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Competition, selection, and productivity growth in the Chilean manufacturing industry

Roberto Álvarez[1,]* and Aldo Gonzalez[2]

[1]Department of Economics, Universidad de Chile, Diagonal Paraguay 257 Of. 1504, Santiago 8320000, Chile. e-mail: robalvar@fen.uchile.cl and [2]Department of Economics, Universidad de Chile, Diagonal Paraguay 257 Of. 1504, Santiago 8320000, Chile. e-mail agonzalez@econ.chile.cl

*Main author for correspondence.

Abstract

Competition is considered as a key driver of productivity growth. However, the empirical evidence on its impact is scant in developing countries. Using information from manufacturing plants for the period 1995–2007, we analyze the impact of competition on firm selection and productivity growth in Chile. Our results indicate that competition has a positive effect on total factor productivity (TFP) growth, especially for laggard firms. We find weaker evidence that competition affects the probability of exit for low-productivity firms. In general, these results for productivity growth are robust to alternative methodologies for calculating productivity and to the inclusion of other variables that may affect firms' TFP growth. We find support for Schumpeterian forces, but the quantitative impact is small.

JEL classification: D22, L25

1. Introduction

Productivity is one of the key factors in explaining differences in economic development (Hall and Jones, 1999; Bosworth and Collins, 2003). However, there is no consensus regarding what the main determinants of productivity growth are. There is a long list of potential drivers of productivity such as structural change, competition, and resource misallocation due to market failures and regulation, among others (Syverson, 2011). Of these potential drivers, competition has received great attention in the literature. Nevertheless, in the case of developing countries, there is scant evidence looking at the impact of competition on productivity.

In this paper, we focus on the relationship among competition, selection, and productivity in Chile. This is an interesting setting because this country has been considered an early reformer, but it has experienced a strong slowdown in productivity since the Asian financial crisis (Figure 1). We study the impact of higher competition on productivity growth and exit and whether these effects depend on the distance to the technological frontier. We use a differences-in-differences approach in which we analyze the differential impact of competition depending on how close firms are to the industry technological frontier. This is an interesting question because it is not clear theoretically whether increasing competition has a higher or lower effect on the productivity of firms that are further away from the frontier.

We use a direct measure of competition, the Boone index, but we also complement our evidence with more traditional measures, such as indicators of market concentration and foreign competition. We deal with the endogeneity

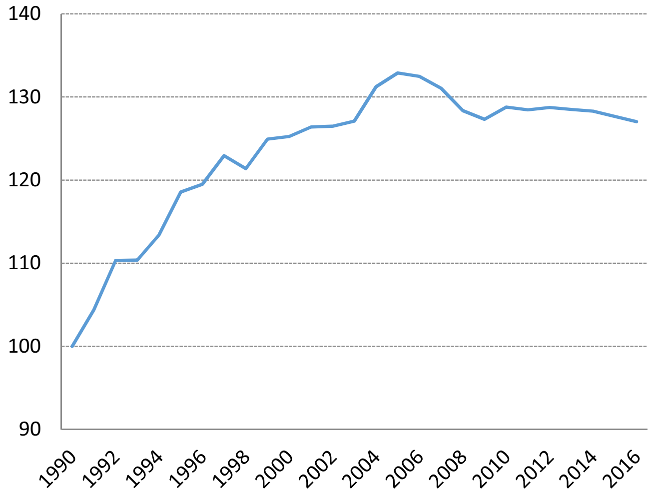

Figure 1. Aggregate TFP: 1990–2016. *Source*: Comisión Nacional de Productividad. Informe de Productividad Anual 2016.

of competition by including time-varying and industry-specific effects that control for all variables such as international trade, industry prices, and costs, which may affect industry competition over time. However, as we do not exploit an exogenous change in competition, we cannot claim that we have clearly identified the causal impact of competition on selection and productivity growth. To address this issue, we use the increase in Chinese imports as source of changes in competition across industries.

The previous literature has mostly found a positive effect of competition on productivity growth. This is the conclusion of several surveys of the literature (Nicoletti and Scarpetta, 2003; Holmes and Schmitz, 2010; Syverson, 2011). In particular, Nickell (1996), using information for 670 British companies during the period 1975–1986 and measuring competition by the numbers of rivals and the level of industry rents, finds a positive effect from competition on total factor productivity (TFP) growth. Using data for a large sample of British firms, Disney *et al.* (2003) confirms these results. Several other studies have also found that regulatory changes enhancing product market competition are associated with productivity growth in the OECD countries (Nicoletti and Scarpetta, 2003).

The microeconomic literature on international trade has also provided evidence that higher competition induced by trade liberalization increases productivity (Syverson, 2011). In the case of Chile, Pavcnik (2002) finds that the opening of the economy in the period 1979–1986 had a significantly higher impact on the productivity of firms that were more exposed to international competition, that is those in export-oriented and import-competing industries. The evidence for Colombia in Eslava *et al.* (2004) is also consistent with the idea that structural reforms aimed to increase competition in domestic markets have a positive impact on productivity.

Some papers have explored the mechanisms behind this positive relationship between competition and productivity, in particular whether competition enhances technological innovation. Bloom *et al.* (2016) finds that Chinese import competition in European countries has a positive effect on innovation. This positive effect has also been found by Baldwin and Gu (2004) and Lileeva and Trefler (2010) for Canadian firms when evaluating the consequences of unilateral trade liberalization and tariffs reductions in NAFTA, respectively.[1] In the case of emerging markets, Gorodnichenko *et al.* (2010) also finds a positive effect of foreign competition on innovation.

Other papers explore additional mechanisms through which competition may increase productivity. One of them is the Darwinian selection, in which higher competition may force lower productivity firms to exit the market or shrink, thus reallocating resources to more productive firms (Syverson, 2011). This is the mechanism behind the

1 Another positive aspect associated with trade liberalization but not related directly to competition is highlighted by Amiti and Konings (2007) which shows a positive impact of trade liberalization on productivity, coming from the expansion in the set of intermediate inputs.

positive effect of trade liberalization on industry productivity illustrated by Melitz (2003). The evidence seems to be consistent with this argument. Several papers have shown that competition increases the probability of exit for low--productivity firms (Foster *et al.*, 2001, 2008; Álvarez and Vergara, 2010; Eslava *et al.*, 2013).

To this literature, we make two contributions. First, we provide novel evidence on the impact of competition on selection and productivity growth for a developing country. Second, we evaluate the differential impact of competition depending on firms' distance to productivity frontier. Other papers have also looked at whether laggard firms are able to catch up with technological leaders, but they have not analyzed the impact of competition on this catching up.[2] This is a relevant empirical contribution because it is not clear from a theoretical perspective whether the impact of competition on productivity for laggard firms is positive or negative. As we discuss in detail in the following sections, some literature, such as that related to the X-inefficiency, would suggest a positive impact of competition on the productivity of lagging firms. In contrast, the productivity ladder literature would indicate that the incentives to innovate and to be more productive generated by competition would be higher for firms that are closer to the frontier (Aghion *et al.*, 2005).

Our findings indicate that higher competition has had a positive and higher impact on low-productivity firms. This impact is relevant but relatively small compared to the average gap with technologically advanced firms. We find weaker evidence that competition generates a Darwinian selection by increasing the probability of low-productivity firms closing. We check the robustness of our results to alternative methodologies for calculating productivity and competition and to alternative hypotheses such as exporting and multinational spillovers.

The paper is linked with several strands of the literature. First, it is related to models of industrial dynamics, where higher competition increases in productivity by either reallocating resources to more productive firms or increasing within-firm innovation and productivity. These mechanisms have been highlighted, for example, in models where trade liberalization increases industry productivity (Melitz, 2003; Bustos, 2011). Second, our results are also related to the strategic management literature and the analysis of differential profitability across firms and its sustainability over time. Our paper shows that higher competition reduces productivity differentials—and also possibly profitability also—mainly because it increases productivity growth in lagging firms, but we find weaker effects on exit of low-productivity firms. As in Jacobides *et al.* (2012), where firms invest in idiosyncratic resources and capabilities to extend capacity, the Darwinian mechanism does not imply the full elimination of firms' heterogeneity. Linking both strands of the literature, one relevant research question could be to shed light on which types of idiosyncratic investments help to extend the capacity and competitiveness of firms and how that may differ over the life cycle of industries.

This paper is structured as follows. In Section 2, we describe the dataset. In Section 3, we present the methodology. In Section 4, we discuss the expected results and previous evidence. In Section 5, we show the main results and several robustness analyses. We conclude in Section 6.

2. Data

Our analysis is based on information for Chilean manufacturing plants for the period 1995–2007. The National Annual Survey of Manufactures (ENIA) collects information for about 4000 plants and has data on several variables such as sales, output, employment, wages, exports, foreign ownership, and other characteristics for each plant that has at least 10 employees.[3] All monetary variables were converted to constant Chilean pesos using three-digit International Standard Industrial Classification (ISIC) level price deflators. In addition, plants are classified according to the ISIC, Rev. 3. Table 1 shows the number of plants by year. There are approximately 4500 plants at the beginning of the period and about 4000 plants by 2007.

The main interest variable is TFP. Given the methodological problems for computing TFP, we use three productivity measures to check the robustness of our results. First, we estimate TFP at the firm level using the methodology developed by Olley and Pakes (1996) and extended by Levinsohn and Petrin (2003). Second, we calculate TFP using

2 See Álvarez and Crespi (2007) for Chile, and Iacovone and Crespi (2010) for Mexico.

3 There is more recent data from the ENIA but unfortunately the INE no longer gives the plant identification number, which keeps us from extending the panel.

Table 1. Number of plants

Year	Plants
1995	4414
1996	4720
1997	4547
1998	4291
1999	4185
2000	4044
2001	3965
2002	4159
2003	4210
2004	4259
2005	4204
2006	4104
2007	3933
Average	4233

Source: Own elaboration based on ENIA.

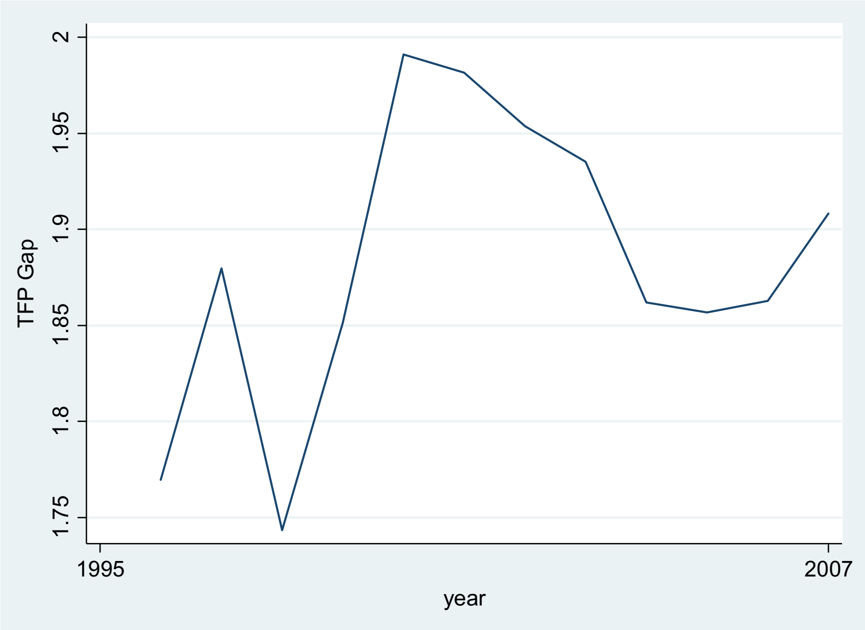

Figure 2. Evolution of the TFP gap. *Source*: Own elaboration based on ENIA.

the methodology developed by Wooldridge (2009). Third, we use the methodology of Ackerberg *et al.* (2015) that deals with the collinearity problems in the estimation of Olley and Pakes (1996). In these three measures, the TFP is the residual from the estimation of a production function by industry where inputs are capital and labor. In addition, the three procedures deal with the endogeneity of inputs given that productivity is observed by the firm but not by the econometrician.

We define frontier firms as those firms—for each year and three-digit industry—at the top 5% of the TFP distribution. To avoid the effects of outliers in the group of frontier firms, we use the median instead of the average productivity. We compute the gap between the group of frontier firms and a nonfrontier firm as the simple differences between the median TFP of frontier firms and the TFP of a laggard firm (in logs). Figure 2 shows the evolution for the simple average productivity gap, indicating that there is a slight increase in this gap over time.

We employ the Boone indicator as a measure of competition. This indicator was proposed by Boone (2008), and it is based on the concept that more efficient firms, that is those with lower marginal costs, obtain higher market shares, and profits in comparison to their less efficient competitors. As competition intensifies, there would be a reallocation of output from less efficient to more efficient firms. This corresponds to the market selection effect described by Aghion and Schankerman (2004).

The Boone index is calculated as the parameter θ from the following equation:

$$\ln(\pi_{it}) = \alpha + \theta_t \ln(\text{CVM}_{it}) + \varepsilon_{it},$$

where $\ln(\pi_{it})$ is the profits of firm i in time t; $\ln(\text{CVM}_{it})$: is the total variable cost over total revenues CVT_{it}/y_{it}.

The intuition for this indicator is simple. The larger the absolute value of θ, the higher the competition level. A large θ value indicates that, in the given industry, the benefits each firm gets are more sensitive to firm costs, which is consistent with a more competitive environment (Boone, 2008).

Using information from ENIA for variable costs, revenues, and profits, we estimate the equation for each three-digit industry using firm-level data. We show the average Boone index for the period under study in Figure 3. Given that the Boone parameter θ is negative, we use its absolute value to represents a higher value as indicator of tougher competition. The evolution indicates that there are some fluctuations over time, but overall there is an increase in average competition in the Chilean manufacturing sector.

Our evidence suggests that changes in competition were not similar across industries, with some of them even experiencing reduced competition. We take the industry average in 2000–2005 and compare it with 1995–1997 for each industry. The distribution of this variation is shown in Figure 4. Note that a similar percentage of industries had increased and reduced competition. To complement this evidence, Figure 5 explores whether changes in competition were related to the changes in the average TFP gap across industries. We do not find evidence in this regard. The correlation between changes in the TFP gap and changes in competition is positive, but not significant.

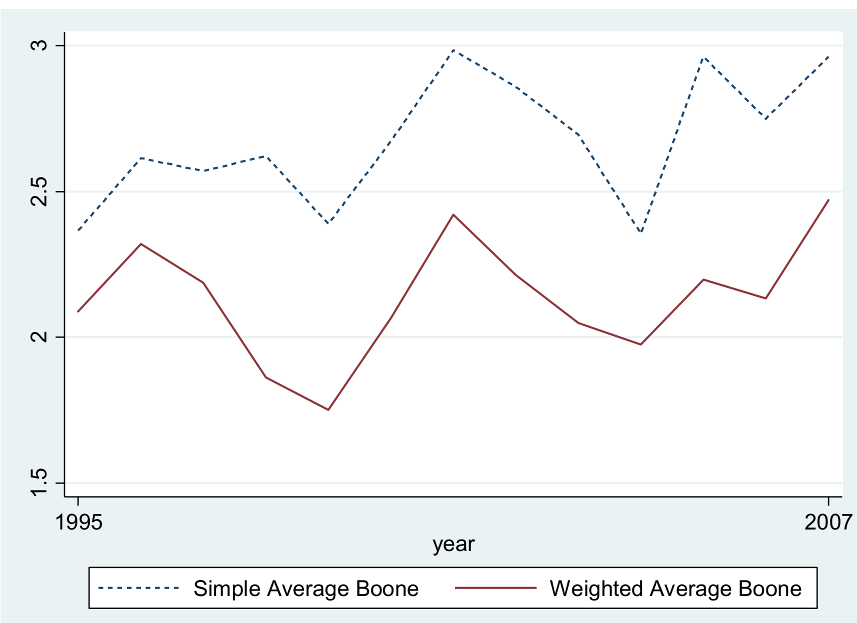

Figure 3. Evolution of the Boone index. *Source*: Own elaboration based on ENIA.

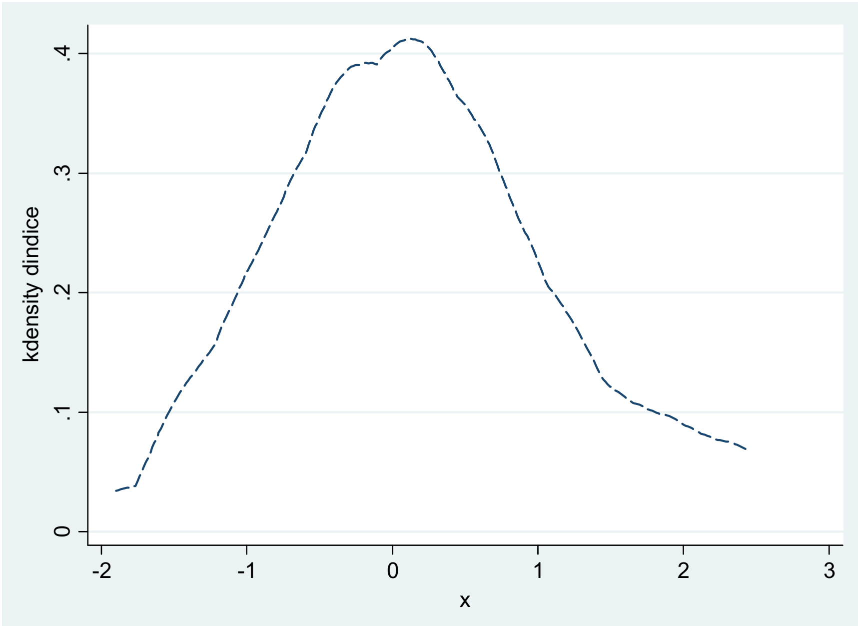

Figure 4. Distribution of changes in competition: kernel density. *Source*: Own elaboration based on ENIA.

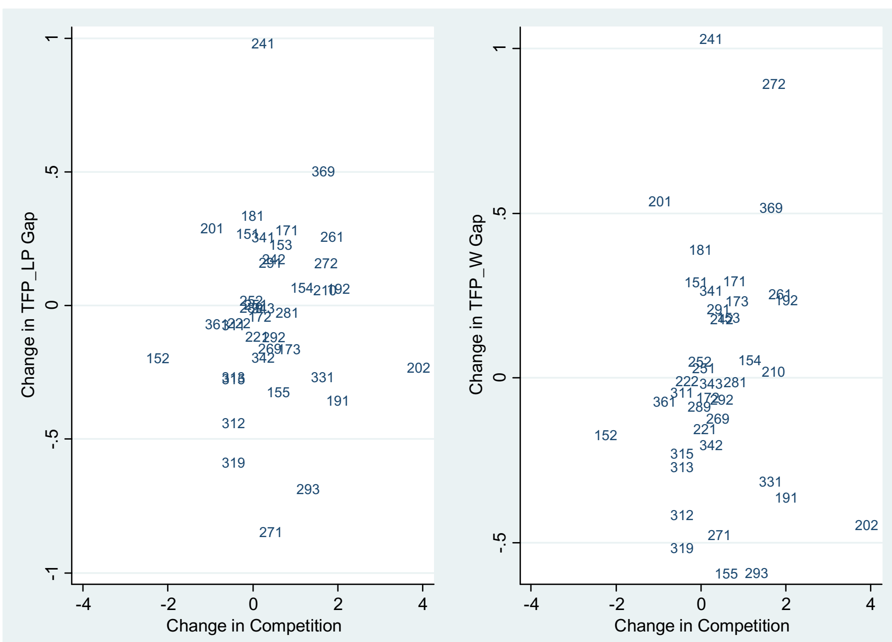

Figure 5. Changes in competition and TFP gap. *Source*: Own elaboration based on ENIA.

3. Methodology

For analyzing the impact of competition on productivity growth and exit, we estimate the following equations:

$$\begin{aligned} \text{TFPG}_{ikt} &= \alpha_i + \alpha_{kt} + \delta_1 \text{GAP}_{it-1} + \beta_1 \text{GAP}_{it-1}\text{COMP}_{kt} + \varepsilon_{c,t} \\ \text{Exit}_{ikt} &= \alpha_i + \alpha_{kt} + \delta_2 \text{GAP}_{it-1} + \beta_2 \text{GAP}_{it-1}\text{COMP}_{kt} + \varepsilon_{c,t}, \end{aligned}$$

where TFPG_{ikt} is the TFP growth for nonfrontier firm i in industry k at year t, and Exit is a dummy variable for firms that go out of business between $t-1$ and t. GAP_{it-1} is the difference between frontier TFP and firm TFP (in logs). COMP_{kt} is the Boone index as measure of competition at industry k and year t. α_i, α_{kt} are firm and industry*year fixed effects.

This differences-in-difference approach is aimed at identifying the differential impact of competition depending on the firm productivity gap, but not the direct effect of changes in the industry's competitive environment. Nevertheless, the advantage of this procedure is that it might reduce endogeneity concerns because all of the determinants of competition are controlled by introducing a set of time-varying and industry-specific effects. However, given that we do not have a source of exogenous variation for competition, we cannot claim that we have identified the causal impact of competition with this approach. Thus, following several recent papers dealing with the impact of China, we also provide evidence from an instrumental variables estimation. We use import penetration from China as a shock to competition across industries.

In the case of exit, even if the variable is discrete, we estimate the relationship between exit and competition using a linear probability model because this allows us to control for unobserved heterogeneity. There are two main reasons for choosing a linear model with fixed effects. First, unobserved plant heterogeneity could be modeled as fixed or random effects, but the use of random effects requires that the plant effects be uncorrelated with the regressors. This assumption is likely to be violated in our estimations, as firms' characteristics, the productivity gap, and size, among others, are correlated with unobserved characteristics such as managerial ability and technology (Bernard and Jensen, 2004). Second, the parameters for interaction terms, as that for the gap and competition, are easier to calculate and analyze in linear models (Ai and Norton, 2003).

We acknowledge that this two-step estimation has some shortcomings. Recent papers have shown that this procedure tends to underestimate the impact of the independent variables on productivity, particularly if these variables have not been included in the estimation of the production function during the first step. This has been shown by Doraszelski and Jaumandreu (2013) which investigated the impact of R&D on productivity using a structural approach. Thus our findings may underestimate the impact of competition on TFP growth, and they should be considered as a lower bound of the true effect. Nevertheless, we show evidence for labor productivity growth that does not suffer from this problem, and our main conclusions hold.

4. Main hypotheses

We discuss the main hypotheses involved in the estimation of both equations for the impact of the productivity gap and competition especially considering the interaction of both variables. The impact of the gap on productivity growth will be: $\delta_1 + \beta_1 - \text{Comp}$, where δ_1 measures the overall impact of the gap, and $\beta_1$captures the differential impact of competition that depends on the gap. The parameter δ_1 can be positive or negative if laggard firms are converging with or diverging from frontier firms. Based on the idea of productivity convergence, we would expect that $\delta_1 > 0$, since that firms further away (a larger gap) from the frontier should have higher productivity growth. This is the traditional hypothesis associated with the idea of the "advantage of backwardness" which underlies that the further a firm is behind the technology frontier the faster it will grow, given the possibility to imitate already existent technologies (Gerschenkron, 1962). Based on the premise that it is easier to adopt a given technology than pushing at the technological frontier, it is inferred that the returns of innovation investments and productivity growth will be higher for laggard firms.

It has also been argued that there may be a negative relationship between the gap and productivity growth. According to Andrews *et al.* (2016), this phenomenon of productivity divergence could arise from two main factors. First, the competition in some product markets would be dominated by a "winner takes all" dynamic. This would be associated with digital technologies which allow the replication of goods and processes at near zero marginal cost and enable that top quality firms capture most—or all—of their market with only a tiny fraction of revenue taken by the next-best. This phenomenon would be reinforced by globalization, which increases the returns from investing in nonrival technologies through increasing the market size for frontier firms (Acemoglu and Linn, 2004). Second, there would be a phenomenon of stalling technological diffusion. According to this view, the superiority of frontier firms would not only reflect their higher capacity to innovate but also to optimally combine technological, organizational, and human capital in production processes. Given that the complexity of technologies has increased over time, frontier firms would have increased their competitive advantage over laggard firms because of the increasing amount and sophistication of complementary investments required for technological adoption (Andrews *et al.*, 2016). In sum, the parameter δ_1 may be positive or negative depending on which force predominates in generating convergence or divergence of laggard firms.

Regarding the interaction between the productivity gap and competition, there are also contrasting hypotheses related to differential impact of competition on productivity growth. The question is whether competition affects the productivity growth of lagging firms more or less than firms close to the frontier. Based on the idea of "advantage of backwardness," it can be inferred that the parameter β_1 is positivebecause higher competition would encourage more innovation and productivity growth for laggard firms. This expected result could be also associated with the literature of X-inefficiency, where less efficient firms would be more likely to survive in low-competition industries. In this case, increased competition forces managers to increase effort, reduce costs, and increase productivity. These effects would be higher for laggard firms.

One alternative view, associated with the literature of Schumpeterian economic growth, suggests that if in each sector there is a distribution of firm productivity, and if firms can innovate step-by-step, only those firms that are either at or very close to the frontier will find it profitable to innovate. Those firms that are further behind the frontier will not find innovation an attractive investment because ex-post returns will be very low compared with those for frontier or near-frontier firms (Aghion *et al.*, 2005). In this model, higher competition would lead to more innovation and productivity growth, but only for those firms close to the frontier. In such a case, we would expect that $\beta_1 < 0$. Thus, from a theoretical point of view, higher competition could either increase or decrease productivity growth for laggard firms.[4]

The empirical evidence about whether the impact of competition on productivity growth is higher for laggard or frontiers firms is mixed. Conway *et al.* (2007) uses the interaction between the productivity gap and an index of product market regulations to look at whether regulation retards or accelerates the speed of convergence to the productivity frontier. Their results using industry-level data for OECD countries indicate that higher competition—or less restrictive product market regulation—increases productivity growth more for less productive industries. They also find that the detrimental impact of regulation is larger in sectors that produce or use ICT intensively. Similar evidence is presented by Scarpetta and Tressel (2002) for 23 industries in 18 countries. Their findings show that regulation reduces productivity growth and that this negative effect is larger the further an industry is from the technological frontier.

There are also papers showing that higher competition induces higher productivity growth in firms/industries close to the frontier. Chevalier *et al.* (2009), using firm-level data for French firms, finds evidence that higher competition reduces the productivity growth of the least productive firms. Aghion *et al.* (2005), for India, look at how firms respond to the entry threat imposed by delicensing and find that that the impact on productivity is greater for more technologically advanced firms. Similarly, for the UK, Aghion *et al.* (2009) shows that higher competition, associated with entry of foreign firms, increases productivity and that the impact is larger for industries close to the technological frontier. Bloom *et al.* (2016) finds also evidence that competition from Chinese imports increases the productivity growth and innovation rates to a greater extent for more technologically advanced firms in 12 European countries.

In the case of exit, most of the theoretical models and empirical evidence show that low-productivity firms are more likely to exit the market. This is one of the main implications of open economy models and firms' heterogeneity (Bernard *et al.*, 2003; Melitz, 2003). Also, in these models, higher competition reinforces the effect of the productivity gap. Thus, we expect both δ_2 and β_2 to be positive in the exit equation. Recent evidence in this regard has been found, for example, by Álvarez and Vergara (2010) for Chile, Eslava *et al.* (2013) for Colombia, and Foster *et al.* (2008) for the United States. In the case of European countries, Bloom *et al.* (2016) finds that Chinese competition has a greater effect on the survival probability for low-productivity firms. This has also been found by Bernard *et al.* (2006) in the United States when analyzing the impact of higher competition coming from low wage countries.

4 See also Amable *etal* (2010) for a theoretical discussion and empirical evidence on how the impact of competition on innovation depends on the distance to the frontier.

Table 2. Descriptive statistics

Variable	Mean	Median	SD	Min.	Max.
TFP growth	−0.037	−0.033	0.714	−10.357	9.690
TFP gap	1.869	1.683	1.024	−3.781	12.406
Foreign	0.056	0.000	0.230	0.000	1.000
Marketing	0.008	0.000	0.026	0.000	0.689
Exports	0.068	0.000	0.204	0.000	1.000
Size	3.649	3.332	1.108	0.000	8.656
Boone index	2.708	2.745	1.051	0.190	4.194
Export share	0.449	0.412	0.186	0.112	0.887
Multinational share	0.148	0.119	0.118	0.000	0.788

Source: Own elaboration based on ENIA.

5. Results

The results for the relationship between TFP growth and competition are presented in columns (1) and (2) of Table 3. We have calculated TFP using the methodologies developed by Levinsohn and Petrin (2003), Wooldridge (2009), and Ackerberg *et al.* (2015), but we only present the results for the first. The other two have very similar results and are presented in the Supplementary Appendix. Thus, in general, our main findings do not depend on how TFP is estimated. In column (2), we have included additional control variables that may affect TFP growth. These are Foreign, a dummy for foreign-owned firms; Marketing for marketing expenditures over sales; Exports, defined as exports over sales; and Size calculated as the log of employment. The descriptive statistics for all variables used in the estimations are shown in Table 2.

We find that the parameter for the gap is always positive and significant, indicating that laggard firms tend to experience a higher TFP growth. Thus, our results are more consistent with the hypotheses of productivity convergence. Regarding the interaction between the gap and the competition variable, the parameter is also positive and significant. This is evidence that higher competition contributes to closing the productivity gap for laggard firms. These findings hold also when we include the set of additional firm characteristics.[5]

To provide a general estimate of the magnitude of the productivity enhancing effect of competition, by using the estimations from column (2), we calculate the quantitative impact of increasing competition. When moving the Boone index by one standard deviation, the differential impact on productivity growth between firms at 90% and 10% of the productivity gap distribution is 4.7%. These are relevant figures for productivity growth, but relatively small ones compared to the differences in the productivity gap.[6] In fact, growing at this rate, firms at 10% of the productivity gap would reach the productivity of firms at the 90% only after 18 years.

In columns (3) and (4) of Table 3 we show the results for firm exit. Following for example Bernard *et al.* (2006), we expect that a larger productivity gap increases the probability of exit and that higher competition reinforces this effect. In general, our findings are consistent with the hypothesis of Darwinian selection. Though the coefficient for the gap is not significant, the interaction between the gap and competition is positive and almost significant at 5%, indicating that increases in competition disproportionately affect low-productivity firms. The difference, however, is small. Taking the estimation in column (4) into account, we find that increasing the Boone index in one standard deviation generates a differential impact of 0.7% percentage points in the exit probability comparing firms at 10% and 90% of the productivity gap distribution.[7] This is quite low effect considering that average annual exit rates are about 9%.

5 We find that when dividing the period in two subperiods 1995–1999 and 2000–2008, the interaction between the gap and competition turns out to be not significant. Thus, the results should be interpreted as valid for the whole period but may not hold when the economy experiences growing or stagnant productivity.

6 The differential impact on productivity growth for firms at 75% and 25% of the productivity gap distribution is 2.2%.

7 The differential impact on exit probability for firms at 25% and 75% of the productivity gap distribution is 0.3 percentage points.

Table 3. Productivity growth and selection

	TFP growth		Exit	
	(1)	(2)	(3)	(4)
Gap	0.702	0.698	0.003	0.003
	(21.68)**	(21.51)**	(0.63)	(0.62)
Gap*Competition	0.020	0.022	0.003	0.003
	(2.22)*	(2.37)*	(1.98)	(2.00)
Foreign		−0.029		−0.003
		(1.67)		(0.22)
Marketing		−1.741		0.042
		(5.90)**		(0.70)
Exporting		0.070		−0.055
		(1.17)		(3.61)**
Size		−0.121		−0.058
		(6.41)**		(8.48)**
R^2	0.41	0.41	0.08	0.09
N	41,537	41,537	39,426	39,426

t-Statistics in parentheses. Clustered error to the three-digit industry level.

TFP is calculated using the methodology of Levinsohn and Petrin. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exporting is exports over sales, and Size is the log of employment.

*Significant at 5%, **significant at 1%.

Table 4. Productivity growth and selection for a sample of industries

	TFP growth		Exit	
	(1)	(2)	(3)	(4)
Gap	0.702	0.698	0.007	0.006
	(21.49)**	(21.33)**	(1.47)	(1.31)
Gap*Competition	0.020	0.022	0.002	0.002
	(2.18)*	(2.33)*	(1.25)	(1.43)
Foreign		−0.032		0.002
		(1.82)		(0.18)
Marketing		−1.744		0.044
		(5.88)**		(0.66)
Exporting		0.072		−0.062
		(1.20)		(3.61)**
Size		−0.120		−0.054
		(6.32)**		(7.90)**
R^2	0.41	0.41	0.08	0.08
N	41,283	41,283	38,193	38,193

t-Statistics in parentheses. Clustered error to the three-digit industry level.

TFP is calculated using the Levinsohn and Petrin methodology. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exporting is exports over sales, and Size is the log of employment.

*Significant at 5%, **significant at 1%.

One concern with our identification strategy is that the competition measure may not be exogenous in the case of industries with a small number of firms. It may be argued that TFP growth in some lagging firms may also affect competition. To check the robustness of our results, we estimate the model only for industries with more than 30 firms. We present the results in Table 4. These findings are very similar to our previous estimations.

Another concern regards our measure of competition, the Boone index. The idea of this index is that more productive firms grow faster and increase their market share, but this mechanism of "growth of the fittest" may be not always smooth (Metcalfe, 1994; Coad, 2007; Bottazzi *et al.*, 2010). There are several reasons why less productive firms may grow more than more productive ones: (i) low-cost firms do not want to grow because they want high profits rather than market share growth; (ii) high-cost firms have empire-building CEOs; (iii) firms are not rational; (iv) high-cost firms can reduce their costs by growing; and (iv) low-cost firms lack opportunities for market growth. Thus, it can be argued that the Boone index may not be a good measure of competition.

To deal with this issue we carry out estimations using traditional measures of market concentration such as the Herfindahl–Hirchsman index and the market share of the top five firms in each industry. In this case, to be consistent with our previous results, the sign for the interaction between gap and concentration needs to be negative because more concentrated markets (lower competition) would not generate incentives for increased productivity for laggard firms. We present the results in Table 5. In the case of productivity growth, shown in columns (1) and (2), we find similar evidence to what we found from the Boone index: laggard firms have higher productivity growth, and higher concentration reduces the impact of the productivity gap. However, the interaction term is only significant at 10%. In the case of exit, presented in columns (3) and (4) of Table 5, the gap is found to be positive and significant as expected. However, in this case, the parameter for the interaction between gap and concentration is not significant.

We undertake several additional robustness checks regarding alternative hypotheses, other productivity measurements, and different industry aggregations. First, we check whether our estimations are robust to alternative explanations. Specifically, we consider the literature on technological spillovers associated with exports and the presence of multinationals (Keller, 2010). For this, we include the interactions between the TFP gap and the importance of exporters and multinational firms in industry employment. According to the literature of technological spillovers, laggard firms could learn from more productive firms in the industry. These are, in general, exporting and multinational ones. Thus we expect a positive parameter for these interactions in the case of productivity growth. In the case of exit, a greater amount of high-productivity firms may increase exit through other channels besides direct competition or may reduce exits if productivity spillovers increase the chances of survival.

The results are presented in Table 6. For TFP growth, we do not find any impact of a higher presence of exporters in the industry, but the interaction between the gap and the multinational participation is negative. Regarding the impact of competition, our previous results are robust to the inclusion of both interactions. In the case of exit, there are not any changes with respect to the main results presented in Table 3. Thus, we conclude that both sets of results are robust to the potential effect of technological spillovers from exporters and foreign firms.

Table 5. Productivity and selection with a concentration measure

	TFP growth		Exit	
	(1)	(2)	(3)	(4)
Gap	0.773	0.773	0.009	0.009
	(36.37)**	(35.97)**	(3.10)**	(3.07)**
Gap*Concentration	−0.246	−0.257	0.046	0.046
	(1.41)	(1.48)	(1.87)	(1.93)
Foreign		−0.030		−0.003
		(1.68)		(0.23)
Marketing		−1.727		0.046
		(5.98)**		(0.76)
Exporting		0.069		−0.056
		(1.18)		(3.57)**
Size		−0.120		−0.058
		(6.38)**		(8.46)**
R^2	0.41	0.41	0.08	0.09
N	41,537	41,537	39,426	39,426

t-Statistics in parentheses. Clustered error to three-digit industry level.

TFP is calculated using the methodology of Levinsohn and Petrin. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exporting is exports over sales, and Size is log of employment. Concentration is measured by the Herfindahl–Hirchsman index.

*Significant at 5%, **significant at 1%.

Table 6. Productivity growth, selection, and spillovers

	TFP growth	Exit
Gap	0.756	0.004
	(22.94)**	(0.46)
Gap*Competition	0.020	0.003
	(2.62)*	(1.85)
Gap*Exp_Ind	−0.053	−0.014
	(0.94)	(0.96)
Gap*Mult_Ind	−0.197	0.040
	(2.42)*	(1.52)
Foreign	−0.031	−0.002
	(1.73)	(0.16)
Marketing	−1.733	0.041
	(5.73)**	(0.67)
Exporting	0.067	−0.055
	(1.12)	(3.60)**
Size	−0.122	−0.057
	(6.58)**	(8.49)**
R^2	0.42	0.09
N	41,537	39,426

t-Statistics in parentheses. Clustered error to the three-digit industry level.

TFP is calculated using the Levinsohn and Petrin's methodology Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exporting is exports over sales, and Size is log of employment. Exp_Ind is the importance of exporters in a three-digit industry employment, and Mult_Ind is the importance of multinationals in a three-digit industry employment.

*Significant at 5%, **significant at 1%.

We estimate the model using labor productivity instead of TFP due to the problems with the two-step estimations that we discussed in Section 3. In the case of labor productivity (value added per worker), we find that the relationship between the gap and productivity growth (and exit) continues to be positive, meaning that low-productivity firms tend to increase TFP faster and are also more likely to exit (Table 7). The parameter for the interaction between the productivity gap and competition is similar to the previous estimations presented in Table 3 as are the main conclusion with respect to a low impact of competition on productivity growth and exit holds.

We also estimate both equations using a higher aggregation level for the industries (two-digit level). We find that for productivity growth the association with the productivity gap holds, but the interaction with competition turns out to be not significant. In the case of exit, most of the results are not significant.[8] This could be interpreted as using a higher aggregation does not capture relevant competition for firms.

The most important concern with our estimation is the endogeneity of competition. To deal with this problem, we follow previous literature and we employ Chinese import penetration as an exogenous indicator of competition. However, it can be argued that changes in import penetration from China are an exogenous supply shock from the Chilean producers' perspective. Autor *et al.* (2013) suggests that realized imports from China may be correlated with industry import demand shocks, in which case the OLS estimate will be also inconsistent. Following that paper, we identify the supply-driven component of Chinese imports by instrumenting Chinese imports to Chile with Chinese import penetration in other Latin American countries.

We use two alternative instrumental variables. First, we construct import penetration for a sample of the seven main Latin American countries with information about Chinese imports: Argentina, Brazil, Colombia, Ecuador, Uruguay, Paraguay, and Peru. The other indicator considers only Chines imports to Mexico, a country with relatively little trade with Chile, thus it would be not affected by changes in the productivity of Chilean industries.[9] The results

8 To save space we do not show these results, but they are available upon request.

9 We would like to thank an anonymous referee for the suggestion of using import penetration from China as an exogenous shock to competition.

Table 7. Productivity and selection using labor productivity

	Productivity growth	Exit
Gap	0.758	0.012
	(40.77)**	(3.48)**
Gap*Competition	0.002	0.001
	(0.64)	(1.24)
Foreign	0.002	−0.002
	(0.08)	(0.21)
Marketing	−1.528	0.125
	(7.04)**	(1.74)
Exporting	0.147	−0.057
	(3.19)**	(3.05)**
Size	−0.270	−0.055
	(12.21)**	(6.98)**
R^2	0.43	0.09
N	49,809	45,447

t-Statistics in parentheses. Clustered error to three-digit industry level.

Productivity is calculated as value added per worker. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exporting is exports over sales, and Size is log of employment.

*Significant at 5%, **significant at 1%.

Table 8. IV estimations

	Productivity growth		Exit	
	Mexico	Lat Am	Mexico	Lat Am
Gap	0.706	0.739	0.003	0.006
	(38.20)**	(73.64)**	(0.38)	(1.23)
Gap*Competition	1.604	0.561	0.311	0.213
	(2.83)**	(2.09)*	(1.15)	(1.58)
Foreign	−0.032	−0.031	0.001	0.001
	(1.30)	(1.23)	(0.09)	(0.10)
Marketing	−1.725	−1.720	0.044	0.045
	(8.76)**	(8.78)**	(0.43)	(0.44)
Exporting	0.066	0.068	−0.061	−0.061
	(1.84)	(1.92)	(3.26)**	(3.25)**
Size	−0.116	−0.119	−0.053	−0.054
	(12.54)**	(13.01)**	(10.78)**	(10.91)**
N	41,537	41,537	38,430	38,430

$^*P < 0.05$, $^{**}P < 0.01$.

for both IV estimations are similar and we present them in Table 8. The evidence suggests a robust effect of competition and that its interaction with the productivity gap affects productivity growth. Similar to previous estimations, an increase in competition is associated with higher productivity growth for laggard firms. In contrast to previous results, however, the IV estimations show that there are not significant effects on exit.

6. Conclusions

There is evidence that several countries have recently experienced lower TFP growth. There is not much research on the causes of this phenomenon especially for developing countries and regarding the impact of competition on product markets. In this paper, we have analyzed the relationship among competition, selection, and productivity in Chile, particularly whether competition contributes to closing the gap between laggard firms and those at the technological frontier. We use a direct measure of competition, the Boone index, but we also complement our estimations with traditional measures of market concentration and import penetration.

We find that that the productivity gap is associated with faster productivity growth. Thus, our results are consistent with the hypothesis of convergence. We also find that higher competition is associated with increased productivity of laggard firms. The impact is relevant, but relatively small compared to the average gap with frontier firms. Thus, our results indicate that increasing competition has not been able to significantly close the productivity gap in the Chilean manufacturing industries.

Regarding Darwinian selection, our results indicate that generally low-productivity firms are more likely to go out of business. The evidence that higher competition increases the probability of closure for low-productivity firms is weaker and does not hold in several robustness checks. This selection effect—as the literature of misallocation suggests—could help to raise aggregate productivity, but for some reasons is not happening in Chile. This may be an interesting issue for future research.

Our findings provide some interesting elements for the discussion about theoretical and empirical issues. From a theoretical perspective, there are several strands of the literature looking at the main explanations for heterogeneity and sustainability. In a simple model of perfect competition, it is hard to explain why inefficient firms survive and laggard firms do not increase productivity. In other models, such as those with monopolistic competition, this can be rationalized by exogenous differences in productivity causing persistent differences in size and profitability. The evidence suggest that these models are more consistent with empirical evidence of great differences in productivity.

In the case of the strategic management literature, the resource-based view indicates that firms' heterogeneity comes from different resources, which makes firms differentially effective. Also in this context some authors have argued that this view is limited, and even with competition there will be sustainable differences in firm capacity, which originate in idiosyncratic investments in resources and capabilities (Jacobides *et al.*, 2012). It could be interesting to examine what these investments are and how they affect the firms' responses to changes in competition. Some evidence has been provided that firms can survive and increase productivity by innovating and improving management techniques (Van Reenen, 2011). For both, economics and strategy literature, our results indicate that more intense competition does reduce, but surely it does not eliminate firm capability discrepancies.

Our results have some relevant policy implications. First, competition has been found to increase TFP, but the impact seems to be modest. Government policies should be oriented to introduce higher competition and to increase its impact on TFP growth and firms' selection. Second, other barriers or regulations should be reconsidered regarding their impact on TFP growth. In particular, to remove distortions in resource allocation, policy makers must have a better understanding of why higher competition has not induced the exit of low-productivity firms. Further evidence is required to explore additional factors that may help to close the productivity gap and to enhance productivity growth.

Supplementary Data

Supplementary materials are available at *Industrial and Corporate Change* online.

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