Competition, Selection, and Productivity Growth in the Chilean Manufacturing Industry*

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Abstract

Recent evidence for several countries shows a decline in TFP growth. However, there is not much evidence for developing countries and much less regarding the impact of competition in product markets on TFP. In this paper, we analyze the impact of competition on firm selection and productivity growth in Chile. Our results indicate that competition has a positive effect on TFP growth and increases the probability of exit for lagging firms. Our results are robust to alternative methodologies for calculating TFP and to the inclusion of other variables that may affect firms' TFP growth and selection. We find support for Schumpeterian forces, but the quantitative impact is small.

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1. Introduction

During the past two decades, after a period of strong economic growth, total factor productivity (TFP) has practically not grown in Chile. There are several questions about this phenomenon, but little empirical evidence about its causes. One of the most interesting questions is on the factors behind this productivity slowdown. There are some potential culprits suggested in the literature, such as structural change, measurement problems, lack of competition, and resource misallocation due to market failures, among others (Syverson, 2011).

This seems to be a worldwide phenomenon and not specific to the Chilean economy. Andrews, et al. (2016) document and explore some of these issues for rich OECD countries. However, there is not much evidence for developing countries and much less regarding the impact of competition in product markets. 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 has experienced a strong productivity slowdown since the Asian financial crisis (Figure 1).

We study specifically whether higher competition increases productivity growth in laggards firms using a measure of distance to the technological frontier. Given that variations on competition at industry-specific level may capture other changes in the industry, we cannot identify their impact directly. Thus we use a differences-in-differences approach in which the differential impact of competition is identified depending on how close to the frontier the firms are. Our main hypothesis is that higher competition has a larger effect on firms that are further away from the frontier.

We use a direct measure of competition, the Boone index, which has not been previously used in this type of studies, and we exploit across industry changes in this indicator over time. We deal with the endogeneity of competition by including time-varying industry-specific effects that control for all variables, such import competition, industry prices and costs, which may affect rivalry among firms over time. Thus our main identification assumption is that industry competition is exogenous for individual firms. This may be not true for highly concentrated industries, but we check that our results are robust to the exclusion of such industries.

The previous literature has mostly found a positive effect of competition on productivity growth. This is the conclusion of several literature surveys (Syverson, 2011; Holmes and Schmitz, 2010; Nicoletti and Scarpetta, 2005). In particular, Nickel (1996), for example, using information for 670 U.K. companies during the period 1975-1986 and measuring competition by the numbers of rivals and the level of industry rents, finds a positive effect on total factor productivity growth. Using more recent data and a large sample of U.K. firms, Disney et al. (2003) confirms these results. Several other studies have also found that regulatory changes enhancing product market competition have been associated with productivity growth in OECD countries (Nicoletti and Scarpetta, 2005).

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 more exposed to international competition, i.e. those in export oriented and import competing industries. The evidence for Colombia in Eslava et al. (2004) is also consistent with the positive productivity effects of structural reforms that increase competition in domestic markets.

Some papers have explored the mechanisms for this positive relationship between trade and productivity, in particular whether competition enhances innovation. For example, Bloom et al. (2011) finds that Chinese import competition in European countries had a positive effect on innovation. This positive effect has been also found by Baldwin and Gu (2004) and Lileeva and Trefler (2010) for Canadian firms due to 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 named as Darwinian selection by Syverson (2011). It is argued that competition may force to low productivity firms to exit the market or shrink them, thus reallocating resources to more productive firms. This is the mechanism behind the 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

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

probability of exit for low productivity firms (Alvarez and Vergara, 2010; Eslava et al. 2013; Foster et al. 2001; Foster et al. 2008).

We make two contributions to this empirical literature. First, we provide novel evidence on the relationship between competition and productivity growth using a direct measure of competition, the Boone index. Second, we use a different empirical strategy for dealing with endogeneity issues. We exploit the expected 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[2]. Our differences-in-differences approach identifies the differential impact of competition depending on 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 reduces endogeneity concerns because all time varying industry determinants of competition are controlled by introducing a set of time-varying industry-specific effects.

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 also find evidence that competition has generated a Darwinian selection by increasing the probability of low productivity firms closing. Given the importance of productivity measurements, we provide evidence that our results are robust to alternative methodologies for calculating firm-level TFP.

[2] See Alvarez and Crespi (2007) for Chile, and Crespi and Iacovone (2010) for Mexico.

This paper is structured as follows. In the second section, we describe the dataset. In section 3, we present the methodology. In section 4, we show the results. In section 5, we conclude.

2. Data

Our analysis is mainly based on information for Chilean manufacturing plants covering the period 1995-2007. The National Annual Survey of Manufactures (ENIA) collects information for about 4,000 plants and contains data on several variables such as sales, output, employment, wages, exports, foreign ownership, and other plant characteristics for each plant that has at least 10 employees.[3] All monetary variables were converted to constant Chilean pesos using 3-digit ISIC level price deflators. In addition, plants are classified according to the International Standard Industrial Classification (ISIC), Rev. 3. Table 1 shows the number of plants by year. There are approximately 4,500 plants at the beginning of the period and about 4,000 plants by 2007.

The main interest variable is total factor productivity (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 the methodology developed by Wooldridge (2009). Third, we use the methodology of Ackerberg et al. (2015) that solves the collinearity problems in the estimation of Olley and Pakes (1996). In these

[3] There is more recent data of the ENIA but unfortunately the INE has decided do not give information of the plant identification number for extending the panel.

three cases, 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 as frontier firms as those firms being — for each year and 3-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 mean for representing their productivity. We compute the gap between the group of frontier firms and a non-frontier 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. The evolution is similar with both measures of TFP and shows that there is some trend towards a slight increase in the gap.

We employ the Boone indicator as a measure of competition. This indicator was proposed by Boone (2008) and is based on the concept that more efficient firms, i.e. those with lower marginal costs, obtain higher market shares and profits in relation to their less efficient rivals. As competition intensifies, there is 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:

$$\ln(\pi_{it}) = \alpha + \theta \ln(CVM_{it}) + \varepsilon_{it}$$

Where

- $\ln(\pi_{it})$: Profits of firm i in time t based
- $ln(CVM_{it})$: Total variable cost over total revenues $\frac{CVT_{it}}{y_{it}}$.

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 industry, the benefits each firm gets are more sensitive to firm costs, which is consistent with a more competitive environment (Boone, 2008).

We estimate the equation for each 3-digit industry. We show the 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 tougher competition. The evolution indicates that there are some fluctuations over time, but overall, there is an increase in average competition in the manufacturing industry.

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. As can be appreciated, a similar percentage of industries suffered increases and reductions in competition. To complement this evidence, Figure 5 explores whether changes in competition were related with changes in the average TFP gap across industries. We do not find evidence on this regard. In fact, the correlations are positive but not significant.

3. Methodology

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

$$TFPG_{ikt} = \alpha_i + \alpha_{kt} + \delta_1 GAP_{it-1} + \beta_1 GAP_{it-1} COMP_{kt} + \varepsilon_{c,t}$$

$$Exit_{ikt} = \alpha_i + \alpha_{kt} + \delta_2 GAP_{it} + \beta_2 GAP_{it-1} COMP_{kt} + \varepsilon_{c,t}$$

Where $\mathrm{TFPG_{ikt}}$ is the TFP growth for non-frontier firm i in industry k at year t, and Exit is a dummy variable for firms that die between t-1 and t. $\mathrm{GAP_{it-1}}$ 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.

We expected the following results. Based on the idea of productivity convergence, we expect that $\delta_1 > 0$, since that firms further away (larger gap) from the frontier should have higher productivity growth. Second, we expect that $\beta_1 > 0$ because this effect should be reinforced by higher competition. In the case of exit, δ_2 and β_2 should be both negative given that a larger productivity gap increases the probability of exit, and competition is expected to exacerbate this selection effect.

This differences-in-differences approach identifies the differential impact of competition depending on 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 reduces endogeneity concerns because all time varying industry determinants of competition are controlled by introducing a set of time-varying industry-specific effects.

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 allows us to control for unobserved heterogeneity.

4. Results

The results for the relationship between TFP growth and competition are presented in Table 3. Each column corresponds to a different measure of TFP. We have calculated TFP using the methodologies developed by Levinsohn and Petrin (2003), Wooldridge (2009), and Ackerberg, et al. (2015). We also include 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.

The findings are similar for the three TFP measures, indicating that these results are not driven by a particular methodology for calculating firm-level productivity. We find that the parameter for the gap is always positive and significant, indicating that laggard firms tend to experience higher TFP growth. Regarding the interaction between the gap and the competition variable, as expected the parameter is also positive and significant. This is evidence that higher competition contributes towards closing the productivity gap for laggard firms. These findings hold also when we include a set of firm characteristics such as a dummy for foreign-owned ones, expenditures on marketing, exports, and size.

The quantitative impact is also similar for the three measures of TFP. Increasing the gap by one standard deviation increases productivity growth between 5% and 10%. When moving from less competitive (25^{th} percentile of the Boone distribution) to more competitive industries (75^{th} percentile), the impact of changing the gap by one-standard deviation changes from 20% to a maximum of 40%. The lowest change is found with TFP_ACF where the change is from 9% to 16% (Figure 6). These are relevant figures, but relatively small ones compared to the average gap.

In Table 4 we show results for firm death. Following, for example Bernard et al. (2006), who focus on import competition from low-wage countries to the US, we expect that a larger productivity gap increases the probability of death and that higher competition reinforces this effect. In general, our findings are consistent with this hypothesis of Darwinian selection. The coefficient for the interaction between the gap and competition is always positive and significant. With respect to the other variables, we find that larger and more export oriented firms are less likely to die.

In quantitative terms the impact is relevant. A change of one standard deviation in the competition index — measured at the average gap for every TFP indicator — elevates the probability of death by about 1 percentage point. This is compared with an average exit probability of 9.7%. Moving from low to high competition industries — using the 25th and 75th percentiles of the Boone index — increases the exit probability to 2% to 4% depending on the TFP indicator (Figure 7). Thus we find a significant but small impact of competition on the exit of laggard firms.

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, which is 10% of the number of firms' distribution by industry in our sample. We present the results in Tables 5 and 6. These findings are very similar to our previous estimations.

We also check whether our estimations are robust to alternative explanations. Specifically, to consider the literature on technological spillovers associated with exports and the presence of multinationals (Keller, 2010). To do this, we include 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, exporter and multinational ones. Then, we expect a positive parameter for these interactions in the case of productivity growth. In the case of exit, a greater presence of high-productivity firms may increase exit through other channels besides direct competition in product market or may reduce exits if productivity spillovers increase the chances of survival.

The results are presented in Tables 7 and 8 for TFP growth and survival respectively. For TFP growth, there is not any impact of the higher presence of exporters in the industry and the effect for laggard firms in an industry with higher multinationals participation is negative. Regarding the impact of competition, our previous result is robust to the inclusion of both interactions. In the case of exit, the impact of competition still holds. Thus both set of results are robust to the potential effect of technological spillovers.

5. Conclusions

There is evidence that several countries have recently experienced lower TFP growth, but there is not much research on their causes especially for developing countries and regarding the impact of competition in 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 the technological frontier and laggard firms. Thus we used a direct measure of competition, the Boone index, which has not previously been used in this type of studies, and exploited differences across industries and over time using this indicator.

We find that that higher competition is associated with increasing productivity of laggard firms. The impact is relevant, but relatively small compared to the average gap with frontier firms. Thus our results indicate that competition has not been able to significantly close the productivity gap in Chilean manufacturing industries. More evidence is needed to explore additional factors that may help to close this gap and to enhance productivity growth. Regarding Darwinian selection, our results indicate that higher competition increases the probability of closure for low productivity firms. This — as the literature of misallocation suggests — may help to raise aggregate productivity. However, the impact is also small. These results are robust to using three alternative measures of TFP and also considering the role of other industry-specific variables when looking at the potential impact of technological spillovers.

This evidence poses interesting questions about how to increase productivity. Competition has been found to increases TFP, but the impact seems to be modest. More research needs to be done to explain how to introduce higher competition and to increase its impact on TFP growth and selection. Second, other barriers or regulations should be studied for looking at their impact on TFP and Darwinian selection.

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Table 1

Number of Plants

Year	Plants
1995	4,414
1996	4,720
1997	4,547
1998	4,291
1999	4,185
2000	4,044
2001	3,965
2002	4,159
2003	4,210
2004	4,259
2005	4,204
2006	4,104
2007	3,933
Average	4,233

Table 2

Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
TFPG_LP	-0.037	0.714	-10.357	9.690
TFPG_W	-0.039	0.710	-10.358	9.694
TFP_ACF	-0.037	0.711	-10.389	9.749
Gap_LP	1.869	1.024	-3.781	12.406
Gap_W	1.839	1.024	-3.611	12.392
Gap_ACF	1.742	0.991	-3.394	12.283
Foreign	0.056	0.230	0.000	1.000
Marketing	0.008	0.026	0.000	0.689
Exports	0.068	0.204	0.000	1.000
Size	3.649	1.108	0.000	8.656
Competition	2.708	1.051	0.190	4.194
Exp_Ind	0.449	0.186	0.112	0.887
Mult_Ind	0.148	0.118	0.000	0.788

Source: Own elaboration based on ENIA

Table 3

Productivity Growth

	TFPG_LP	TFP_LP	TFP_W	TFP_W	TFP_ACF	TFP_ACF
Gap	0.625	0.621	0.600	0.596	0.695	0.700
	(11.33)**	(11.12)**	(9.72)**	(9.46)**	(15.07)**	(14.74)**
Gap*Competition	0.053	0.054	0.060	0.062	0.025	0.026
	(2.86)**	(2.91)**	(2.84)**	(2.88)**	(1.61)	(1.67)
Foreign		-0.028		-0.038		-0.039
		(1.57)		(1.87)		(2.41)*
Marketing		-1.760		-1.861		-1.967
		(6.01)**		(6.22)**		(5.95)**
Exports		0.068		0.059		0.077
		(1.16)		(1.00)		(1.38)
Size		-0.121		-0.132		-0.282
		(6.47)**		(6.30)**		(11.85)**
Constant	-1.690	-1.263	-3.192	-1.528	-0.681	0.364
	(4.08)**	(2.89)**	(17.39)**	(7.63)**	(3.87)**	(1.88)
Observations	41537	41537	41560	41560	41597	41597
Plants	7663	7663	7659	7659	7638	7638
R-squared	0.41	0.42	0.41	0.42	0.42	0.43

t-statistics in parentheses. Clustered error to 3-digit industry level. * significant at 5%; ** significant at 1%. TFPG_LP is TFP growth calculated using Levinsohn and Petrin; TFPG_W using Wooldridge; and TFPG_ACF using Ackerberg, Caves and Frasier. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exports is exports over sales, and Size is log of employment.

Table 4

Probability of Death

	TFP_LP	TFP_LP	TFP_W	TFP_W	TFP_ACF	TFP_ACF
Gap	-0.001	-0.002	-0.000	-0.001	-0.000	0.001
	(0.25)	(0.37)	(0.03)	(0.14)	(0.03)	(0.25)
Gap*Competition	0.005	0.006	0.005	0.005	0.004	0.005
	(3.01)**	(3.03)**	(2.85)**	(2.86)**	(2.94)**	(3.14)**
Foreign		-0.002		-0.003		-0.004
		(0.21)		(0.26)		(0.36)
Marketing		0.040		0.050		0.062
		(0.66)		(0.85)		(1.07)
Exports		-0.055		-0.053		-0.043
		(3.60)**		(3.50)**		(3.55)**
Size		-0.058		-0.058		-0.057
		(8.46)**		(8.20)**		(8.19)**
Constant	-0.360	-0.130	-0.335	-0.104	-0.309	-0.080
	(11.00)**	(2.93)**	(10.17)**	(2.29)*	(9.51)**	(1.74)
Observations	39426	39426	39462	39462	39526	39526
Plants	7045	7045	7045	7045	7031	7031
R-squared	0.08	0.09	0.08	0.09	0.08	0.09

t-statistics in parentheses. Clustered error to 3-digit industry level. * significant at 5%; ** significant at 1%. TFP_LP is TFP calculated using Levinsohn and Petrin; TFP_W using Wooldridge; and TFP_ACF using Ackerberg, Caves and Frasier. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exports is exports over sales, and Size is log of employment.

Table 5

Productivity Growth, Robustness

	TFP_LP	TFP_LP	TFP_W	TFP_W	TFP_ACF	TFP_ACF
Gap	0.622	0.619	0.599	0.595	0.695	0.699
	(11.17)**	(10.98)**	(9.62)**	(9.37)**	(14.91)**	(14.60)**
Gap*Competition	0.054	0.055	0.060	0.062	0.025	0.026
	(2.87)**	(2.93)**	(2.84)**	(2.88)**	(1.61)	(1.66)
Foreign		-0.031		-0.038		-0.043
		(1.72)		(1.87)		(2.74)*
Marketing		-1.762		-1.867		-1.977
		(5.98)**		(6.20)**		(5.94)**
Exports		0.071		0.060		0.078
		(1.20)		(1.02)		(1.39)
Size		-0.120		-0.132		-0.281
		(6.39)**		(6.26)**		(11.75)**
Constant	-0.811	-0.381	-0.620	-0.161	-0.477	0.493
	(3.39)**	(1.50)	(2.45)*	(0.59)	(5.88)**	(3.98)**
Observations	41283	41283	41300	41300	41328	41328
Plants	7604	7604	7598	7598	7579	7579
R-squared	0.41	0.42	0.41	0.41	0.42	0.43

t-statistics in parentheses. Clustered error to 3-digit industry level. * significant at 5%; ** significant at 1%. TFPG_LP is TFP growth calculated using Levinsohn and Petrin; TFPG_W using Wooldridge; and TFPG_ACF using Ackerberg, Caves and Frasier. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exports is exports over sales, and Size is log of employment.

Table 6

Probability of Death, Robustness

	TFP_LP	TFP_LP	TFP_W	TFP_W	TFP_ACF	TFP_ACF
Gap	-0.001	-0.001	0.000	-0.000	0.000	0.001
	(0.19)	(0.30)	(0.05)	(0.07)	(0.01)	(0.30)
Gap*Competition	0.005	0.005	0.005	0.005	0.004	0.005
	(2.97)**	(2.99)**	(2.80)**	(2.81)**	(2.90)**	(3.10)**
Foreign		-0.002		-0.003		-0.004
		(0.20)		(0.26)		(0.33)
Marketing		0.041		0.049		0.064
		(0.66)		(0.84)		(1.10)
Exports		-0.056		-0.054		-0.043
		(3.62)**		(3.53)**		(3.56)**
Size		-0.058		-0.058		-0.058
		(8.42)**		(8.16)**		(8.16)**
Constant	-0.051	0.132	-0.055	0.128	-0.057	0.124
	(0.78)	(2.19)*	(0.81)	(2.05)*	(0.87)	(2.03)
Observations	39185	39185	39217	39217	39274	39274
Plants	6991	6991	6990	6990	6977	6977
R-squared	0.08	0.09	0.08	0.09	0.08	0.09

t-statistics in parentheses. Clustered error to 3-digit industry level. * significant at 5%; ** significant at 1%. TFP_LP is TFP calculated using Levinsohn and Petrin; TFP_W using Wooldridge; and TFP_ACF using Ackerberg, Caves and Frasier. Foreing is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exports is exports over sales, and Size is log of employment.

Table 7

Productivity Growth and Spillovers

	TFPG_LP	TFPG_W	TFPG_ACF
Gap	0.663	0.634	0.765
	(9.99)**	(7.42)**	(15.31)**
Gap*Competition	0.052	0.059	0.022
	(3.21)**	(2.81)**	(1.75)
Gap*Exp_Ind	-0.019	-0.062	-0.035
	(0.34)	(0.82)	(0.80)
Gap*Mult_Ind	-0.179	-0.019	-0.238
	(3.53)**	(0.29)	(3.92)**
Foreign	-0.030	-0.038	-0.040
	(1.64)	(1.85)	(2.40)*
Marketing	-1.752	-1.857	-1.954
	(5.87)**	(6.20)**	(5.78)**
Exports	0.066	0.058	0.074
	(1.13)	(0.99)	(1.33)
Size	-0.122	-0.132	-0.282
	(6.60)**	(6.42)**	(12.00)**
Constant	-1.182	-2.832	0.328
	(2.72)*	(14.06)**	(1.67)
Observations	41537	41519	41597
Plants	7663	7652	7638
R-squared	0.42	0.42	0.44

t-statistics in parentheses. Clustered error to 3-digit industry level. * significant at 5%; ** significant at 1%. TFPG_LP is TFP growth calculated using Levinsohn and Petrin; TFPG_W using Wooldridge; and TFPG_ACF using Ackerberg, Caves and Frasier. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exports is exports over sales, and Size is log of employment. Exp_Ind is the importance of exporters in 3-digit industry employment, and Mult_Ind is the importance of multinationals in 3-digit industry employment.

Table 8

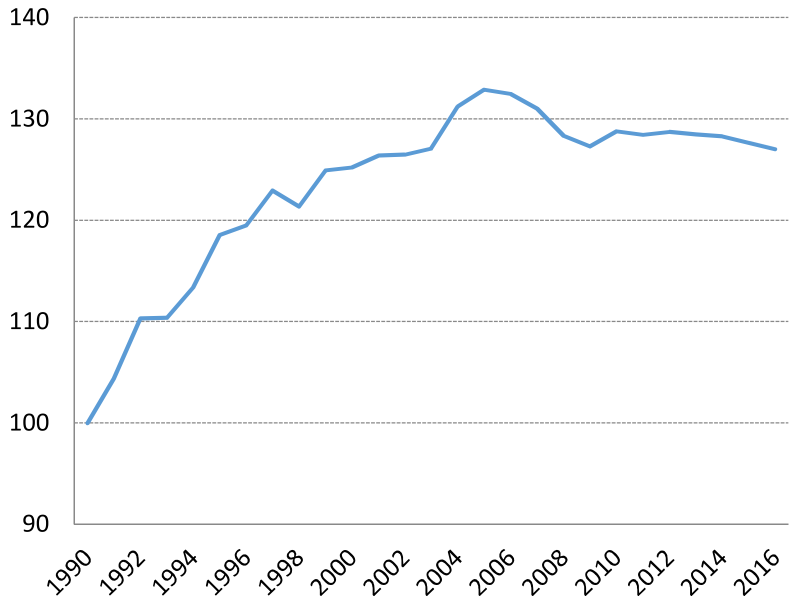
Probability of Death and Productivity Spillovers

	TFP_LP	TFP_W	TFP_ACF
Gap	-0.003	-0.002	0.000
	(0.41)	(0.27)	(0.04)
Gap*Competition	0.006	0.005	0.005
	(2.37)*	(2.29)*	(2.46)*
Gap*Exp_Ind	-0.011	-0.008	-0.010
	(0.86)	(0.68)	(0.71)
Gap*Mult_Ind	0.043	0.036	0.031
	(1.97)	(1.83)	(1.44)
Foreign	-0.002	-0.003	-0.004
	(0.15)	(0.23)	(0.32)
Marketing	0.039	0.047	0.061
	(0.63)	(0.81)	(1.05)
Exports	-0.055	-0.052	-0.043
	(3.60)**	(3.50)**	(3.55)**
Size	-0.058	-0.059	-0.058
	(8.46)**	(8.21)**	(8.19)**
Constant	-0.119	-0.093	-0.068
	(2.51)*	(1.95)	(1.41)
Observations	39426	39424	39526
Plants	7045	7039	7031
R-squared	0.09	0.09	0.09

t-statistics in parentheses. Clustered error to 3-digit industry level. * significant at 5%; ** significant at 1%. TFP_LP is TFP calculated using Levinsohn and Petrin; TFP_W using Wooldridge; and TFP_ACF using Ackerberg, Caves and Frasier. Foreign is a dummy for foreign-owned firms, Marketing is marketing expenditures over sales, Exports is exports over sales, and Size is log of employment., Exp_Ind is the importance of exporters in 3-digit industry employment, and Mult_Ind is the importance of multinationals in 3-digit industry employment

Figure 1

Aggregate TFP: 1990-2016



Fuente: Comisión Nacional de Productividad. Informe de Productividad Anual 2016.

Figure 2

Evolution of the Boone Index

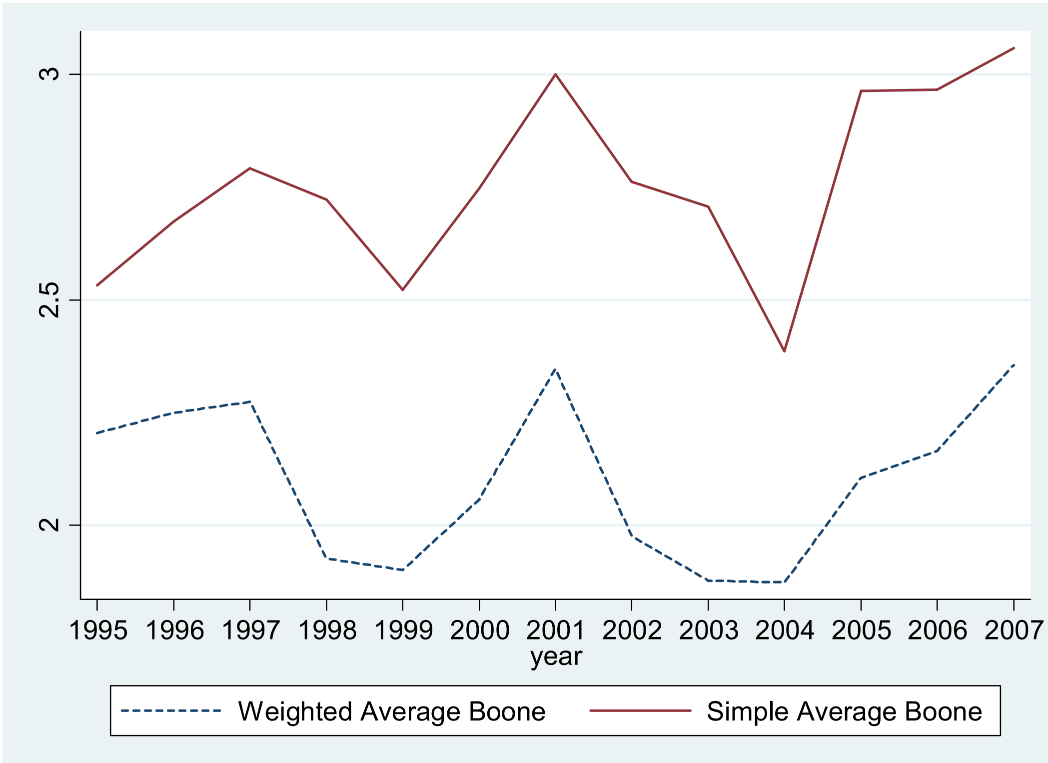


Figure 3

Evolution of the TFP Gap

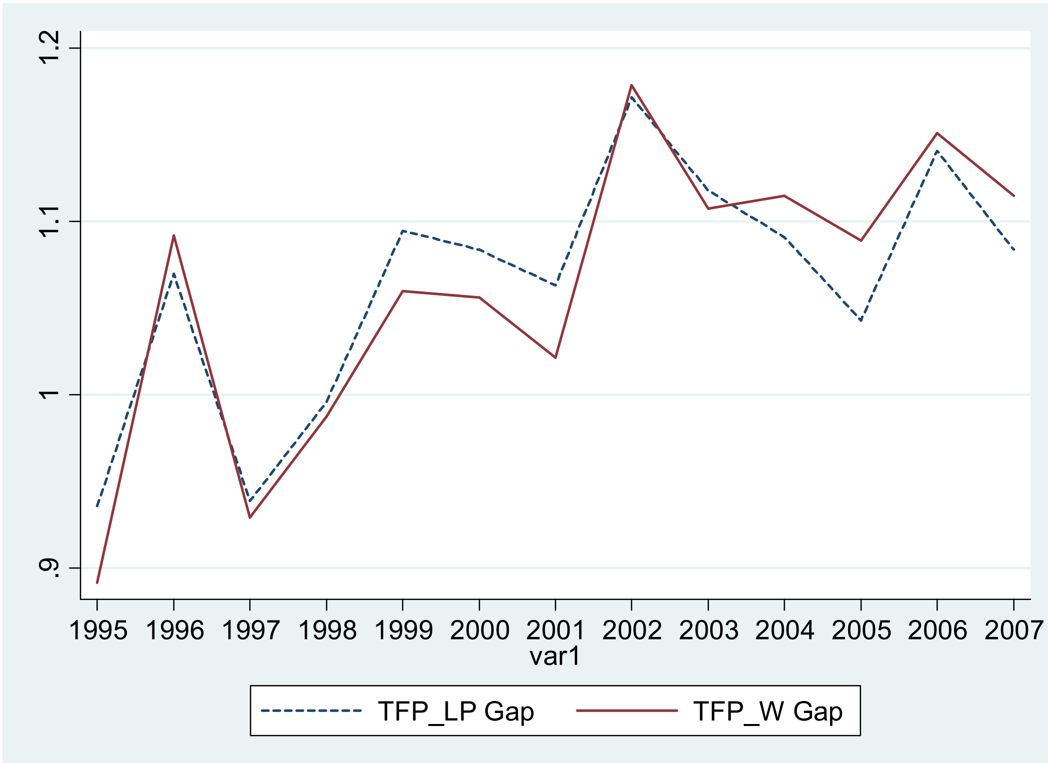


Figure 4

Distribution of Changes in Competition, kernel density

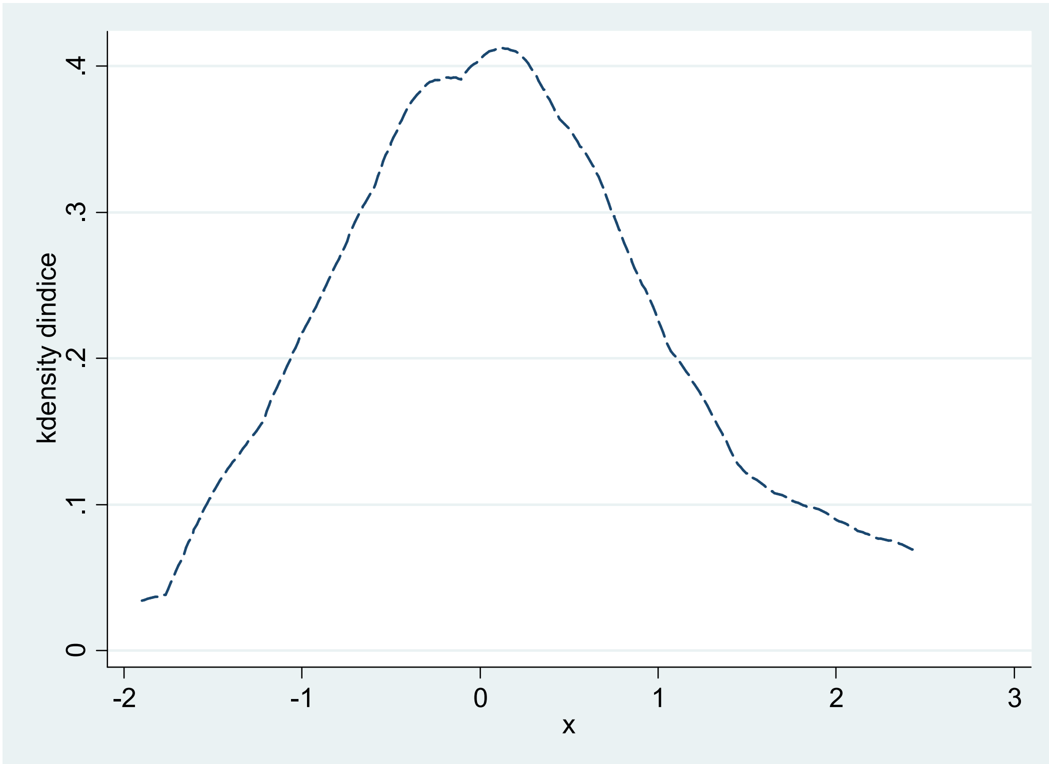


Figure 5

Changes in Competition and TFP Gap

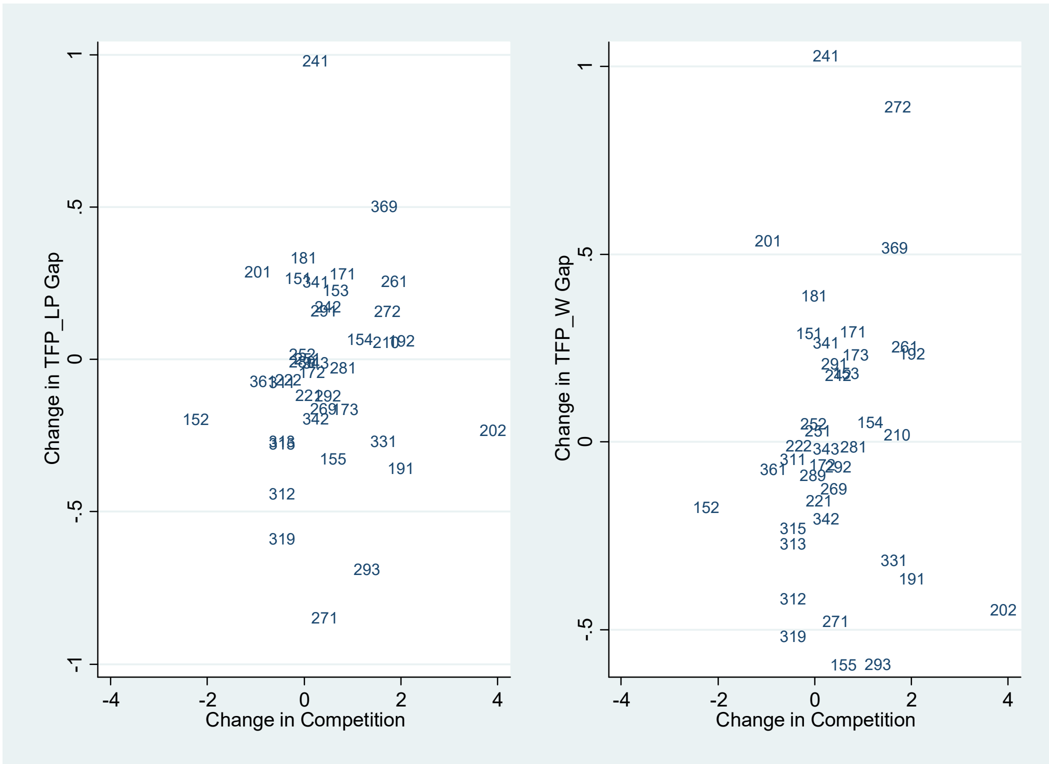
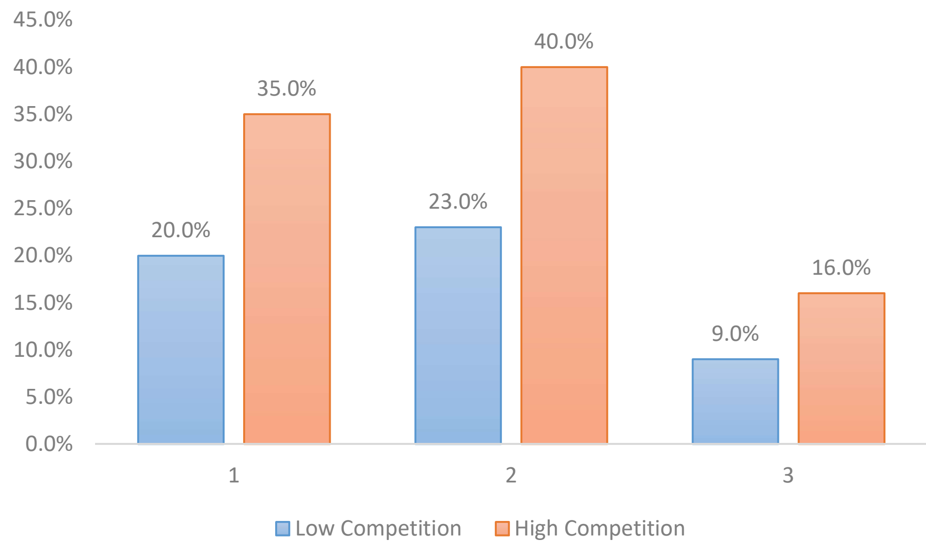


Figure 7

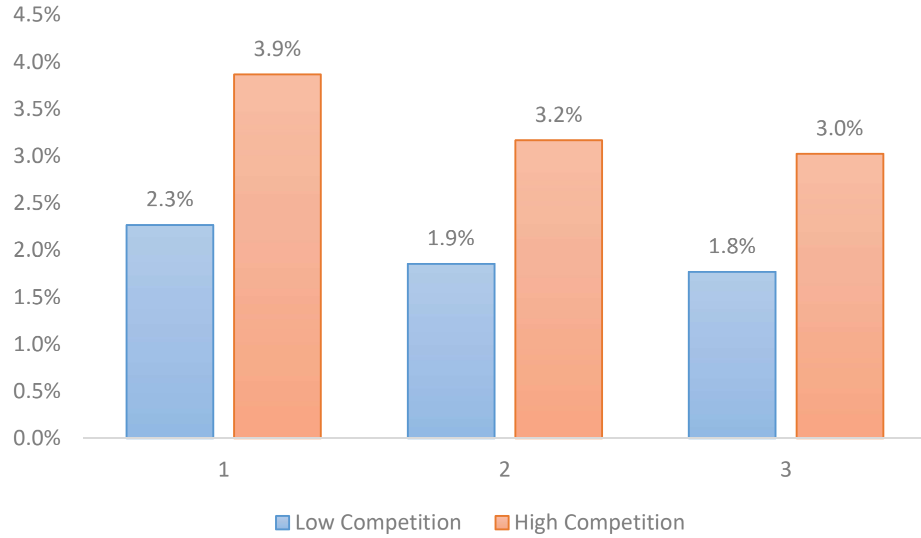
Impact of Competition on TFP Growth



Notes: 1 corresponds to the estimation with TFP_LP, 2 to the estimation with TFP_W, and 3 to the estimation with TFP_ACF. For the three cases, it is calculated at the average gap and the estimation with control variables.

Figure 8

Impact of Competition on Exit Probability



Notes: 1 corresponds to the estimation with TFP_LP, 2 to the estimation with TFP_W, and 3 to the estimation with TFP_ACF. For the three cases, it is calculated at the average gap and the estimation with control variables.