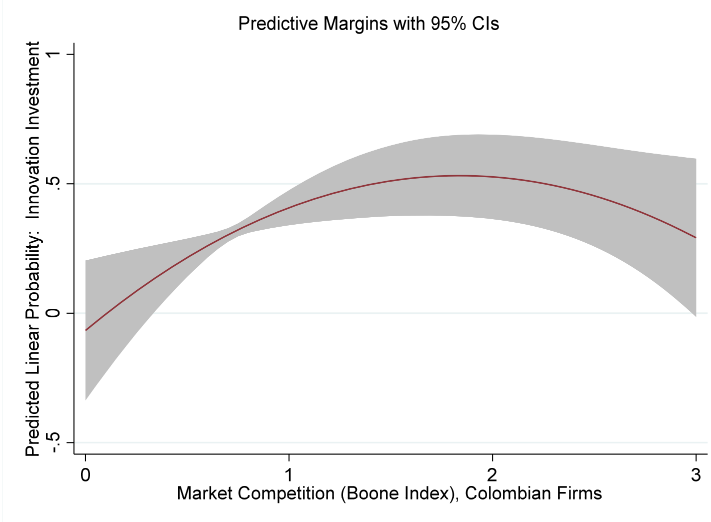
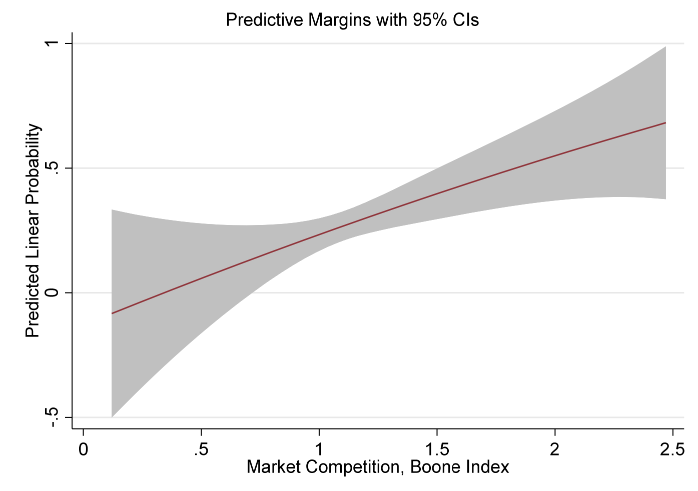


Figure 4: Market Competition and Innovation Engagement, Chilean Firms

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



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 (% in capital). Another interesting finding is the different innovation behaviour between exporters and non-exporting firms. According to estimates reported by IV-2SLS in column (3), a Colombian firm who has been an exporter over the last two years has a 6% larger probability to invest in innovation than firms who 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% 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). It must be noted that when we use 2SLS-FE panel regression, the significance of several coefficients fades away.

4.1 First stage regressions: the importance of competition policy enforcement

Table 2 report our estimations concerning the first stage regressions for market competition -only the first stage equation for the linear terms are 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% 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 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 1-2 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% 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% smaller (more oligopolistic industries) than non-intervened industries. These results validate the effectiveness of competition policy enforcement in reestablishing market 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 -i.e., which means that industries with larger output participation are associated with concentrated markets; the opposite prevails in Chilean industries. In Chilean industries, sectors that grow (average sales growth rate in the last three years) and larger market size are positively associated with intensified market competition.

Table 2: FIRST STAGE REGRESSIONS: THE IMPORTANCE OF POLICY ENFORCEMENT AND REGULATORY REFORMS

EXPLAINED VARIABLE: MARKET COMPETITION (BOONE PROFIT ELASTICITY INDEX)

	COLOMBIAN FIRMS			CHILEAN ENTERPRISES		
	Competition		Comp.*Firm Gap$_{(t-1)}$	Competition	Competition*Firm Gap$_{(t-1)}$	
	IV-2SLS	IV-2SLS FE	IV-2SLS FE	IV-2SLS	IV-2SLS FE	IV-2SLS FE
	(1)	(2)	(3)	(4)	(5)	(6)
Competition Law Sanctions	0.116***	0.230***	0.241***	---	----	----
	(0.022)	(0.035)	(0.045)	---	----	----
Sanctioned Sectors	-0.022**	----	----	---	----	----
	(0.012)					
Entry Costs$_{t-1}$	-1.146***	-1.067***	-0.926***	-0.639***	-0.085*	-0.226
	(0.141)	0.176	(0.198)	(0.135)	(0.336)	(0.256)
Market Size$_{t-1}$	-0.0209**	-0.009	-0.017*	0.058***	0.059***	-0.056***
	(0.006)	(0.008)	(0.009)	(0.011)	(0.017)	(0.016)
Market Growth	-2.589***	-2.541***	-2.430**	---	----	----
	(0.665)	(0.807)	(0.982)			
2013 Entry Law Reform	---	----	----	-0.281***	---	----
				(0.032)		
2013 Entry Reform*Entry Costs$_{t-1}$	---	----	----	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-test).	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.

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 by definition 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 Business Entry Reform; afterwards 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 -which probably hesitated to open a plant or create a new company before the reform due to weaknesses in the business regulatory framework.[21] 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.[22]

4.2 Firm and Sector Heterogeneity: Do technology distance and Asymmetry matter?

According to theory and previous empirical research, we should expect firm distance to the frontier to strongly 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 of industries exhibit a persistent division between a small number of large and productive firms, and a long tail of micro, small and midsize companies with considerably weaker productivity performance (i.e., Pelaez and Hurtado, 2015; Blyde and Fentanes, 2019).

[21] It must be noted that 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.

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

Table 3 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.

Table 3: 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 Asymetry (average gap)			0.134***				2.478		
			(0.051)				(1.394)		
Competition x Asymetry (av. Gap)			-0.364***				-1.757*		
			(0.131)				(0.382)		
Sectoral Asymetry (std. Dev.)				-0.005				-0.020	
				(0.016)				(0.043)	
Competition x Asymetry (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

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 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). For Colombia, the interaction term is significant and negative but is not significant in the Chilean 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 non-linearity detected previously was basically driven by firm heterogeneity.

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%. 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. More specifically, this negative effect starts at the top 80 percentile of the gap distribution and further amplifies with larger gaps. 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 becoming only significant at a firm gap value of 0.85; that is, from the bottom 80th percentile of the firm gap distribution and beyond); for those firms very far from the frontier.

At this point, estimates coefficients indicate that at this gap level, the marginal effect of competition is -0.5 (-5%), with a standard error of 0.04 and significant at the 10% p-value level (z = -1.63). At larger distance values, the negative marginal effect of competition further amplifies. This result has important policy implications and should be considered when engaging into competition reforms. This highlight the need for productivity support policies, especially for the most lagging firms. For these companies at the top 80% of firm gap distribution (with the largest gaps)-, reinforcing competition reduces innovation incentives, and makes innovation investment in these firms less likely, which will eventually contract productivity performance and widen gaps vis-à-vis the leaders. In contrast, for firms with small gaps, reinforcing competition encourages firm innovation engagement -as predicted in Aghion et al., (2005).

In contrast, the marginal effect of competition for firms closer to the frontier firms is positive and significant. For firms at the top 25% of the firm gap distribution or with the shortest gaps (at the top p-25%, the marginal effect of competition is 7% with a standard error of 0.018 and significant at 1% (z-test=3.68); whereas for those between the 50% percentile (with a firm gap=73%) and 75% percentiles, the marginal effect is quite small (0.2) and not significantly different from zero. Thus, around the middle of the distribution no significant responses exist vis-à-vis competition. If we consider how the impact of firm gap changes with changes in market competition, the predicted marginal effects are also quite striking. The marginal effect of firm gap becomes negative when markets move from less competitive to more competitive markets, according to the Boone index. As competition raises, the negative effect of firm gap amplifies; laggards have less probability to invest in innovation. In other words, reinforcing competition discourages innovation investment in less efficient firms and makes it harder for them to compete.[23] These findings for Colombia are in line with those reported by Pelaez and Hurtado (2021) using the same dataset, and with those reported by Ding et al., (2016) for Chinese firms, but differ with those recently reported by Alvarez et al., (2020) for a sample of Latin American firms where no firm gap effects were found when interacting firm technology distance with competition to explain innovation engagement propensity.[24]

In columns (5) and (10) we include the interaction of market competition with two groups of firms: leaders -those at top 25% of the productivity distribution- and followers -all the rest of firms, and 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 behaviour-, only the interaction term referring to the group of followers is significant (at the 1% 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 and may hide different responses within it.

To further deepen our analysis on the role of firm heterogeneity, we test whether the way competition impacts innovation is non-linear with respect to firms' level of productivity performance. Following Bustos (2011) and Alvarez et al., (2019), in **Table 4** we include dummies reflecting firms' position in the productivity distribution (productivity quartiles) and interact these with competition. Given that endogeneity of competition disappears once we introduce these three quartiles dummies and their interaction with competition, we implement random and fixed effect regressions. Following Bustos (2011), we expect that competition may induce innovation efforts in firms at the

[23] Moving from a weakly competitive market (25th percentile of the Boone distribution: -0.66) to more competitive markets (75th percentile: 0.401) –and keeping values of other variables at their means-; moves the marginal effect of firm gap from a positive effect of 0.28 to a negative effect (-0.19). One standard deviation increase in the Boone Index (1.001) is associated with a negative marginal effect of firm gap of -0.465; which means that as competition raises, the negative effect of firm gap amplifies; laggards have less probability to invest in innovation when competition raises.

[24] If we find negative responses for laggard firms in terms of innovation engagement, the results of Alvarez and Gonzalez suggest that firms may be opting for other forms of productivity-enhancing strategies, such as organizational change or quality upgrading (certifications and norms), or responses in terms of other productive investments (e.g. capital and machinery), etc.

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 specially 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 25% quartile, especially if these firms are already below the innovation investment threshold (i.e. technology adoption threshold in the model of Bustos, 2011). For Colombian firms, our productivity measure is the logarithm of the TFP whereas for Chilean firms we use labor productivity. All quartiles dummies refer to the previous period.

The estimates indicate important differences in competition responses across firms within the two country samples. Interestingly, the four interaction terms are significant at 1% 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 groups under fixed effects estimation. In other words, market competition only influences innovation behaviour from a medium level of productivity performance. Our analysis therefore rejects the hypothesis of negative impacts from competition expected to prevail in laggards. Both country samples indicate that the largest responses are within the group of third and fourth top quartiles, which are medium and high performing firms (Chile). The **figures 1 and 2** in the Annex report the estimated predicted linear probability per group.

Table 4: COMPETITION EFFECTS BY PRODUCTIVITY QUARTILE
EXPLAINED VARIABLE: INNOVATION INVESTMENT DECISION

	COLOMBIAN FIRMS		CHILEAN FIRMS	
VARIABLES	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

Note: RE denotes Random Effects; FE denotes Fixed Effects. 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. Control variables as described in Table 4. Robust standard errors in parentheses clustered at the firm unit. *** p<0.01, ** p<0.05, * p<0.1

4.4 Robustness tests

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, 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 allow 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). And third, we also include firm persistence in innovation activities (i.e., Mulkay, 2019). As discussed in the literature, firm innovation is path dependent (i.e., Mansfield, 1968; Romer, 1990; Malerba and Orsenigo, 1993); 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 (i.e. Romer, 1990; Peters, 2005). 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 comes 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 this data and match them

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

to our innovation surveys since the classification is only compatible with the last Innovation Survey (10^{th}) of Chile (2015-16).

Table 7: 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***

Note: 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 behaviour (=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.

Table 5 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 provide further light on how the competition effects influence firm innovation. We find that competition still displays a causal non-linear relationship as before, but this non-linearity 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 magnitude, 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% 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 decision. Firms who were engaged in innovation in the previous year have 30% (average in columns 4-6) higher probability of engaging into 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 estimation to deal with the autocorrelation 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 an increased firm innovation investment. 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 identify past innovation engagement (lagged dependent variable) with two instruments: the average proportion of firms in the same sector that engaged in any innovation activity in the previous period and the proportion of firms that received public financial support for innovation activities in the previous period and same sector. It must be noted that 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) losses significance; it is now significant at 15% 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 magnitude reflecting firm persistence in innovation engagement over time (Peter, 2005; Mansfield, 1968); firms who were engaged in innovation investment activities in the previous period report a 18% 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 appears again non-significant, as in the previous analysis.

5. 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 on the role of market competition in fostering firm innovation in Latin American manufacturing industries. We confirm the predominance of innovation-encouraging effects ("escape-competition") from market competition as reflected in firms' propensity to engage in innovation activities.

We confirm that competition enhances innovation efforts in Colombian and Chilean firms; with a non-linear (inversed U) relationship prevailing in the Colombian context while a linear positive causal relation os found in the Chilean firm sample. In line with the literature, discouraging effects (decreasing incentives to innovate) predominate in highly asymmetrical sectors, whereas firm technology distance from sector leaders affects differently innovation engagement. Hence our analysis confirms that firm heterogeneity matters -but mostly from a medium level of productivity performance in determining firm response of competition on firm innovation propensity with more significant and larger effects found in the medium range of the productivity distribution. In the case of Chile, firms in the bottom first and second productivity quartiles are unresponsive to market competition in terms of firm innovation.

Our analysis is not exempted of caveats. We are aware that must of this innovation investment mostly concerns firm's acquisition of external technology or technology transfer activities (i.e. machinery and equipment, and ICT technologies) -as these represent more of the 85% of firm innovation investments, on average in Latin American countries (i.e. Navarro *et al.,* 2011). It is very likely that market competition may affect R&D investment in different ways -as such investments are more costly to undertake, more uncertain (in terms of returns and innovation results), and funding market failures are more pronounced compared to existing technology acquisition. An additional limitation we are confronted is the limited panel coverage in most innovation surveys in the region (an exception is Colombia). Although quite informative about the innovation process, and types of innovation activity and outputs, the time dimension covered by national innovation surveys is quite limited; sample design changes over time and only a small share of firms is followed permanently. These drawbacks reduce our chances to properly evaluate market competition effects over time on a sufficiently number of heterogenous firms. Finally, the analysis of firm heterogeneity could be further enriched by looking at other ways in which firms compete; for instance, by distinguishing global competitors from local market-oriented firms. Further research should also look in detail whether competition effects varies across firms according to other forms of firm heterogeneity such as the role of financial constraints in moderating impacts of market competition on innovation; and the distinction between innovation or technologically-based vs. non-technologically motivated sectors. We will look at these interplays in our future research.

REFERENCES

Acemoglu Daron & Philippe Aghion & Fabrizio Zilibotti, 2006. "Distance to Frontier, Selection, and Economic Growth," *Journal of the European Economic Association*, MIT Press, vol. 4(1), pages 37-74, March. Ackdigit et al., 2018), Aghion Philippe & Richard Blundell & Rachel Griffith & Peter Howitt & Susanne Prantl, 2009. "The Effects of Entry on Incumbent Innovation and Productivity," *The Review of Economics and Statistics*, MIT Press, vol. 91(1), pages 20-32, February.

Aghion, P. & Mark Schankerman (2004): On the welfare effects and political economy of competition-enhancing policies. *Economic Journal,* Royal Economic Society, vol. 114(498), pages 800-824, October.

Aghion, P., Antonin Bergeaud & Timo Boppart & Peter J. Klenow & Huiyu Li (2019). Missing Growth from Creative Destruction, *American Economic Review*, American Economic Association, vol. 109(8), pages 2795-2822, August.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted-U relationship. *The quarterly journal of economics*, *120*(2), 701-728.

Aghion, P., Stefan Bechtold, Lea Cassar & Holger Herz (2014). The Causal Effects of Competition on Innovation: Experimental Evidence. NBER Working Paper 19987. DOI 10.3386/w19987

Aghion, Philippe & Howitt, Peter, (1992). A Model of Growth through Creative Destruction, *Econometrica*, *Econometric Society*, vol. 60(2), pages 323-351, March.

Alvarez R., and Campusano, R. (2014). Do competition spur innovation in Developing Countries, Serie de Dcoumentos de Trabajo, SDT 388, Universidad de Chile.

Álvarez, R. and Gonzalez, A. (2017). Competition, Selection, and Productivity Growth in the Chilean Manufacturing Industry, Working Papers wp453, University of Chile, Department of Economics.

Álvarez, R. and Robertson, R. (2007) Exposure to foreign markets and plant-level innovation: evidence from Chile and Mexico, The *Journal of International Trade & Economic Development*, Taylor & Francis Journals, vol. 13(1), pages 57-87.

Alvarez, R. and Sebastian Claro (2008). David versus Goliath: The Impact of Chinse Competition on Developing Countries. Working Paper No.478, Central Bank of Chile.

Alvarez, R., Benavente, J., M., and Crespi, G. (2019). Foreign Competition and Innovation in Latin America. Inter-American Development Bank, Competitiveness and Innovation Division, Discussion paper no. IDB-DP 0072.

Amiti, M. & Khandelwal, A. (2013). Import Competition and Quality Upgrading, *The Review of Economics and Statistics*, MIT Press, vol. 95(2), pages 476-490, May. Amiti and Konings (2007)

Amiti, M. & Konings, J. (2007). Trade Liberalization, Intermediate Inputs, and Productivity: Evidence from Indonesia, *American Economic Review,* American Economic Association, vol. 97(5), pages 1611-1638, December.

Andrews, D., Nicoleti, G. and Timiliotis, C. (2018). Digital Technology Diffusion: A matter of capabilities, Incentives or Both?. Economics Department Working Papers No. 1476, OECD Publishing, Paris. www.oecd.org/eco/workingpapers

Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In: The rate and direction of inventive activity: economic and social factors. Princeton, NJ: Princeton University Press.

Arrow, K. J. (1972). Economic welfare and the allocation of resources for invention. In *Readings in industrial economics* (pp. 219-236). Palgrave, London.

Askenazy, Philippe, Christophe Cahn, Delphine Irac (2013). Competition, R&D, and the cost of innovation: evidence for France. *Oxford Economic Papers,* Volume 65, Issue 2, 1 April 2013, Pages 293–311, https://doi.org/10.1093/oep/gps071

Autor, David & Dorn, David & Hanson, Gordon & Pisano, Gary & Shu, Pian (2016). Foreign Competition and Domestic Innovation: Evidence from U.S. Patents, CEPR Discussion Papers 11664, C.E.P.R. Discussion Papers.

Autor, David, David Dorn, and Gordon Hanson (2013). The China Syndrome: Local Labor Market Effects of Import Competition in the United States. *American Economic Review* 103(6).

Beneito, P., Coscollá-Girona, P., Rochina-Barrachina, M. E., & Sanchis, A. (2015). Competitive pressure and innovation at the firm level. *The Journal of industrial economics*, *63*(3), 422-457.

Bergoeing, R., V., and Hernando, A., and Repetto, A. (2010). Market Reforms and Efficiency Gains in Chile, *Estudios de Economia,* University of Chile, Department of Economics, vol. 37(2 Year 20), pages 217-242, December.

Bérubé, C. & Marc Duhamel & Daniel Ershov (2012). Market Incentives for Business Innovation: Results from Canada, *Journal of Industry, Competition and Trade*.

Bloom, Nicholas and John Van Reenen (2007). Measuring and Explaining Management practices across firms and nations, *Quarterly Journal of Economics*, Vol. 122, No. 4: 1351–1408

Blundell, R., Griffith, R., van Reenen, J. (1999), Market share, market value and innovation in a panel of British manufacturing firms, *Review of Economics and Statistics* 66, 529-554.

Blyde, J., and Fentanes, O. (2019). The Heterogeneous Impacts of Import Competition on Mexican Manufacturing Plants. Inter-American Development Bank (IDB) Working Paper Series, Nº IDB- WP -0108 7, December 2019.

Boone J, Griffith R, Harrison R (2005). Measuring competition. AIM Working Paper No. 22

Boone, J. (2000), Competitive pressure: the effects on investments in product and process innovation, *RAND Journal of Economics* Vol. 31, No. 3, pp. 549–569.

Boone, J. (2001), Intensity of competition and the incentive to innovate, International Journal of Industrial

Boone, J. (2008a) A new way to measure competition. *The Economic Journal*, 118(531):1245–1261.

Boone, J. (2008b), Competition: theoretical parametrizations and empirical measures, *Journal of Institutional and Theoretical Economics*, 164 (4): 587-611.

Buccirossi, P., Ciari, L., Duso, T., Spagnolo, G., & Cristiana Vitale (2013). Competition Policy and Productivity Growth: An Empirical Assessment, *The Review of Economics and Statistics*, MIT Press, vol. 95(4), pages 1324-1336, October.

Bustos, P. (2011). Trade liberalization, exports, and technology upgrading: Evidence on the impact of mercosur on Argentinian firms. *American Economic Review*, 101(1):304–40.

Calligaris, S., Criscuolo, C. and Marcolin, L, (2018). Mark-ups in the Digital Era, OECD STI working appers, OECD 2018 Publishing, Paris.

Carlin, W., M.E. Schaffer and P. Seabright (2004), A Minimum of Rivalry: Evidence from Transition Economies on the Importance of Competition for Innovation and Growth, C.E.P.R. Discussion Papers.

Cohen, W.M. (2010), Fifty years of empirical studies of innovative activity and performance, in: Hall, B.W., Rosenberg, N. (ed.), Handbook of the economics of innovation, Elsevier, Amsterdam, 129-213.

Correa, J. A., & Ornaghi, C. (2014). Competition & innovation: Evidence from US patent and productivity data. *The Journal of Industrial Economics*, *62*(2), 258-285.

Correa, J. and Carmine *Ornaghi* (2014). Competition & Innovation: Evidence from U.S. Patent and Productivity Data," *Journal of Industrial Economics*, Wiley Blackwell, vol. 62(2), pages 258-285, June.

Correa, Juan A. (2012). "Innovation and competition: An unstable relationship," *Journal of Applied Econometrics*, John Wiley & Sons, Ltd., vol. 27(1), pages 160-166, January

Crépon, B., Duguet, E., Mairesse, J. (1998), Research and Development, innovation and productivity: an econometric analysis at the firm level, *Economics of Innovation and New Technology* 7(2), 115-158

Crespi, Gustavo & Zuñiga, Pluvia (2011). Innovation and Productivity: Evidence from Six Latin American Countries," IDB Publications (Working Papers) 1985, IADB.

De Bondt, R., Vandekerckhove, J. (2012), Reflections on the relation between competition and innovation, *Journal of Industry, Competition and Trade* 12, 1: 7-19

Ding, S., Sun, P. and Jiang, W. (2016) The effect of import competition on firm productivity and innovation: does the distance to technology frontier matter? *Oxford Bulletin of Economics and Statistics*, 78(2), pp. 197-227. (doi:10.1111/obes.12110)

Dixit, A. K., & Stiglitz, J. E. (1977). Monopolistic competition and optimum product diversity. *The American economic review*, *67*(3), 297-308.

Elejalde, R., Ponce, C. J., & Roldán, F. (2019). *Innovation, Competition, and Incentives: Evidence from Uruguayan Firms* (No. inv328). Universidad Alberto Hurtado/School of Economics and Business.

Eslava, M., Haltiwanger, J., Kugler, A., & Kugler, M. (2004). The effects of structural reforms on productivity and profitability enhancing reallocation: evidence from Colombia. *Journal of development Economics*, *75*(2), 333-371.

Federico, G., Scott M., F. and Shapiro, C. (2019). "Antitrust and Innovation: Welcoming and Protecting Disruption," NBER Chapters, in: Innovation Policy and the Economy, Volume 20, pages 125-190, National Bureau of Economic Research, Inc.

Fernandes, A. (2003). *Trade policy, trade volumes, and plant-level productivity in Colombian manufacturing industries*. The World Bank.

Geroski, P. A. (1990). Innovation, technological opportunity, and market structure. *Oxford economic papers*, *42*(3), 586-602.

Gilbert, R. J., & Newbery, D. M. (1982). Preemptive patenting and the persistence of monopoly. *The American Economic Review*, 514-526.

Gomellini (2013). Innovation and Competition: A Survey. Bank of Italy, Structural Economic Analysis Department – *Economic* and Financial History Division, Unpublished manuscript.

Gorodnichenko, Y. Svejnar, Y. and Terrell K. (2008). Globalization and Innovation in Emerging Markets, IZA Discussion Paper No. 3299 January 2008.

Griffith Rachel & Rupert Harrison & Helen Simpson, 2010. "Product Market Reform and Innovation in the EU," *Scandinavian Journal of Economics*, Wiley Blackwell, vol. 112(2), pages 389-415, June.

Hale, U. & Ruiz, Luis B. Torres (2013). "International competition and industrial evolution: Evidence from the impact of Chinese competition on Mexican maquiladoras," *Journal of Development Economics*, Elsevier, vol. 105(C), pages 267-287.

Hall Bronwyn H. & Josh Lerner (2009). The Financing of R&D and Innovation, NBER Working Papers 15325, National Bureau of Economic Research.

Hall, Bronwyn H. (2002). "The Financing of Research and Development," NBER Working Papers 8773, National Bureau of Economic Research, Inc.

Hashmi, A. R. (2013). *Competition* and innovation: The inverted-u relationship revisited. *Review of Economics and Statistics*, 95(5):1653–1668.

Haskel, J. and Westlake, S. (2017) Capitalism Without Capital: The Rise of the Intangible Economy. Princeton University Press.

Howitt, P. and Mayer-Foulkes, D. (2002)0 R&D, Implementation and Stagnation: A Schumpeterian Theory of Convergence Clubs. Working Paper 9104, August 2012. DOI: 10.3386/w9104

Iacovone, L. & Rauch, Ferdinand & Winters, L. Alan (2013). "Trade as an engine of creative destruction: Mexican experience with Chinese competition," *Journal of International Economics*, vol. 89(2), pages 379-392.

Kamien M, Schwart, N. L. (1982), Market Structure and Innovation. Cambridge University Press, Cambridge.

Klinger, Bailey & Lederman, D. (2011). Export discoveries, diversification and barriers to entry, *Economic Systems*, Elsevier, vol. 35(1), pages 64-83, March.

Lee, C. Y. (2009). Competition favors the prepared firm: Firms' R&D responses to competitive market pressure. *Research Policy*, *38*(5), 861-870.

Levinsohn, J., & Petrin, A. (2003). Estimating production functions using inputs to control for unobservable. *The review of economic studies*, *70*(2), 317-341.

Maloney, William F.; Sarrias, Mauricio (2014). Convergence to the Managerial Frontier. Policy Research Working Paper;No. 6822. World Bank, Washington, DC.

Nicholas Bloom & John Van Reenen, 2010. "Why Do Management Practices Differ across Firms and Countries?," *Journal of Economic Perspectives,* American Economic Association, vol. 24(1), pages 203-224, Winter.

Nickel, S. (1996), Competition and corporate performance, *Journal of Political Economy* 104: 724-746.

Parisi, M. L., Daveri, and Decat (2016). Service Deregulation, Competition, and the Performance of French and Italian Firms. *Scottish Journal of Political Economy* 63(3):278-302 · July 2016.

Pavcnik, Nina (2002). Trade Liberalization, Exit, and Productivity Improvements: Evidence from Chilean Plants. *Review of Economic Studies* 69: 245–76.

Peneder, M. & Martin Woerter (2014). Competition, R&D and innovation: testing the inverted-U in a simultaneous system," *Journal of Evolutionary Economics*, Springer, vol. 24(3), pages 653-687, July.

Polder, M., & Veldhuizen, E. (2012). Innovation and competition in the Netherlands: Testing the inverted-U for industries and firms. *Journal of Industry, Competition and* Trade, 12(1), 67-91.

Reinganum, J.F. (1989) The timing of innovation: research, development and diffusion. In Schmalensee: Handbook of Industrial Organization Volume 1 (1989) Chapter 14, Pages 849-908.

Roberts, T. (2014). When bigger is better: A critique of the Herfindahl-Hirschman Index's use to evaluate mergers in network industries. *Pace L. Rev.*, *34*, 894.

Romer, P. M. (1990). Endogenous technological change. *Journal of political Economy*, *98*(5, Part 2), S71-S102.

Santos, A., Cincera, M., Neto, P. Manuel Serrano (2018). Competition effect on innovation and productivity -The Portuguese Case, *Public Policy Portuguese Journal* 2018, vol 3 No. 2, pp: 58-84, Universidad de Evora, UMPP.

Scherer F.M. (1965), Firm Size, Market Structure, Opportunity, and the Output of Patented Inventions, *American Economic Review*, December 1965: 1097-1112.

Scherer F.M. (1967), Market Structure and the Employment of Scientists and Engineers, *American Economic Review*, June 1967: 524-53

Schumpeter, J. (1942). Creative destruction—Capitalism, socialism and democracy (Vol. 825). *New York City, NY: Harper and Brothers*.

Shapiro, C., (2012), Competition and innovation: did arrow hit the bull's eye? in: Lerner, J. and S. Stern (2012), The Rate and Direction of Inventive Activity Revisited, University of Chicago Press.

Vives, X. (2008) Innovation and competitive pressure. *Journal of Industrial Economics* 56:419–469.

ANNEX

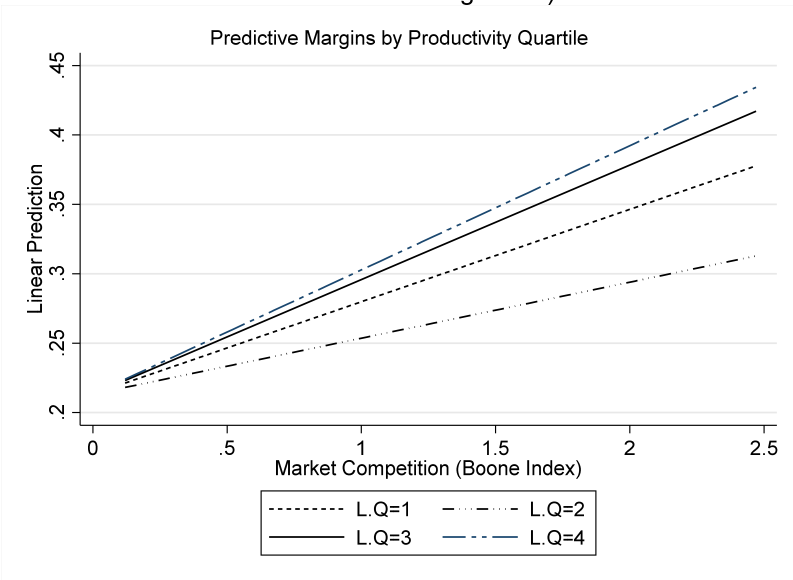
TABLE 1: SUMMARY STATISTICS, COLOMBIAN MANUFACTURING FIRMS (2003-16)

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	3.841	1.114	0.00	8.63
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 (2011-16)

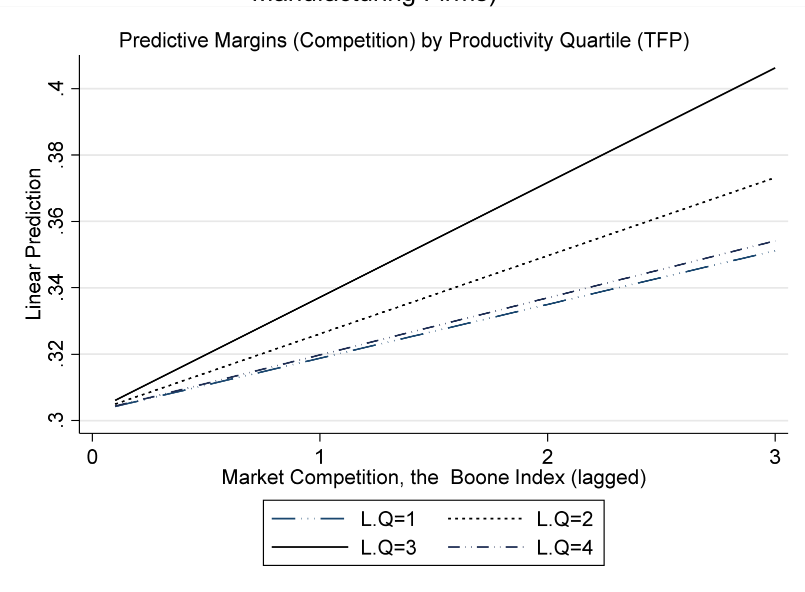
Variable	Obs	Mean	Std. Dev.	Min	Max
Innovation Investment (dummy)	3773	0.21	0.40	0.00	1.00
R&D engagement (dummy)	4,312	0.12	0.32	0.00	1.00
R&D intensity	4,305	0.12	1.41	0.00	40.00
Technology Purchasing Intensity	4,305	0.03	0.60	0.00	25.06
R&D per employee (thousands 2009 CH$)	4,292	6518.73	80197.43	0.00	2148910
Innovation Expenditures per employee (thousands 2009 CH$)	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
Skills (% of with univ. & post-graduates)	4,312	0.24	0.28	0.00	1.88
Young firm (with< 10 years)	4,312	0.15	0.36	0.00	1.00
Multinational (Capital>=10%)	4,312	0.31	0.46	0.00	1.00
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
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
Firm Gap t-1	4,312	0.23	0.60	-3.97	0.96
Obstacle_Finance (Very High)	4,312	0.28	0.45	0.00	1.00
Obstacle_Finance (Medium High)	4,312	0.27	0.45	0.00	1.00
Obstacle_Finance (Low)	4,312	0.15	0.36	0.00	1.00
kurtosis	4,312	24.53	15.35	4.66	78.03

Figure 1: Innovation Investment Propensity per Productivity Quartile, Predictive Margins (Chilean Manufacturing Firms)



Note: 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. Control variables as described in Table 4.

Figure 2: Innovation Investment Propensity per Productivity Quartile, Predictive Margins (Chilean Manufacturing Firms)



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