Trade integration and within-plant productivity evolution in Chile

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Abstract   We analyze the impact of trade integration on plant TFP using Chilean plant-level data (1982–1999) and 3-digit bilateral trade flows. Our contribution is to disentangle the impact of export and import barriers, estimated as border effects within a multilateral context. A fall in export barriers is positively correlated with plant productivity in traded sectors. The reduction of import barriers, however, can only be associated to productivity improvements in export-oriented sectors. In import-competing sectors a robust positive correlation shows up between plant productivity and protection. We then test several channels linking trade integration and firm productivity.

Keywords   Trade barriers · Plant productivity · Firm heterogeneity · Plant-level data

JEL Classification   F1 · F4 · O1

1 Introduction

Trade liberalization was at the core of reform packages carried out in many developing economies during the 1980s. In this paper we revisit the case of Chile, one of the earliest and most radical examples of trade liberalization. We aim at testing the link between trade integration and productivity in Chilean manufacturing

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plants. At the micro level, the impact of trade reforms is generally studied from a unilateral perspective through direct measures of trade costs or through aggregate trade ratios that may neglect several features of trade integration. The novelty of this paper is to estimate trade barriers in a multilateral context to disentangle within a unique framework, the effect of export- and import-oriented policies on plant productivity.

By differentiating between export and import barriers we deal with the multiple channels linking trade integration and plant productivity. This task of identification is important since the underlying forces can go in opposite directions. The reduction of import barriers increases foreign competition, which is often viewed as a positive engine of productivity (Pavcnik 2002; Amiti and Konings 2007). It pushes the least productive firms to cease production and surviving ones to trim down their inefficiencies. However, the presence of increasing returns to scale and imperfect competition may modify the relationship between import competition and plant productivity (Devarajan and Rodrik 1989; Rodrik 1992). One consequence of scale economies is precisely that average cost falls as output increases. In this case, foreign competition reduces domestic sales restricting the possibility to exploit scale economies.

Import-oriented policies not only implies the exposition to foreign competition. They also determine the extent of foreign technology transmissions. In developing countries, the access to high-quality capital equipment and intermediate goods from developed countries enables firms to raise their productivity level. Using plant-level data, Schor (2004) for Brazil, and Amiti and Konings (2007) for Indonesia show that input tariff reductions boost productivity gains. Similarly, Kasahara and Rodriguez (2008) for Chile find that the use of imported intermediates foster plant productivity.

On the export side, trade integration allows firms to benefit from positive spillovers stemming from foreign markets. The literature suggests learning-by-exporting as a plausible mechanism to explain a positive impact of trade liberalization on plant productivity. While the question is still empirically open, there is some evidence on ex post productivity gains arising from knowledge and expertise gained in the export process.[1]

These different mechanisms of trade liberalization call for further analysis on the multiple dimensions of trade. We carry out a three-step empirical strategy. Firstly, we obtain estimates of plant total factor productivity (TFP) by estimating the production function at 2-digit industry level while addressing simultaneity issues thanks to the Levinsohn and Petrin (2003) methodology. These estimates draw on plant-level data (1979–1999) from the annual industry survey ENIA (Encuesta Nacional Industrial Anual) of the Chilean manufacturing sector provided by the INE (Instituto Nacional de Estadisticas). Secondly, we use bilateral trade flows of Chile and its main trade partners at the industry level (2-digit) to capture export and import barriers. To do so we rely on the border effect gravity framework developed by Fontagné et al. (2005) and use the Trade and Production database provided by the CEPII (Centre d'Etudes Prospecives

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[1] See Kraay (2002) on China, Alvarez and Lopez (2005) on Chile, De Loecker (2007) on Slovenia.

et d'Information Internationales). This strategy enables us to obtain time-varying measures of trade integration at the industry level. Unlike Chilean tariff rates, these measures do present heterogeneity across industries. Finally, in the third step we estimate the impact of import and export barriers on plant productivity by combining the results of the first two steps. Here we regress plant productivity on border effect estimates.

The paper yields new findings on trade policy implications. Considering productivity gains relative to non traded sectors, our results suggest that: (1) a reduction in export barriers fosters plant productivity in both export-oriented and import-competing industries; and that (2) the impact of import barriers depends on trade orientation. In import-competing industries a decrease in import barriers has a negative effect on plant productivity. We show that this result is related to the presence of increasing returns to scale (IRS) in these industries. Foreign competition may have dampened domestic sales and, thereby, reduced the possibility to exploit scale economies. In the case of export-oriented industries, a fall in import barriers is associated to plant productivity improvements. This result is present in different static specifications. Nevertheless, in the dynamic specification, when we control for past productivity levels, the negative effect of foreign competition also shows up in export-oriented industries.

Besides the above-mentioned mechanism of scale economies, we test other channels linking trade integration and productivity. Results here reveal productivity improvements arising from the access to foreign capital equipment (in both export-oriented and import-competing industries). Moreover, searching for deeper insights on the impact of foreign competition, we find that it depends on the distance to the technology frontier and on whether this competition comes from low-wage or high-wage countries.

We carried out several robustness checks. The list includes alternative measures of productivity, different specifications dealing with potential mark-ups bias and dynamic concerns of the persistence of plant productivity over time. We also run our three-steps estimation using more disaggregated regressions of production functions and border effects (at 3-digit instead of 2-digit) and considering an enlarged sample of trade partners. Furthermore, in the different empirical stages we deal with the potential risk of reversal causality between trade barriers and plant productivity. This is done by purging productivity effects in the gravity specification, by using a 4-year rolling horizon in step 2 and by treating trade barriers as endogenous in GMM estimations.

Our findings contribute with new evidence on trade liberalization and plant productivity in Chile. The identification setting has been chosen to allow for a close comparison with previous results obtained by Pavcnik (2002) and Bergoeing et al. (2006).[2] Both studies acknowledge the presence of time-varying firm heterogeneity and deal with the effects of trade integration on productivity gains in a similar and comparable identification strategy. Using plant-level data, Pavcnik (2002) estimates the impact of trade on plant productivity in Chile during the

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[2] Several works have investigated the relationship between Chilean market-oriented reforms and plant productivity. See also Liu and Tybout (1996), Bergoeing et al. (2002, 2004), Alvarez and Lopez (2005).

period 1979–1986. By the means of a difference-in-difference framework, Pavcnik (2002) concludes that trade liberalization induces the growth of within-plant productivity in import-competing industries. Productivity improvements in export-oriented industries are observed only for initial years.[3] Using our sample, we are able to reproduce these results. However, contrary to what the difference-in-difference specification assumes, trade exposure in Chile does not increase continuously during Pavcnik's sample period. Indeed, in the context of the 1982 debt crisis, the government rose import tariffs from 15% in 1982 up to 35% in 1985.

Chilean trade reforms have been recently revisited by Bergoeing et al. (2006). They study the impact of the financial and trade reforms on productivity gains in Chile during a longer period (1980–2001). The authors show that if one uses effective tariffs instead of year dummies to capture trade liberalization, plant productivity advantages in export-oriented industries are not significant and, similar to our results, productivity gains of plants belonging to import-competing industries fall after trade liberalization.

Nevertheless, both studies suffer from the lack of cross-section variance on the right-hand side of regressions. Indeed, the identification of trade liberalization effects can be problematic since the reduction in import tariffs was homogeneous across industries and remained almost constant during the 1990s. The radical drop in the average nominal tariff rate from 98% in 1973 to 10% in 1979 came along with the homogenization of tariff rates among industries. Even their rise in early 1980s, during the debt crisis, was uniform. This homogeneous tariff reduction is probably the reason why Pavcnik (2002) is constrained to use time dummy indicators and Bergoeing et al. (2006) can not get enough variance for their estimates concerning export-oriented industries.

Considering direct measures of trade policy such as import tariffs also neglects two important features of trade integration. First, a unilateral import tariff reduction does not necessarily imply a symmetric response across trade partners. Second, several direct and indirect trade barriers might be omitted (Anderson and van Wincoop 2004). Among them, one finds not only non-tariff barriers (NTBs), but also bilateral agreements, institutional arrangements, infrastructure and even political efforts. The picture depicted by the evolution of tariffs in Chile does not completely reflect the different policy instruments applied by the government in order to promote exports and imports. For instance, during the eighties the government established an export promotion program and an economic positioning campaign to diffuse the country image in external markets. At the beginning of 1990s a Commercial Information System (CIS) was implemented to provide firms with information about international markets. During that decade, the new democracy set several free trade agreements (FTAs) with Latin American countries. This meant further reductions of import tariff and non-tariff barriers and the improvement of market access for Chilean exporters in manufacturing. Table 14 in

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[3] Pavcnik (2002) also performs the Olley and Pakes (1996) aggregate productivity decomposition and shows that, in the period, aggregate productivity growth is mainly explained by the exit of the least productive firms and the reallocation of market shares towards most productive ones.

Appendix 2 summarizes the key trade policy instruments implemented by Chile from 1975 to 2004.

By estimating the evolution of trade integration between Chile and its trading partners, we are able to capture this type of missing information. This strategy also allows us to address the lack of cross-section variance of standard trade measures and to capture the multiple channels of trade integration. These are the main contributions relative to previous works.

The rest of the paper is structured as follows. Section 2 presents the estimation strategy of our empirical exercises. Section 3 shows the results and, finally, Sect. 4 presents a brief conclusion.

2 Estimation strategy

The estimation strategy consists of three steps. In the first one, we estimate the production function using ordinary least squares (OLS), fixed-effect (FE) specification and the Levinsohn and Petrin (2003) methodology to obtain plant TFP as a residual. In the second step, we construct the measure of trade liberalization by estimating border effects between partners following Fontagné et al. (2005). Finally, in the third step, we estimate the impact of trade barriers by regressing productivity on border effect estimates. Within this methodology, we address simultaneity issues in the estimation of TFP (step 1) and reversal causality between productivity and trade flows (step 2 and 3).

2.1 Step 1: production function

We estimate the following specification of a Cobb–Douglas production function at the 2-digit industry level:

$$y_{pt} = \beta_0 + \beta_x x_{pt} + \beta_k k_{pt} + \varepsilon_{pt} \tag{1}$$

where all variables are expressed in natural logs, y_{pt} is the value added of plant p at time t, which is explained by short-term adjustable inputs x_{pt} (i.e. skilled and unskilled labour) and capital stock k_{pt}. The error term can be decomposed into an intrinsical "transmitted" component ω_{pt} (productivity shock) and an i.i.d. component χ_{pt}. Consequently, plant TFP a_{pt} is calculated as the residual given by the difference between the observed output and the predicted factor contribution:

$$\widehat{a}_{pt} = y_{pt} - \widehat{\beta}_x x_{pt} - \widehat{\beta}_k k_{pt} \tag{2}$$

When estimating production functions using firm panel data, eventual problems concerning simultaneity and selection should be considered. Simultaneity arises because input demand and unobserved productivity are positively correlated. Firm-specific productivity is known by the firm but not by the econometrician. If a firm expects a high productivity shock it will anticipate an increase in its final good demand and, consequently, it will purchase more inputs. OLS will tend to provide upwardly biased estimates of the labour elasticity and downwardly biased estimates

of the capital one.[4] Selection problems are likely to be present because the unobserved productivity influences the exit decision of the firm and we can only observe those firms that stay in the market. On the other hand, if capital is positively correlated with profits, firms with larger capital stock will decide to stay in the market even for low realizations of productivity shocks. This implies a potential source of negative correlation in the sample between productivity shocks and capital stock, which translates into a downward bias in capital elasticity estimates.

Olley and Pakes (1996) (henceforth OP) propose a three-stage methodology to control for the unobserved firm productivity. They deal explicitly with exit and investment behaviour. The rationale is to reveal the unobserved productivity through the investment behaviour of the firm, which in turns depends, theoretically, on capital and productivity. Selection issues are taken into account by inferring that firms that stay in the market have decided to do it accordingly to their capital stock and their expectations of productivity. By the means of this theoretical exit rule, OP estimate survival probabilities conditional on firm's available information. These probabilities are then used in the productivity estimation.

Levinsohn and Petrin (2003; henceforth LP) extend the OP idea, by noting that some inputs, such as electricity or materials, can be better proxies than investment to control for the unobserved firm productivity when one deals with simultaneity. Inputs adjust in a more flexible way, so they are more responsive to productivity shocks. Moreover, inputs usually have more non-zero observations than investment, a property that has consequences on estimation efficiency. In the case of the ENIA survey this property is important. Thus, in order to maximize sample size we keep the LP strategy and use electricity as a proxy for unobserved productivity.[5]

There are some advantages of OP-LP methodologies. Firstly, they perform better than fixed-effect specifications because the unobserved individual effect (productivity) is not constrained to be constant over time. Secondly, approaches based on instrumental variables can be limited by the instruments availability. Finally, OP-LP do not assume restrictions on the parameters. For instance, an alternative approach is the one developed by Katayama et al. (2009) who show how misleading can be the use of sale revenues to measure productivity. Factor prices and mark-ups can produce important distortions if they are not homogeneous. However, their methodology assumes constant returns to scale and neglect entry-exit process to facilitate likelihood estimates. Again both assumptions are not neutral in the case of the ENIA. In the third step, we allow for plant's individual fixed effects and control for market concentration at a disaggregated industry level in order to reduce the potential risk of mark-up bias.

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[4] OLS elasticities can be stated as $\hat{\beta}_x = \beta_x + \frac{\hat{\sigma}_{kk}\hat{\sigma}_{x\varepsilon} - \hat{\sigma}_{xk}\hat{\sigma}_{k\varepsilon}}{\hat{\sigma}_{xx}\hat{\sigma}_{kk} - \hat{\sigma}_{xk}^2}$ and $\hat{\beta}_k = \beta_k + \frac{\hat{\sigma}_{xx}\hat{\sigma}_{k\varepsilon} - \hat{\sigma}_{xk}\hat{\sigma}_{x\varepsilon}}{\hat{\sigma}_{xx}\hat{\sigma}_{kk} - \hat{\sigma}_{xk}^2}$. Where $\hat{\sigma}_{rs}$ is the covariance between variables r and s in the sample. If capital is positively correlated with labour and labour's correlation with the productivity shock is higher than capital one (which is the realistic case) then the coefficient of capital $\hat{\beta}_k$ will be underestimated and the one of labour $\hat{\beta}_x$ upward biased.

[5] Besides technical concerns, a key difference between LP and OP is that the former does not directly take into account selection. However, as LP show, the risk of selection biases are significantly reduced by considering an unbalanced panel.

2.2 Step 2: border effects

It is well-known that the reduction of tariffs in Chile was homogeneous across industries. As a consequence, tariff rates do not provide enough cross-section variance. On the other hand, tariffs are not the only measure that matters to capture trade costs. One should also consider bilateral agreements, asymmetries between export and import costs and indirect difficulties to trade.[6] Considering all these features of trade, we do obtain heterogeneity in both industrial and time dimensions.

To do so, we apply a border effect methodology. This type of empirical strategy provides an assessment of the level of trade integration by estimating a gravity-like model that considers, as a very intuitive benchmark, the difficulties encountered by domestic producers in reaching domestic (intra-border) destinations.[7]

2.2.1 The methodology

The identification strategy of Fontagné et al. (2005) builds on Head and Mayer (2000) gravity model derivation. This strategy seems suitable to measure Chilean trade integration as it corrects for the lack of theoretical foundations of earlier works and keeps the idea of using intra-national trade as a benchmark of trade integration. Moreover, it allows for asymmetries in the identification of trade barriers among partners, one of the main focus of this paper. Fontagné et al.'s (2005) theoretical foundation builds on a static monopolistic competition setting with increasing returns to scale for one-sector economies. Consider an instantaneous constant elasticity of substitution (CES) utility function in which the representative consumer of country i has specific preferences a_{ijt}^s for each variety h depending on the exporter country j (for the sake of clarity in the exposition of our empirical implementation, we indicate explicitly both industry s and time t specificity):

$$U_{it}^s = \left[\sum_{j=1}^{N_t^s} \sum_{h=1}^{M_{jt}^s} \left(a_{ijt}^s c_{ijht}^s \right)^{\frac{\sigma_t-1}{\sigma_t}} \right]^{\frac{\sigma_t}{\sigma_t-1}} \tag{3}$$

Thus, varieties belonging to the same country share the same weight in the utility function. Imports $m_{ijt}^s (= c_{ijt}^s p_{ijt}^s)$ of country i from country j are valued at the point of consumption $p_{ijt}^s = p_{jt}^s \tau_{ijt}^s$. This includes the producer price p_{jt}^s augmented of all trade cost τ_{ijt}^s, modeled as iceberg costs. Total expenditure for the industry $Y_{it}^s = \sum_{j'=1}^{N_t^s} m_{ij't}^s$ considers all imports, including intra-national ones m_{iit}^s. For symmetric varieties, this utility function (3) with constant elasticity σ_t leads to the well-known demands:

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[6] Theoretically, these indirect difficulties include a large list of country specificities, namely bias of consumption towards home goods and the like. As long as they can be interpreted, at least in part, as the outcome of history and political efforts, we consider them as a part of the measure of trade integration.

[7] McCallum (1995) applies this methodology to study market access between Canada and the US. Despite the high expected trade integration, trade between US and Canada is found to be around 22 times more difficult than Canadian intra-national trade. Anderson and van Wincoop (2003) reestimate McCallum's (1995) model, correcting for multilateral price bias, and the assessment still remains striking.

$$m_{ijt}^s = \left(\frac{p_{jt}^s \tau_{ijt}^s}{a_{ijt}^s P_{it}^s}\right)^{1-\sigma_t} M_{jt}^s Y_{it}^s \qquad (4)$$

In this gravity-like Eq. 4, $P_{it}^s = \left[\sum_{j'=1}^{N_t} \left(\frac{p_{ij't}}{a_{ij't}}\right)^{1-\sigma_t} M_{j't}^s\right]^{\frac{1}{1-\sigma_t}}$ is the consumer price of all varieties in the industry. This index takes into account differences in price setting across countries. If omitted, not only a multilateral control is missing but also a bias is induced between the error term and the partners dummies (border effect). Anderson and van Wincoop (2003) argue that the omission of multilateral price effects (what they call "multilateral resistances") explains the upward bias in border effects of Canada vis-à-vis the US estimated by McCallum (1995).[8]

One might mention four possible strategies to consistently estimate a gravity equation including price effects. The first one is to use price index data. Baier and Bergstrand (2001) follow this strategy measuring prices with GDP deflators. However, as highlighted by Anderson and van Wincoop (2004), empirical counterparts of P_{it}^s such as consumer price index (CPI) measures neglect changes in the true set of varieties and do not accurately reflect non-tariff barriers and indirect trade policies. The second strategy is the one followed by Anderson and van Wincoop (2003). They develop a two-step methodology in which border effect estimates are used to measure multilateral price effects. Besides practical difficulties of implementation, one crucial limitation for our purposes is the assumption of symmetry in bilateral trade costs. A third alternative approach uses fixed-effect specification to control for unobservable prices. The effect of price indexes is captured by the coefficients of individual fixed effects related to country source and destination (Harrigan 1996). Feenstra (2003) shows that the coefficients of fixed-effect estimation are consistent and reports values very similar to the non-linear least squares estimation of Anderson and van Wincoop (2003). Redding and Venables (2004) construct market access measures to explain cross-country differences in per capita income. Their market access estimation relies on fixed country effects to capture exporting and importing country characteristics. These country indicators take into account unobserved economic variables associated with supply and market capacity.

If the economic and geographic determinants captured by fixed effects vary over time, a useful strategy consists in eliminating the price index in the CES demand setting by expressing inter-national imports relative to intra-national ones. This is what Head and Mayer (2000) do. We follow this solution and divide Eq. 4 by m_{iit}^s:

$$\frac{m_{ijt}^s}{m_{iit}^s} = \left(\frac{a_{ijt}^s}{a_{iit}^s}\right)^{\sigma_t-1} \left(\frac{p_{jt}^s}{p_{it}^s}\right)^{-\sigma_t} \left(\frac{\tau_{ijt}^s}{\tau_{iit}^s}\right)^{1-\sigma_t} \left(\frac{v_{jt}^s}{v_{it}^s}\right) \qquad (5)$$

where $\frac{v_{jt}^s}{v_{it}^s}$ is the relative value added between countries i and j for the industry s. It allows to capture the relative number of symmetric varieties within a model of monopolistic competition. To obtain an empirical counterpart of Eq. 5 we assume, as Fontagné et al. (2005), that trade costs (τ_{ijt}^s) are composed of transport cost

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[8] See previous footnote

(captured by distance d_{ij}), ad valorem tariffs (t^s_{ijt}) and the "tariff-equivalent" of non-tariff barriers (NTB^s_{ijt}). That is to say, $\tau^s_{ijt} \equiv \left(d_{ij}\right)^{\delta t} \left(1 + t^s_{ijt}\right) \left(1 + NTB^s_{ijt}\right)$.

Protection (tariffs and non-tariff barriers) varies across all partner pairs and depends on the direction of the flow for a given pair. To capture this, we define $\left(1 + t^s_{ijt}\right) \left(1 + NTB^s_{ijt}\right) \equiv \exp\left[\sum_a \sum_b \gamma^s_{abt} B_{ab}\right]$, where B_{ab} is a dummy that equals 1 if country i belongs to region a and country j to region b.

Preferences a^s_{ijt} are supposed to have a random component e^s_{ijt} and a systematic domestic bias β^s_{it} for goods produced in the home country i. This home market bias is reduced when countries i and j share the same language and are contiguous. The dummies L_{ij} and C_{ij} are defined to capture each situation, respectively. Under these assumptions preferences can be written as $a^s_{ijt} \equiv \exp\left[e^s_{ijt} - \left(\beta^s_{it} - \lambda_{Lt}L_{ij} - \lambda_{Ct}C_{ij}\right) \sum_a \sum_b B_{ab}\right]$, where λ_{Lt} and λ_{Ct} represent the extent to which the home market bias is mitigated by common language and contiguity. Taking into account all this dummy structure, Eq. 5, can be written as:

$$\ln\left(\frac{m^s_{ijt}}{m^s_{iit}}\right) = \ln\left(\frac{v^s_{jt}}{v^s_{it}}\right) - (\sigma_t - 1)\delta_t \ln\left(\frac{d_{ij}}{d_{ii}}\right) - (\sigma_t - 1)\lambda_{Lt}L_{ij} - (\sigma_t - 1)\lambda_{Ct}C_{ij}$$
$$- \sigma_t \ln\left(\frac{p^s_{jt}}{p^s_{it}}\right) - \sum_a \sum_b (\sigma_t - 1)\left(\beta^s_{it} + \gamma^s_{abt}\right)B_{ab} \qquad (6)$$
$$+ (\sigma_t - 1)\left(e^s_{ijt} - e^s_{iit}\right)$$

2.2.2 Empirical specification

The number of observations in our bilateral flow sample does not allow to split the regressions by each year and 2-digit industry. In order to consistently estimate Eq. 6, we run pooled regressions in a 4-years rolling window for each industry. This allows us to obtain time-varying elasticities. Our estimable equation is now given by:

$$\ln\left(\frac{m^s_{ijt}}{m^s_{iit}}\right) = \alpha_{1t'} \ln\left(\frac{v^s_{jt}}{v^s_{it}}\right) + \alpha_{2t'} \ln\left(\frac{d_{ij}}{d_{ii}}\right) + \alpha_{3t'}L_{ij} + \alpha_{4t'}C_{ij} + \alpha_{5t'} \ln\left(\frac{p^s_{jt}}{p^s_{it}}\right)$$
$$+ \sum_a \sum_b \eta^s_{abt'}B_{ab} + \epsilon_{ijt} \qquad (7)$$

Where the theoretical counterpart of $\left\{\alpha_{1t'}, \alpha_{2t'}, \alpha_{3t'}, \alpha_{4t'}, \alpha_{5t'}, \eta^s_{abt'}\right\}$ is given by Eq. 6. We split the sample by each 2-digit industry and periods $t = t' - 3$ to t', where t' runs from 1982 to 1999. Hence, $\eta^s_{abt'}$ will capture the average border effects of import of a from b (i.e. $-(\sigma_t - 1)\left(\beta^s_{it} + \gamma^s_{abt}\right)$) for $t \in [t' - 3, t']$. Conversely, the border effect associated to export from a to b will be given by $\eta^s_{bat'}$. As Fontagné et al. (2005), we drop the constant and incorporate all dummy variables B_{ab}, whose estimated coefficients can be directly interpreted as border effects.

In our regressions we consider bilateral trade flows of the main trade partners of Chile. The list includes the United States (USA), 9 European countries (EU) and 6 Latin American countries (LA). Thus $a, b \in \{EU, LA, USA, CHL\}$. Hence, we obtain the border effects for each combination of regions, including intra-regional trade in

the case of the European Union and Latin American partners. For each time period t', industry s and flow direction (export or import), our proxies of trade barriers are aggregated as the weighted average of all border effects estimates in which Chile is involved. Weights are given by the share of the export or import flow on total export or import of Chile at time t'.

We run OLS regressions and, due to the form of the error term, use Hubert and White corrected standard errors clustered at the importer-industry-year level to control for the expected correlation. In Eq. 7 we do not impose $\alpha_{1t'} = 1$, as the theoretical Eq. 6 suggests, and allow for its empirical estimation.

Note that a potential endogeneity problem exits in the estimation of Eq. 7. In a monopolistic competition framework, prices and output are determined simultaneously. Fontagné et al. (2005) use aggregate prices (instead of industry-level ones). The underlying assumption is that prices at the national level are less correlated with profit maximization at the firm level. In our estimation, we adopt a different approach and use relative wages at the industry level. This choice is motivated by the potential reverse causality in step 3. As previously mentioned, we will use the border effect estimates to test the impact of trade liberalization on plant productivity for different industries. Most productive industries (or those producing high quality goods) will tend to increase their trade flows and induce a downward bias in the border effect estimates (step 2). Our assumption is that relative wages capture potential asymmetries in technology or efficiency and thereby they help to remove productivity concerns from the border effect estimates.[9] Moreover, due to the 4-year rolling horizon the border effect estimates include past values of trade flows, which allows for a lagged effect of the change in trade barriers. This also contributes to reduce the risk of reversal causality in step 3. We go further in the series of robustness checks of step 3 and treat border effects as endogenous regressors in the context of generalized method of moments (GMM) and dynamic estimates.

2.3 Step 3: the impact of trade policy on plant TFP

In this final step, we use the previous estimates of trade barriers to measure the impact of trade liberalization on plant productivity across export-oriented and import-competing industries relative to non-traded ones. The following reduced equation is estimated, analogous to the difference-in-difference framework implemented by Pavcnik (2002):

$$\widehat{a}_{pt} = \theta_0 + \beta B_{st} + \zeta T_{s'} + \delta B_{st} \cdot T_{s'} + \varphi Z_{pt} + \xi_{pt} \tag{8}$$

where θ_0 is the constant and ξ_{pt} the error term. $\widehat{a}_{pt}$ is the log of TFP of plant p at time t estimated by the LP strategy. B_{st} is a vector of trade barriers estimates (import and export border effects) for the 2-digit industry (s) in which the plant operates. $T_{s'}$ is a vector of trade orientation dummies indicating if the plant belongs to export-oriented or import-competing industries. Similar to Pavcnik (2002), we classify

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[9] In non-reported regressions we have used relative aggregate prices and also the lag of relative aggregate prices and relative wages. The resulting border-effect estimates are very close to those used in what follows.

industries by trade orientation (s') at the 3-digit industry level (see Appendix 1). Plants are classified as export-oriented if they belong to a 3-digit industry which has more than 15% of exports over total production and as import-competing if the industry has more than 15% of imports over total production. The rest are considered as non-traded.[10] Our classification concerns the initial period of 1980–1986. The initial sample classification also helps to avoid endogeneity problems arising from the classification. As Pavcnik (2002) notes, classification at 3- or 4-digit does not change significantly. Neither does it when considering the pre-sample period.

Z_{pt} is a vector of plant characteristics: industry affiliation at 2-digit[11], indicators of entry and exit and plant characteristics that may change over time, namely the use of imported inputs and credit constraints. Similar to Bergoeing et al. (2006), we identify plants that may face liquidity constraints using as a proxy a loan tax payment at the plant level. In Chile, financial credits are subject to this tax. Credit is a dummy variable equal to one if the plant reports having paid this tax in a given year. This information is used as a signal that the plant has not been financial constraint. We also introduce year indicators to control for other macroeconomic shocks. The excluded categories are non-traded industries, the year 1982 and the industry 38. As a robustness check we use alternative measures of plant productivity and also control for variable mark-ups.

We are mainly interested in the estimates of the vector coefficient δ of the interaction terms ($B_{st} \cdot T_{s'}$). Negative and significant coefficients mean that a reduction of trade barriers has a positive effect on productivity in traded industries (export-oriented and import-competing) relative to non-traded ones. The full set of interaction terms enables us to measure separately the effect of import and export barriers, depending on trade orientation.

2.4 Data

In the first step, we use plant-level data from the ENIA survey, which is provided by the Chilean institute of statistics INE. This survey is a manufacturing census of Chilean plants with more than 10 employees. Our data covers the period 1979–1999 and contains information of added value, materials, labour, investment and exports (only available from 1990).[12] We used different specific deflators at the 3-digit level (ISIC Rev-2) and year base 1992 for added value, exports, materials and investment. For the latter, specific deflators are considered for infrastructure, vehicles and machinery. Capital series were constructed using the methodology of Bergoeing

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[10] There are only two industries (351 and 384) that matched up to both categories. Nevertheless, the industry 351 (384) presents an export-output ratio of 0.82 (0.21) and an import-output ratio of 1.32 (2.01). Therefore these industries were classified as import competing. Our results remain unchanged if we consider a fourth category of export-import competing for industries 351 and 384.

[11] We introduce industry indicators to control for specific characteristics of industries. In order to avoid possible colineality issues, following Pavcnik (2002), the industry affiliation dummies are defined at the 2-digit industry level, while trade orientation dummies are defined at the 3-digit industry level.

[12] The ENIA survey has been used in previous studies such as Pavcnik (2002), Liu and Tybout (1996), Levinsohn and Petrin (2003) and Bergoeing et al. (2006) for different sample periods.

et al. (2006).[13] Table 7 in Appendix 2 shows a description of the variables and Table 8 in Appendix 2 reports general descriptive statistics of the plant-level sample.

In the second step we use data from the *Trade and Production Database* constructed by CEPII. This is an extension of the data collected by Nicita and Olarreaga (2001) at the World Bank. The CEPII has filled many missing values for production variables using UNIDO and OECD-STAN (for OECD members). It has also completed trade data with the international trade database BACI of CEPII. The final bilateral trade data covers the period 1976–1999 for 67 developing and developed countries. It provides information on value added, export and import trade flows, origin and destination countries, wages and labour at the 3-digit industry level (ISIC Rev-2).

Detailed intra-national trade flows for our sample of countries are not available. Intra-national trade is computed as output minus exports. This requires an appropriate measure of internal distance that should take into account economic activity to weight internal regions (Head and Mayer 2000). For distance variables, contiguity and common language, we also used the CEPII database of internal and external distances. The CEPII uses specific city-level data in order to compute a matrix of distance including the geographic population density for each country. Distance between two countries is measured based on bilateral distance between cities weighted by the share of the city in the overall country's population.

In the regressions we use bilateral trade data for the main trading partners of Chile: nine members of the European Union throughout the whole period 1979–1999 (Germany, France, the United Kingdom, Italy, Belgium, Luxembourg, Ireland, the Netherlands and Denmark), the United States and seven Latin-American countries (Argentina, Brazil, Bolivia, Chile, Mexico, Uruguay and Venezuela). In the robustness checks we use a significantly enlarged sample including 177 countries.

3 Results

3.1 Results of step 1: plant TFP estimates

In this step we estimate the Cobb–Douglas production function in Eq. 1 at the 2-digit industry level using OLS, fixed effects and the LP methodology. Table 1 shows the results. As expected, LP estimates of unskilled labour elasticities are generally the lowest and those of capital elasticities the highest. This means that the bias induced by the larger responsiveness of unskilled labour relative to capital is addressed. Considering the production function estimates by LP, we can not reject at 5% the null hypothesis of constant returns to scale in the Wald test in five export-oriented industries [Food (31); Wood (33); Non-metallic minerals (36) and Basic metals (37)]. On the other hand, industries with increasing returns are mainly import-competing [Textile (32), Paper (34), Chemicals (35) and Machinery(38)]. Thus, in these industries market size can affect the cost structure of firms.

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[13] We thank the authors for providing us with their Stata routine for capital series.

Table 1 Production function estimates

Industry	Factors[a]	OLS	SE	Fixed effects	SE	LP[b]	SE
Food and beverage (31)	U	0.815	(0.010)	0.627	(0.012)	0.570	(0.024)
	S	0.359	(0.009)	0.159	(0.008)	0.212	(0.015)
Obs: 18559	K	0.250	(0.005)	0.083	(0.007)	0.208	(0.046)
Textile (32)	U	0.833	(0.011)	0.777	(0.014)	0.710	(0.024)
	S	0.202	(0.010)	0.165	(0.009)	0.174	(0.018)
Obs: 11063	K	0.206	(0.005)	0.102	(0.008)	0.249	(0.034)
Wood (33)	U	0.865	(0.017)	0.849	(0.021)	0.681	(0.034)
	S	0.208	(0.015)	0.095	(0.014)	0.131	(0.021)
Obs: 5711	K	0.209	(0.009)	0.104	(0.013)	0.275	(0.040)
Paper (34)	U	0.763	(0.018)	0.539	(0.024)	0.692	(0.044)
	S	0.252	(0.014)	0.175	(0.015)	0.207	(0.025)
Obs: 3175	K	0.229	(0.010)	0.182	(0.014)	0.299	(0.055)
Chemicals (35)	U	0.604	(0.016)	0.639	(0.017)	0.528	(0.045)
	S	0.337	(0.015)	0.168	(0.013)	0.266	(0.028)
Obs: 6588	K	0.294	(0.008)	0.149	(0.011)	0.354	(0.057)
Non metalic products (36)	U	0.780	(0.028)	0.797	(0.031)	0.577	(0.074)
	S	0.241	(0.026)	0.130	(0.025)	0.103	(0.049)
Obs: 2153	K	0.244	(0.013)	0.136	(0.018)	0.281	(0.074)
Basic metals (37)	U	0.280	(0.070)	0.346	(0.061)	0.217	(0.104)
	S	0.485	(0.063)	0.161	(0.045)	0.263	(0.094)
Obs: 640	K	0.412	(0.042)	0.059	(0.049)	0.290	(0.189)
Machinery (38)	U	0.897	(0.012)	0.766	(0.015)	0.767	(0.033)
	S	0.242	(0.011)	0.204	(0.011)	0.178	(0.022)
Obs: 8524	K	0.164	(0.006)	0.111	(0.010)	0.236	(0.058)

Standard errors (SE) in parentheses

[a] *U* unskilled labour (production workers), *S* skilled labour (non-production workers), *K* capital stock

[b] Levinsohn and Petrin (2003) methodology using electricity to control for the unobserved plant heterogeneity. 250 replications are used for bootstrap. The Wald test of constant returns to scale is rejected for Textile (32), Paper (34), Chemicals (35) and Machinery (38) industries

After estimating production function elasticities, we calculate plant TFP as a residual. Figure 1 presents the average evolution of different measures of plant productivity: fixed effects (tfp_fe), LP (tfp_lp), OLS (tfp_ols) and labour productivity (ln productivity).

As a first robustness check of our productivity measures, the figure shows that labour productivity and all TFP measures depict similar evolutions. Although FE and LP elasticities exhibit some differences, the TFP path illustrated by both measures is very similar.[14]

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[14] Thus, even if the assumption of fixed effects may overestimate the capital elasticity and underestimate labour one, after computing all factors contribution, the evolution of the residual is not drastically affected.
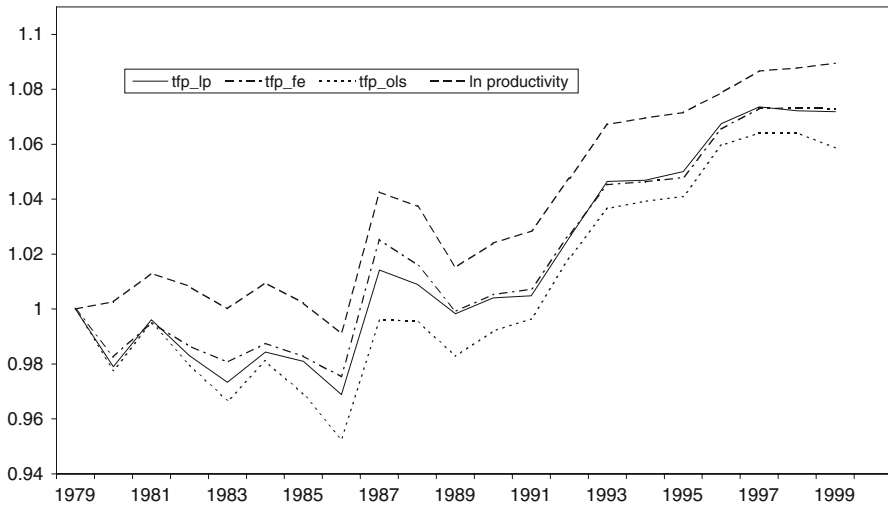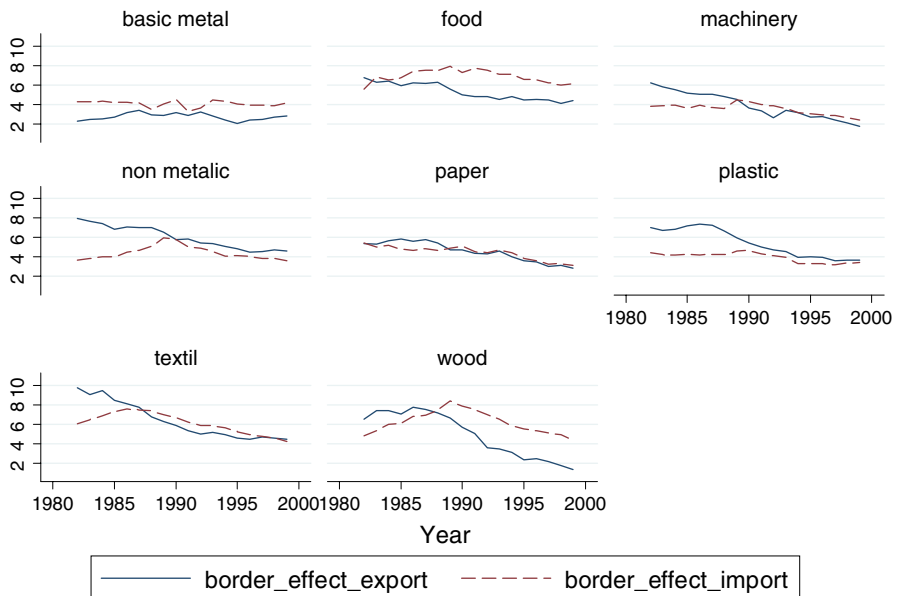
Fig. 1 Evolution of TFP estimates

Fig. 2 Border effect estimates

3.2 Results of step 2: border effect estimates

In the second step, we construct market access measures by estimating Eq. 7 at the 2-digit industry level. This estimation captures the heterogeneity of trade barriers across industries. Figure 2 plots the weighted average of export and import border

effect estimates across trade partners. Weights are based on each country export (import) share over total exports (imports) of Chile. All coefficients are significant at least at 5%. The solid line depicts export border effects and the dashed line those corresponding to import.

Difficulties of Chilean exporters to access foreign markets (export border effect) were relatively constant at the beginning of the eighties. Reflecting the active trade agreement agenda, most industries switch to a downward trend at the end of the 1980s. This becomes specially pronounced during the 1990s. This is the case of Wood, Textiles, Plastics and Machinery. Two important export-oriented industries, Basic metals and Food, show an evolution of export border effect almost flat. The former, however, is the most traditional export-oriented industry and in this industry trade barriers were already low at the beginning of the period. On the other hand, the rather flat evolution of export barriers on Food industry might be explained by quality controls set by EU and the US. Home biases are also likely to be present in this type of industry. Once again one observes the extent to which direct trade measures such as import tariffs do not capture all dimensions of trade integration: export barriers have considerably diminished in all industries during the 1990s, even if import tariffs were already low.

Figure 2 also shows the evolution of the weighted measure of industry-level barriers faced by EU, LA and the US to access the Chilean market (import border effect). In many industries, import barriers increased during the first half of the 1980s (Food, Textiles, Wood, Non-metallics and Machinery). This is consistent with the raise in import tariffs during this period and also with other discretionary policy measures set to control the current account deficit during the debt crisis. Since we use a moving average of border effects, this tendency is observed even in the late 1980s as a lagged effect of protection. During the 1990s import border effects fall in almost all industries except in Basic metals. This reduction and convergence of import border effects seem also consistent with the new trade integration agenda of Chile based on bilateral and multilateral trade agreements.

3.3 Results of step 3: the impact of trade barriers on plant TFP

The final step consists in identifying the influence of each type of trade barrier on the evolution of plant productivity. Equation 8 disentangles the variation in productivity due to changes in trade barriers depending on trade orientation. We are interested in the vector coefficient δ of the interaction terms between trade orientation indicators and our border effect estimates.

3.3.1 Reproducing Pavcnik's (2002) results

In order to provide a baseline estimation, we start by reproducing Pavcnik's (2002) regressions for our full sample period. We use within group estimates in a difference-in-difference framework. In this specification, year indicators capture trade liberalization effects. These estimates are illustrated in Fig. 3. We obtain similar results to Pavcnik (2002). Once controlling for exit and plant-specific characteristics, trade liberalization (captured by time dummies) has a positive
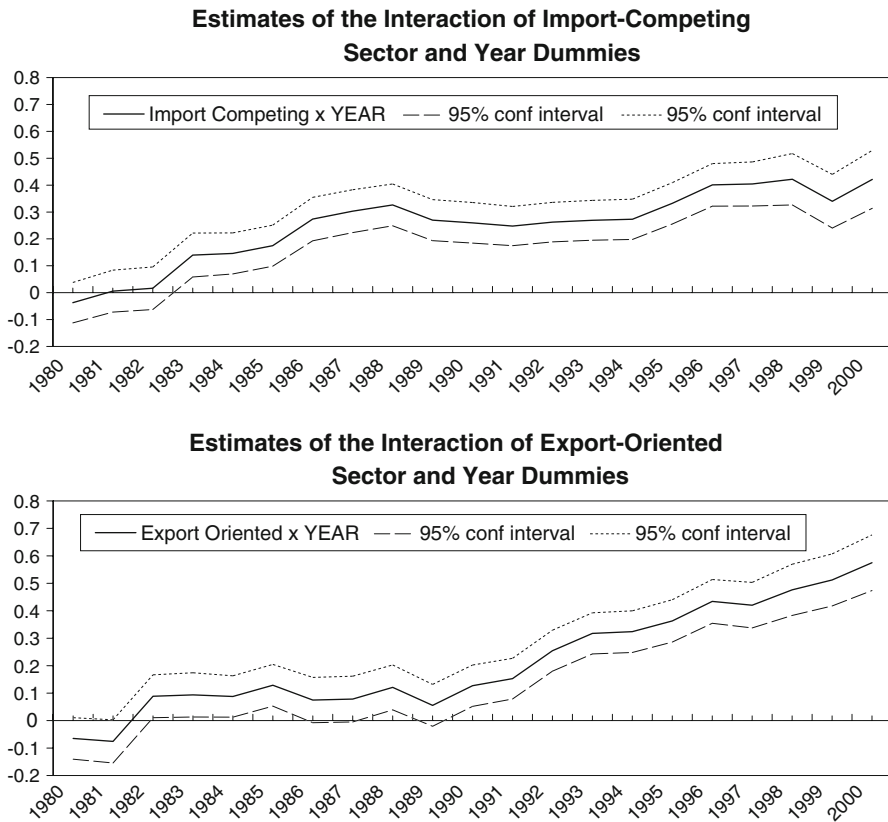
Estimates of the Interaction of Import-Competing Sector and Year Dummies

Estimates of the Interaction of Export-Oriented Sector and Year Dummies

Fig. 3 Reproducing Pavcnik's (2002) results

impact on plant productivity in traded industries (export-oriented and import-competing) relative to non-traded ones. Considering only the period 1980–1986, Pavcnik (2002) also highlights that plant productivity gains in export-oriented industries are minor. Using the full sample period, this trend changes after the 1990s.

3.3.2 Disentangling the effects of export and import barriers

In this section, we employ the weighted average border effects estimated in step 2. As previously mentioned, we use a 4-year rolling window for each industry. Hence, the border effect measures capture not only the current but also the lagged effect of trade integration on plant TFP. This implies the loss of initial years in the sample (1979–1981). On the other hand, these lagged measures of border effects and the controls introduced in step 2 to address asymmetric technologies reduce the risk of potential endogeneity between our measure of trade barriers and productivity. Additionally, in robustness check of dynamic specification we treat border effects as endogenous regressors in GMM estimations.

Table 2 reports the results using the plant TFP measured by the LP methodology (TFP_LP). After controlling for industry-specific effects (2-digit industry indicators) and macroeconomic shocks (year indicators), the coefficients of the other variables should only capture the effects of within-industry productivity variation. We consider plant-fixed effects and use Huber–White standard errors in all estimations. In the last column, these errors are corrected for clustering at the plant level.

The first column presents the baseline estimation. In this specification we include the indicators for export-oriented (Export) and import-competing (Import) industries, the measures of import border effects (BM) and export border effects (BX) and their interactions (Export × BX, Import × BX, Export × BM, Import × BM). In this difference-in-difference framework we interpret the coefficients of interaction

Table 2 The impact of trade barriers on plant TFP (LP measure)

	1	2	3	4	5	6[a]
Export	0.636	0.633	0.633	0.638	0.635	0.635
	(0.078)***	(0.078)***	(0.078)***	(0.078)***	(0.078)***	(0.111)***
Import	0.283	0.290	0.291	0.288	0.291	0.291
	(0.065)***	(0.065)***	(0.065)***	(0.065)***	(0.065)***	(0.090)***
Export × BX	−0.023	−0.024	−0.023	−0.025	−0.025	−0.025
	(0.007)***	(0.007)***	(0.007)***	(0.007)***	(0.007)***	(0.011)**
Import × BX	−0.063	−0.062	−0.062	−0.062	−0.062	−0.062
	(0.007)***	(0.007)***	(0.007)***	(0.007)***	(0.007)***	(0.010)***
Export × BM	−0.103	−0.101	−0.101	−0.101	−0.100	−0.100
	(0.011)***	(0.011)***	(0.011)***	(0.011)***	(0.011)***	(0.015)***
Import × BM	0.040	0.038	0.038	0.039	0.039	0.039
	(0.012)***	(0.012)***	(0.012)***	(0.012)***	(0.012)***	(0.016)**
BX	0.095	0.095	0.095	0.095	0.095	0.095
	(0.007)***	(0.007)***	(0.007)***	(0.007)***	(0.007)***	(0.011)***
BM	0.083	0.083	0.083	0.081	0.081	0.081
	(0.011)***	(0.011)***	(0.011)***	(0.011)***	(0.011)***	(0.014)***
Exit indicator		−0.134	−0.139	−0.137	−0.137	−0.137
		(0.013)***	(0.013)***	(0.013)***	(0.013)***	(0.013)***
Entry indicator			−0.063	−0.063	−0.063	−0.063
			(0.016)***	(0.016)***	(0.016)***	(0.016)***
Imported inputs				0.051	0.050	0.050
				(0.010)***	(0.010)***	(0.012)***
Credit					0.024	0.024
					(0.009)***	(0.011)**
Constant	5.284	5.275	5.280	5.259	5.249	5.249
	(0.107)***	(0.108)***	(0.107)***	(0.107)***	(0.107)***	(0.136)***
Plant, ISIC 2 and year ind	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs	46894	46894	46894	46894	46894	46894
Adjusted R^2	0.220	0.228	0.229	0.238	0.241	0.241

Huber–White standard errors in parentheses

[a] Standard errors corrected for clustering at the plant level

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

terms relative to non-traded industries (the omitted category). Export border effects interacted with both export-oriented (Export × BX) and import-competing (Import × BX) indicators present a negative and significant coefficient. This suggest a positive and significant impact of export barrier *reductions* on plant productivity in both traded industries. This result can be related to learning-by-exporting and international knowledge spillovers (Kraay (2002) on China, Alvarez and Lopez (2005) on Chile and De Loecker (2007) on Slovenia). In the case of plants belonging to import-competing industries, the positive effect of export barrier reductions on their productivity could be driven by new-exporters within these industries. Bergoeing et al. (2005) show that, even if with a small aggregate export share, a number of plants entered the export market during the nineties in those Chilean industries.

The impact of import barriers depends on trade orientation. We find evidence of a negative effect of import barrier reductions on productivity of plants belonging to import-competing industries (Import × BM). Therefore, contrary to Pavcnik's (2002) results, in our regressions foreign competition appears to dampen plant productivity in those industries. The production function estimates (step 1) show that import-competing industries (Textile, Paper, Chemicals and Machinery) operate under increasing returns to scale (IRS). In this case, import competition reduces market shares of domestic firms shrinking the opportunities to exploit scale economies. This possible explanation has also been emphasized by Bergoeing et al. (2006) for different production function estimates and data treatment.

On the other hand, the reduction of import barriers has a positive impact on plant productivity in export-oriented industries (Export × BM). While import competition does not affect export sales, exporters also sell in the domestic markets and have to face foreign competitors. Hence, this category of exporters may help to isolate the "trimming fat" effect of foreign competition, since economies of scale are guaranteed for these firms by the access to international markets. The positive effect of the reduction of import barriers on plant productivity in export-oriented industries, in these static regressions, might come from innovative strategies implemented to improve domestic competitiveness. However, if one might expect a positive and a negative effect of foreign competition, for plants belonging to import-competing industries the effect of market size reduction is negative enough to offset a positive outcome of import barrier reductions.

The above results (interaction terms) remain almost unchanged after the progressive inclusion of several controls.[15] As expected, the exit indicator (Exit ind) has a negative coefficient (column 2). Exiting plants are on average 14% less productive than surviving plants. The entry indicator (Entry ind) coefficient is also negative showing that new-entrants are roughly 6% less productive than incumbents (column 3). The use of imported inputs (Imported input) also appears to be positively correlated with productivity (column 4). The last column introduces a financial indicator (Credit). Although the coefficient is small, it has the expected

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[15] It is well documented in plant-level studies that multinationals are relatively productive, technology-intensive, and trade-intensive. Unfortunately, in our database, plant foreign status is only available since 1993.

positive sign (column 5). Column 6 reports the results correcting for clustering at the plant level. Our estimates are still significant if one controls for intra group correlation.

3.3.3 Robustness checks

Alternative measures of productivity gains The previous results remain robust using alternative measures of plant productivity. First, we use the estimates of the production function using an individual fixed-effect specification (within-group estimates) instead of LP strategy to obtain the plant TFP in step 1. The first two columns of Table 3 report the results using this alternative measure of TFP (TFP_FE). Columns 3 and 4 show the results using labour productivity (Labour pr), measured as (deflated) value added per worker, and controlling for capital intensity (deflated capital stock over total labour). In both cases, the sign and the magnitude of the coefficients of the interaction terms between trade barriers and trade orientation indicators are very similar to those obtained in the previous specification (Table 2). Export barrier reductions improve plant productivity of firms in export-oriented and import-competing industries, while the fall in import barriers has only a positive impact on export-oriented industries and a negative effect on import-competing ones. These findings confirm the previous results using plant TFP estimated by the LP strategy.

Enlarged country sample and 3-digit industry level intermediate estimates So far, we have estimated border effects at the 2-digit industry level and for the most representative trade partners of Chile for the manufacturing sector: the US, Latin America and Europe.[16] As a robustness check, we compute border effects by estimating Eq. 7 at 3-digit (instead of 2-digit) over a significantly enlarged sample, including almost all countries of in the available information (177 countries).[17] We follow Santos Silva and Tenreyro (2006) and estimate the gravity model in its multiplicative form. The aim is to take into account the risk of bias due to heteroskedasticity and zero flows, which is significantly more prominent in this new sample. We use Zero Inflated Poisson (ZIP) to allow for a particular regime asociated to zero flows (see Greene 2008). Table 9 in Appendix 2 depicts the correlation between the previous estimates of border effects at 2-digit industry level and the ones estimated at 3-digit.

We also estimate the production function at 3-digit industry level in order to allow for further industry heterogeneity in technologies. Table 10 in Appendix 2 shows the average TFP of each desegregated industry at 3-digit. We then carry out the same baseline regressions using these more disaggregated estimates of border

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[16] Exports to these countries represent 85% of total Chilean exports, while Chilean manufactured imports from these countries represent almost 80% of total imports in the nineties (ECLAC). During the nineties, manufactured exports to Asia represent only 3% of total Chilean exports, while imports from this continent represent 7%.

[17] We include all countries from the "Trade and Production" database except by African countries. The average trade flow between Africa and Chile is seven times lower than the average trade flow between Chile and the rest of the world. Even in the 75 percentile trade flow between Africa and Chile we find zero trade flows.

Table 3 Alternative measures of productivity and controls for mark-up

	1 TFP FE	2 TFP FE[a]	3 Labour pr.	4 Labour pr.[b]	5 TFP LP	6 TFP LP[c]
Export	0.524 (0.074)***	0.520 (0.105)***	0.489 (0.063)***	0.540 (0.098)***	0.617 (0.111)***	0.798 (0.162)***
Import	0.227 (0.062)***	0.232 (0.082)***	0.296 (0.058)***	0.291 (0.083)***	0.304 (0.092)***	0.358 (0.097)***
Export × BX	−0.019 (0.007)***	−0.020 (0.010)*	−0.020 (0.006)***	−0.022 (0.010)**	−0.024 (0.011)**	−0.024 (0.011)**
Import × BX	−0.059 (0.007)***	−0.059 (0.010)***	−0.067 (0.006)***	−0.066 (0.009)***	−0.062 (0.010)***	−0.064 (0.010)***
Export × BM	−0.090 (0.011)***	−0.090 (0.015)***	−0.083 (0.010)***	−0.090 (0.014)***	−0.099 (0.015)***	−0.104 (0.015)***
Import × BM	0.051 (0.012)***	0.050 (0.016)***	0.048 (0.011)***	0.051 (0.015)***	0.039 (0.016)**	0.040 (0.017)**
BX	0.092 (0.007)***	0.092 (0.010)***	0.078 (0.006)***	0.081 (0.010)***	0.095 (0.011)***	0.095 (0.011)***
BM	0.062 (0.010)***	0.063 (0.014)***	0.069 (0.010)***	0.075 (0.014)***	0.080 (0.014)***	0.086 (0.015)***
Exit indicator	−0.146 (0.013)***	−0.145 (0.013)***	−0.146 (0.010)***	−0.150 (0.013)***	−0.136 (0.013)***	−0.137 (0.013)***
Entry indicator	−0.067 (0.015)***	−0.066 (0.016)***	−0.027 (0.010)***	−0.049 (0.015)***	−0.062 (0.016)***	−0.063 (0.016)***
Imported inputs	0.064 (0.010)***	0.063 (0.012)***	0.065 (0.009)***	0.058 (0.012)***	0.050 (0.012)***	0.050 (0.012)***
Credit		0.032 (0.010)***		0.030 (0.010)***	0.025 (0.011)**	0.024 (0.011)**
Capital intensity				0.081 (0.007)***		
Herfindahl					−0.218 (0.129)*	
Export × BX × concentration						0.047 (0.047)
Import × BX × concentration						0.044 (0.042)
Export × BM × concentration						−0.058 (0.059)
Import × BM × concentration						−0.094 (0.064)
Concentration						−0.178 (0.0192)
Constant	6.660 (0.0106)***	6.647 (0.0130)***	7.152 (0.090)***	6.567 (0.0137)***	5.253 (0.0135)***	5.151 (0.0140)***
Plant, ISIC 2 and year ind	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs	46894	46894	65068	49001	46894	46894
Adjusted R^2	0.207	0.214	0.106	0.235	0.241	0.235

Huber–White standard errors in parentheses

Fixed effect TFP (TFP FE) and labour productivity (labour pr.) are considered as alternative measures of the LP TFP. The last two columns address potential markup bias concerns by adding the Concentration dummy, which indicates if the average Herfindahl index in the pre-sample period is in the 75th percentile

[a], [b], [c] Standard errors corrected for clustering at the plant level

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

effects and TFP. Table 11 in Appendix 2 reports the results. The first column shows the regression using the TFP at 2-digit industry level and the second and third columns report the results considering the TFP based on production function estimates at the 3-digit. Our main results remain robust to all these alternative specifications. The coefficient of the interaction term between trade orientation and export border effects are negative, which suggests a positive link between export promotion and firm productivity. In the case of export oriented industries, however, the coefficient is only significant at 10% for the estimations using the TFP at 3-digit industry level (column 2). Concerning import border effects, results depend on the trade orientation of the industry. Confirming our previous finding, firm productivity in import competing industries is positively correlated with protection. On the other hand, the effect of import border effects on firms belonging to export oriented industries fails this time to show up at conventional levels of significance. For the sake of comparison, column 3 reports the regressions using the border effect estimated at 2-digit industry level and the TFP at 3-digit industry level. Here, results are quite closer to those obtained in the previous regressions of Table 2.[18]

Industry concentration and mark-ups As is common to the empirical literature on plant TFP estimations, this productivity measure is likely to be sensitive to mark-ups variations. It is difficult to disentangle real (physical) productivity improvements from variations in value added arising from market power and price setting. In order to control for mark-up concerns, which are not captured by the individual fixed effects included in our previous regressions, we add the Herfindahl index of market concentration. This index is computed as the sum of the squared market shares in each 3-digit industry. Column 5 of Table 3 shows these results. Once we introduce the Herfindahl index the magnitude of the coefficients of the interaction terms between trade barriers and trade orientation remain entirely unchanged (see column 6 of Table 2). Market concentration is negatively correlated with plant productivity in these regressions.

If productivity improvements due to trade barrier reductions reflect variations in market power, this effect should be more important for firms producing in concentrated industries. Similar to previous works (Amiti and Konings 2007) we compute an additional robustness check introducing an interaction term between an industry concentration indicator, trade barriers and trade orientation indicators (Export × BX × concentration, Import × BX × concentration, Export × BM × concentration, Import × BM × concentration). The industry concentration dummy indicator is equal to one if the average of the Herfindahl index in the pre-sample period (1979–1981) is higher than 0.22, which corresponds to the 75th percentile.[19] The interaction terms of this concentration indicator with trade barriers and trade orientation indicators are not significant (column 6 of Table 3). This suggests that

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[18] It should be stressed that our preferred measures of border effects are those used in the previous regressions (at 2-digit). The reason is that (1) the disaggregation of the analysis and (2) the inclusion of an enormous quantity of flows with little link to the Chilean economy leads to less plausible gravity estimates. Moreover, the use of a pseudo maximum likelihood methods relies on a certain type of heteroskedasticity that not necessarily matches the one implied in relative flows.

[19] We use the pre-sample period due to the difference-in-difference framework and also in order to avoid endogenous changes in the Herfindahl index.

there is no significant difference in productivity gains between low and high concentrated industries. Moreover, the coefficients of our key interaction terms between trade barriers and trade orientation indicators are not altered by the introduction of these controls.

Dynamic specification In this section, we perform a dynamic specification of Eq. 8 in which plant productivity depends on its past values. This implies the following auto-regressive multivariate model:

$$\widehat{a}_{pt} = \theta_0 + \theta_1 \widehat{a}_{pt-1} + \zeta B_{st} + \gamma T_s + \delta B_{st} \cdot T_{s'} + \varphi Z_{pt} + \xi_{pt} \tag{9}$$

If we believe that the error term contains a specific time-invariant unobserved heterogeneity ($\xi_{pt} = \upsilon_p + \mu_{pt}$), the lagged value of TFP, $\widehat{a}_{pt-1}$, is then endogenous to the error term (as it also contains υ_p). Econometric literature provides well-known strategies for this dynamic issue. These strategies exploit moment conditions of exogeneity of the lags of the endogenous dependent variable. Here we use the GMM estimator of Arellano and Bond (1991). We include OLS and within-group (WG) estimators to identify an interval within which a consistent estimate of the autoregressive coefficient θ_1 should lie (Bond 2002). The first column of Table 4 reports the OLS results, the second one the within-group estimates and finally, column 3 shows the GMM results. As expected, the coefficient of the auto-regressive term (tfp_lp($t-1$)) is higher when using OLS than in the case of within-group regressions. This is a signal of a consistent dynamic specification, which means that the number of TFP lags on the right-hand side is correct. The set of instruments used in GMM estimation is composed of deep lags of border effect measures and TFP. Both set of variables are treated as endogenous. This provides an additional robustness check on the potential endogeneity issue between border effects and productivity mentioned in the step 2. The Hansen and Sargan tests validate our instrument choice. The number of individuals relative to the number of instruments is reassuring as regards any possible bias in the test when using a large number of instruments (Windmeijer 2005). We focus on GMM and within-group results. Dynamic regressions confirm the existence of plant productivity improvements after a reduction of export barriers in both traded industries. The positive sign in the interaction between import barriers and the import-competing indicator (Import × BM), also resists the dynamic control in GMM regressions. In the case of a within-group estimates this effect fails to be significant, though the autoregressive coefficient seems clearly downward biased.

On the contrary, the positive impact of import barrier reductions on plant productivity in export-oriented industries depends on the method. Within-group estimations confirm this finding (column 2), while in GMM regressions (column 3) the coefficient of the interaction between import barriers and the export-oriented indicator (Export × BM) becomes positive and significant. If GMM addresses the dynamic panel bias as it is expected, this result means that, once we control for the persistence of plant productivity series, foreign competition might also dampen domestic sales and plant productivity in export-oriented industries. Their high productivity trend overwhelms this effect in a static specification or in the case of a panel data bias in the within-group estimation.

Table 4 Dynamic specification

	1	2[a]	3[b]
TFP$(t-1)$	0.822 (0.005)***	0.482 (0.009)***	0.741 (0.091)***
Export	0.233 (0.044)***	0.400 (0.101)***	−1.853 (2.221)
Import	0.021 (0.037)	0.137 (0.081)*	−1.061 (1.731)
Export × BX	−0.016 (0.006)***	−0.020 (0.008)**	−0.233 (0.067)***
Import × BX	−0.016 (0.005)***	−0.034 (0.008)***	−0.343 (0.110)***
Export × BM	−0.030 (0.008)***	−0.052 (0.012)***	0.358 (0.098)***
Import × BM	0.015 (0.008)*	0.019 (0.013)	0.515 (0.154)***
BX	0.043 (0.006)***	0.066 (0.008)***	0.220 (0.086)**
BM	−0.009 (0.008)	0.030 (0.011)***	−0.346 (0.113)***
Herfindahl	−0.008 (0.065)	0.099 (0.109)	0.593 (0.811)
Exit indicator	−0.148 (0.012)***	−0.115 (0.014)***	−0.262 (0.039)***
Entry indicator	0.000 (0.000)	0.000 (0.000)	
Credit	0.041 (0.006)***	0.013 (0.009)	0.604 (0.266)**
Imported inputs	0.081 (0.006)***	0.035 (0.010)***	0.077 (0.137)
Constant	0.722 (0.049)***	2.672 (0.134)***	
Plant, ISIC 2 and year ind	Yes	Yes	Yes
Number of obs	35117	35117	31853
Adjusted R^2	0.757	0.287	
Sargan p			0.160
Hansen p			0.248
AR(2)p			0.002[c]
AR(3)p			0.810
Instruments			85
Individuals		5392	4911

Huber–White standard errors in parentheses

[a] Standard errors corrected for clustering at the plant level

[b] The set of instruments is composed of lagged values of border effect and plant TFP. Both are treated as endogenous variables. As usual, we use industry and year indicators as exogenous instruments. Orthogonal transformations are used to maximize sample size

[c] Since the Arellano–Bond test of autocorrelation reveals that the disturbance might be in itself auto-correlated of order-1, but not further, we take lags between $t-4$ and $t-6$

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

3.3.4 Trade liberalization channels

Increasing returns to scale One of the novel findings in previous regressions is the negative impact of import barrier reductions on productivity gains of firms producing in import-competing industries. This result is robust to alternative measures of productivity and to controls of market power. In this subsection we provide additional evidence on the mechanism by which import competition might affect plant productivity.

Table 5 Foreign competition and increasing returns to scale

	1	2	3	4[a]
Increasing	−0.505 (0.211)**	−0.953 (0.216)***	−0.949 (0.216)***	−0.949 (0.243)***
BX	0.060 (0.006)***	0.083 (0.007)***	0.083 (0.007)***	0.083 (0.011)***
BM	0.040 (0.008)***	−0.005 (0.009)	−0.006 (0.009)	−0.006 (0.011)
Exit indicator	−0.140 (0.013)***	−0.136 (0.013)***	−0.136 (0.013)***	−0.136 (0.013)***
Entry indicator	−0.061 (0.016)***	−0.062 (0.016)***	−0.062 (0.016)***	−0.062 (0.016)***
Imported inputs	0.047 (0.010)***	0.049 (0.010)***	0.049 (0.010)***	0.049 (0.012)***
Credit	0.028 (0.009)***	0.025 (0.009)***	0.025 (0.009)***	0.025 (0.011)**
Increasing × BM		0.125 (0.010)***	0.124 (0.010)***	0.124 (0.013)***
Increasing × BX		−0.030 (0.006)***	−0.030 (0.006)***	−0.030 (0.009)***
Herfindahl			−0.226 (0.097)**	−0.226 (0.125)*
Constant	6.245 (0.147)***	6.387 (0.151)***	6.401 (0.151)***	6.401 (0.173)***
Plant, ISIC 2 and year ind	Yes	Yes	Yes	Yes
Number of obs	46894	46894	46894	46894
Adjusted R^2	0.232	0.233	0.232	0.232

Huber–White standard errors in parentheses

[a] Standard errors corrected for clustering at the plant level

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

As previously mentioned, the production function estimates in the first step reveal IRS in industries classified as import-competing. Hence, one possible explanation is that foreign competition reduces market shares of all firms and hampers the possibility to exploit economies of scale in import-competing industries. To illustrate this argument we provide regressions interacting trade barriers and a dummy indicating whether the plant operates in an industry under IRS (Increasing).[20]

Table 5 presents these results. Firms producing in industries operating under IRS have a lower productivity level than other firms (column 1). The interaction term between import barriers and the indicator of increasing returns to scale is positive and significant (column 2). This means that firms producing in industries under IRS suffer from foreign competition. As expected, the interaction term between export barriers and the indicator of increasing returns to scale is negative and significant. The reduction of export barriers increases market potential and enlarges the possibility to dynamically exploit scale economies (column 2). These results remain robust when we control for market concentration (column 3) and standard errors corrected for clustering at the plant level (column 4).

The better access to foreign technology In a developing country like Chile, the access to new technologies embodied in high-quality imported inputs and capital equipment may have a major role on productivity enhancements. This channel is present in our data. First, in previous regressions we found that firms producing with imported inputs have a higher TFP than those that only use domestic inputs. Second,

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[20] The production function estimates show that industries operating under Increasing returns are Textile (32), Paper (34), Chemicals (35) and Machinery (38).

Table 6 Import barriers on machinery and productivity (TFP LP)

	1	2	3	4	5	6[a]
Export	0.950	0.950	0.929	0.928	0.925	0.925
	(0.075)***	(0.075)***	(0.075)***	(0.075)***	(0.075)***	(0.108)***
Import	0.482	0.491	0.504	0.502	0.505	0.505
	(0.069)***	(0.069)***	(0.069)***	(0.069)***	(0.069)***	(0.095)***
Export × BK_M	−0.264	−0.263	−0.259	−0.259	−0.259	−0.259
	(0.013)***	(0.013)***	(0.013)***	(0.013)***	(0.013)***	(0.020)***
Import × BK_M	−0.105	−0.107	−0.105	−0.104	−0.104	−0.104
	(0.014)***	(0.014)***	(0.014)***	(0.014)***	(0.014)***	(0.020)***
BK_M	−0.103	−0.143	−0.147	−0.149	−0.149	−0.149
	(0.017)***	(0.017)***	(0.017)***	(0.017)***	(0.017)***	(0.022)***
Exit indicator		−0.141	−0.140	−0.139	−0.138	−0.138
		(0.013)***	(0.013)***	(0.013)***	(0.013)***	(0.013)***
Entry indicator		−0.059	−0.059	−0.060	−0.059	−0.059
		(0.016)***	(0.016)***	(0.016)***	(0.016)***	(0.016)***
Herfindahl			−0.250	−0.251	−0.252	−0.252
			(0.100)**	(0.100)**	(0.100)**	(0.127)**
Imported inputs				0.05	0.050	0.050
				(0.010)***	(0.010)***	(0.012)***
Credit					0.024	0.024
					(0.009)***	(0.011)**
Constant	6.593	6.740	6.749	6.729	6.720	6.720
	(0.114)***	(0.114)***	(0.114)***	(0.113)***	(0.113)***	(0.137)***
Plant, ISIC 2 and year ind	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs	46894	46894	46894	46894	46894	46894
Adjusted R^2	0.116	0.120	0.120	0.121	0.121	0.121

Huber–White standard errors in parentheses

[a] Standard errors corrected for clustering at the plant level

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

in this subsection instead of using the import border effect at the 2-digit industry level for each industry, we only use the one corresponding to Machinery (BK_M) as a proxy of import barriers on capital equipment. The interaction term of this specific import border effect with the trade orientation dummies captures the extent to which plant productivity reacts to a better access to foreign capital goods. Table 6 reports the results of these regressions. Relative to non-traded industries, firms belonging to traded industries enhance their productivity after a reduction of import barriers on machinery industry. Moreover, productivity gains are significantly higher for plants in export-oriented industries (Export × BK_M) than in import-competing ones (Import × BK_M).

Foreign competition from low-wage countries The impact of foreign competition on plant productivity might be different depending on the characteristics of the exporting country. Responses of firms to changes in competition may differ across industries depending on exposure to competition from low-wage countries relative

to high-wage countries. Using import penetration ratios, Bernard et al. (2006) find that US plant survival and employment growth are negatively associated to foreign competition from low-wage countries.[21]

In this subsection, we construct proxies of foreign competition from low-wage and high-wage countries by computing the weighted average of import border effect estimates for Latin American and Asian countries (low-wage countries), on the one hand, and for the US and EU (high-wage countries), on the other hand. Then we regress plant TFP on import border effect of low-wage countries (BM_lw) and on import border effect of high-wage countries (BM_hw). Table 12 in Appendix 2 shows the results. The impact of foreign competition on plant TFP depends on the origin of country. Plant TFP is negatively associated with foreign competition from low-wage country imports (column 1 and 2). However, we find plant TFP improvements after exposure to high-wage countries (column 1 and 2). In order to study whether these results are driven by the increasing returns to scale channel, we introduce an interaction term between the import border effect of low-wage (high-wage) countries and the indicator of IRS (column 3). We find that the interaction term between import border effect of high-wage countries and the indicator of IRS is negative and significant, whereas the interaction term with import barriers from low-wage countries is positive and significant. Since Chile is a middle-income developing country, Chileans plants might benefit from positive technological spillovers from high-wage countries, while foreign competition from low-wage countries might affect negatively plant TFP due to the increasing returns to scale channel previously analyzed.

Distance to the frontier As claimed by Aghion et al. (2009) the response of firms' performance to changes in competition may differ across industries depending on distance to the technology frontier. In this subsection we test this channel by analyzing the impact of import barriers on plant TFP in interaction with the proximity to the technology frontier. The latter is measured as the ratio of the productivity of each plant relative to that of the most productive firm in the industry.[22] Table 13 in Appendix 2 presents the results. We include several specifications: (a) border effects and proximity to the frontier at 2-digit in column 1; (b) the same model with an AR(1) of TFP in column 2; (c) the regressors (border effects and proximity) in lags in columns 3 and 4 in order to avoid, at least partially, reversal causality caveats, and (d) the proximity to the frontier and border effects at 3-digit in columns 5 and 6 under contemporaneous and lagged specifications, respectively. The bottom part of the table shows the marginal effect of foreign competition (measured by the import border effects) at different values of the closeness to the frontier. It starts at the minimum (i.e., maximal distance) and increases gradually towards the maximum value (i.e., when firms are at the frontier).

While a differentiated effect appears it is more controversial than the one claimed by Aghion et al. (2009). In most of regressions what appears is indeed a positive effect of protection at the leading edge, excepting columns 5 and 6 in which the negative effect of protection is only significant for the very maximum level of

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[21] Thanks to an anonymous referee for pointing out this possible channel.

[22] We thank an anonymous referee for pointing out this possible channel.

productivity (i.e., when only the most productive firm is concerned). Whether this is a consequence of the fact that Chile might be itself far from the world technology frontier or a finding that casts doubt on the commonly accepted distance-to-frontier argument it is a matter of further research. In any case, it is worth noting that the empirical literature does not provide clear-cut results on the effect of competition on economic performance.[23]

4 Conclusion

The main contribution of this paper is to construct specific measures of trade barriers at the industry level in order to disentangle the impact of the reduction of export and import barriers on plant productivity. This distinction introduces new results. First, the reduction of export barriers improves productivity of plants belonging to both traded industries. As the export costs fall, more firms are able to export, increasing their size and probably benefiting from knowledge spillovers stemming from international markets. This encouraging result is robust to all robustness checks and specifications. Second, in all static specifications the reduction of import barriers shows a positive impact on the evolution of plant productivity in export-oriented industries relative to non-traded. However, this is not the case for plants belonging to import-competing industries producing with increasing returns to scale. The reduction of import barriers may prevent local firms to exploit economies of scale since they must share the local market with foreign competitors. Moreover, exporters' productivity also appears to have a negative reaction to foreign competition when a dynamic setting is considered.

Appendix 1

Classification of industries

Export oriented industries: 311, 312, 331, 341, 372.
   Import competing industries: 321, 322, 351, 354, 355, 361, 362, 381, 382, 383, 384, 385, 390.
   Non-traded industries: 313, 323, 324, 332, 342, 352, 353, 356, 369, 371.

Appendix 2

See Tables 7, 8, 9, 10, 11, 12, 13 and 14.

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[23] Just to give some examples see Crépon et Duguet (1997); Thingval and Podhal (2007); Blundell et al. (1999); Nicoletti and Scarpeta (2003)

Table 7 Variables description

	Variable	Data
Export border effect	BX	Export barriers at 2-digit industry level estimated by a gravity model in step 2
Import border effect	BM	Import barriers at 2-digit industry level estimated by a gravity model in step 2
Export oriented sector	Export	Dummy variable equal to one if the firm belongs to a 3 digit industry with more than 15% of exports over output
Import competing sector	Import	Dummy variable equal to one if the firm belongs to a 3-digit industry with more than 15% of import over output
Market concentration	Herfindahl	Herfindahl index of market concentration at 3-digit industry level
Pre-sample concentration	Concentration	Dummy variable equal if the average Herfindahl index in the pre-sample period is in the 75th percentile
Imported inputs	Imported inputs	Dummy variable equal to one if the plant reports having used imported inputs
Credit indicator	Credit	Dummy variable equal to one if the plant reports having paid a loan tax in year t

Table 8 Summary statistics by industry (2-digit ISIC Rev-2)

	Labour pr.	Δ Labour pr.	S/L	K/L	Exports share
Food (31)	5108 (10204)	0.10 (0.66)	0.13 (0.11)	3420 (10709)	0.09 (0.2)
Textile (32)	3828 (3770)	0.07 (0.5)	0.13 (0.10)	2198 (8676)	0.02 (0.09)
Wood (33)	4099 (6428)	0.11 (0.93)	0.11 (0.10)	2192 (4143)	0.07 (0.18)
Paper (34)	7119 (9492)	0.02 (0.42)	0.17 (0.15)	4775 (14877)	0.03 (0.12)
Chemicals (35)	10832 (23366)	0.07 (0.57)	0.16 (0.11)	4793 (10573)	0.04 (0.13)
Non metallic (36)	8130 (14480)	0.09 (0.59)	0.13 (0.10)	5356 (16133)	0.01 (0.06)
Basic metals (37)	34409 (93787)	0.13 (0.71)	0.19 (0.14)	7826 (12033)	0.18 (0.31)
Machinery (38)	5375 (5987)	0.10 (0.68)	0.16 (0.13)	3122 (6519)	0.02 (0.07)

Mean of variables reported; standard deviation in parentheses

Labour pr.: labour productivity, Δ Labour pr.: Labour productivity growth, S/L: skill intensity, K/L: capital intensity

Table 9 Correlation border effects at 3-digit and 2-digit industry level

	1 BM 3digit	2 BX 3digit
BM 2dig	0.574 (0.138)***	
BX 2dig		0.195 (0.074)***
constant	−1.743 (0.659)***	−0.184 (0.418)
Isic 2 dig FE	Yes	Yes
Number of obs	421	421
Adjusted R^2	0.109	0.103

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

Table 10 TFP estimates at 3-digit industry level

Industry	TFP LP	SD	TFP FE	SD	TFP OLS	SD
Food	7.61	1.03	8.23	1.09	5.67	0.88
Food	5.25	0.93	6.22	0.97	5.66	0.92
Beverage	6.30	0.95	9.25	1.15	6.58	0.92
Textiles	6.04	0.72	8.12	0.79	6.39	0.72
Wearing apparel	6.52	0.73	6.91	0.73	6.63	0.72
Leather	7.19	0.76	6.77	0.75	5.98	0.73
Footwear	6.56	0.67	7.46	0.72	6.37	0.66
Wood	6.99	0.85	7.39	0.85	6.30	0.81
Furniture	3.75	0.82	7.15	0.81	5.61	0.75
Paper	5.92	0.80	6.84	0.84	5.74	0.79
Printing	6.10	0.64	8.14	0.76	6.68	0.63
Chemical	9.62	1.13	10.76	1.26	6.77	0.99
Other chemicals	6.03	0.74	8.99	0.85	6.61	0.74
Petroleum	4.87	1.15	4.03	1.07	5.86	0.99
Miscellaneous prod of petroleum	9.65	1.32	12.79	1.72	7.18	1.22
Rubber	5.72	0.64	6.60	0.63	5.98	0.62
Plastic	6.19	0.77	7.13	0.75	6.90	0.75
Pottery	4.82	0.75	9.68	1.05	5.50	0.72
Glass	10.59	1.24	6.21	0.79	5.67	0.79
Non-metallic	6.92	0.94	7.53	0.97	6.38	0.90
Iron and steel	5.72	0.90	8.01	1.06	6.26	0.91
Basic metal	10.30	1.99	11.61	2.13	5.98	1.57
Metal products	6.33	0.72	7.67	0.75	6.56	0.72
Machinery	7.80	0.88	7.95	0.90	6.65	0.83
Machinery apparatus	5.55	0.82	7.19	0.84	6.22	0.80
Transport equipement	10.06	0.67	9.42	0.63	7.39	0.56

Table 11 The impact of trade barriers on plant TFP (LP) measured at 3-digit

	1 TFP 2dig	2 TFP 3dig	3 TFP 3dig
Export	−0.003 (0.109)	−0.007 (0.112)	
Import	0.039 (0.098)	0.049 (0.096)	
Export × BX_3dig	−0.024 (0.018)	−0.033 (0.018)*	
Import × BX_3dig	−0.043 (0.008)***	−0.040 (0.008)***	
Export × BM_3dig	0.018 (0.025)	0.031 (0.025)	
Import × BM_3dig	0.025 (0.008)***	0.023 (0.007)***	
BX_3dig	0.009 (0.005)**	0.009 (0.005)*	
BM_3dig	−0.010 (0.005)**	−0.010 (0.005)**	
Export			−0.860 (0.360)**

Table 11 continued

	1 TFP 2dig	2 TFP 3dig	3 TFP 3dig
Import			3.643 (0.350)***
Export × BX_2dig			−0.031 (0.011)***
Import × BX_2dig			−0.069 (0.010)***
Export × BM_2dig			−0.100 (0.016)***
Import × BM_2dig			0.045 (0.017)***
BX_2dig			0.097 (0.011)***
BM_2dig			0.094 (0.015)***
Exit indicator	−0.156 (0.019)***	−0.153 (0.019)***	−0.133 (0.014)***
Entry indicator	−0.041 (0.017)**	−0.042 (0.016)**	−0.061 (0.016)***
Imported inputs	0.056 (0.014)***	0.054 (0.014)***	0.051 (0.013)***
Credit	0.010 (0.012)	0.009 (0.012)	0.022 (0.011)**
Herfindahl	0.038 (0.015)**	0.025 (0.015)*	0.001 (0.012)
constant	6.252 (0.235)***	9.089 (0.341)***	4.915 (0.282)***
Plant and year ind	Yes	Yes	Yes
ISIC 3 digit	Yes	Yes	Yes
ISIC 2 digit	No	No	Yes
Number of obs	34391	34391	44951
Adjusted R^2	0.224	0.528	0.567

Huber–White standard errors in parentheses

Standard errors corrected for clustering at the plant level

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

Table 12 Foreign competition from low-wage and high-wage countries

	1 TFP 2dig	2 TFP 3dig	3 TFP 3dig
BM_lw	0.029 (0.006)***	0.029 (0.006)***	0.007 (0.008)
BM_hw	−0.033 (0.006)***	−0.033 (0.006)***	−0.012 (0.008)
Exit indicator	−0.153 (0.019)***	−0.153 (0.019)***	−0.153 (0.019)***
Entry indicator	−0.041 (0.016)**	−0.041 (0.016)**	−0.041 (0.016)**
Imported inputs	0.053 (0.014)***	0.053 (0.014)***	0.054 (0.014)***
Credit	0.008 (0.012)	0.008 (0.012)	0.011 (0.012)
Herfindahl	0.030 (0.015)**	0.030 (0.015)**	0.041 (0.015)***
Increasing		−3.587 (0.514)***	−3.635 (0.508)***
Increasing × BM_lw			0.053 (0.011)***
Increasing × BM_hw			−0.050 (0.011)***
Constant	9.030 (0.326)***	9.830 (0.236)***	9.859 (0.236) ***
Plant and year ind	Yes	Yes	Yes
ISIC 3 digit	Yes	Yes	Yes

Table 12 continued

	1 TFP 2dig	2 TFP 3dig	3 TFP 3dig
Number of obs	34367	34367	34367
Adjusted R^2	0.522	0.521	0.521

Huber–White standard errors in parentheses

Standard errors corrected for clustering at the plant level

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

Table 13 Distance to the frontier

	(1)	(2)	(3)	(4)	(5)	(6)
Proximity 2dig	0.217 (0.017)***	0.194 (0.022)***				
BM_2dig	−0.128 (0.007)***	−0.117 (0.009)***				
proximity 2dig × BM_2dig	0.064 (0.003)***	0.053 (0.003)***				
Exit indicator	−0.049 (0.008)***	−0.050 (0.009)***	−0.117 (0.014)***	−0.131 (0.014)***	−0.047 (0.007)***	−0.132 (0.015)***
Entry indicator	−0.005 (0.009)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	−0.010 (0.009)	0.000 (0.000)
Imported inputs	0.015 (0.007)**	0.010 (0.007)	0.028 (0.010)***	0.050 (0.011)***	0.021 (0.007)***	0.031 (0.011)***
Credit	0.011 (0.006)*	0.004 (0.006)	0.014 (0.009)	0.014 (0.010)	0.007 (0.006)	0.016 (0.010)
Herfindahl	0.050 (0.007)***	0.038 (0.008)***	0.020 (0.010)**	−0.012 (0.011)	0.158 (0.008)***	0.014 (0.012)
TFP $(t-1)$		0.238 (0.006)***	0.492 (0.011)***			
Proximity 2dig $(t-1)$			0.010 (0.011)	0.199 (0.012)***		
BM_2dig $(t-1)$			0.030 (0.007)***	0.032 (0.008)***		
Proximity 2dig × BM_2dig $(t-1)$			−0.003 (0.002)	0.008 (0.002)***		
Proximity 3dig					0.608 (0.005)***	
BM_3dig					0.017 (0.003)***	
Proximity 3dig × BM_3dig					−0.005 (0.001)***	
Proximity 3dig $(t-1)$						0.243 (0.006)***
BM_3dig $(t-1)$						0.013 (0.004)***

Table 13 continued

	(1)	(2)	(3)	(4)	(5)	(6)
Proximity 3dig × BM_3dig ($t-1$)						−0.005 (0.001)***
Constant	7.522 (0.133)***	3.764 (0.197)***	2.142 (0.285)***	4.642 (0.275)***	3.698 (0.212)***	4.244 (0.303)***
Year and sector dummies	Yes	Yes	Yes	Yes	Yes	Yes
Number of obs	44951	33668	33668	33668	43928	31273
Adjusted R^2	0.800	0.757	0.555	0.295	0.878	0.666
Marginal effects of Import barriers						
Minimum	−0.680 (0.029)***	−0.572 (0.037)***	0.040 (0.012)***	0.003 (0.013)	0.063 (0.010)***	0.031 (0.009)***
Mean less 1 SD	−0.085 (0.006)***	−0.080 (0.007)***	0.027 (0.007)***	0.038 (0.006)***	0.016 (0.002)***	0.011 (0.003)***
Mean	−0.012 (0.005)***	−0.021 (0.005)***	0.024 (0.006)***	0.047 (0.006)***	0.007 (0.001)***	0.004 (0.002)**
Mean plus 1 SD	0.061 (0.005)***	0.038 (0.006)***	0.021 (0.006)***	0.055 (0.007)***	−0.002 (0.001)	−0.003 (0.002)
Maximum	0.168 (0.008)***	0.127 (0.009)***	0.017 (0.007)**	0.068 (0.008)***	−0.026 (0.005)***	−0.021 (0.007)***

Huber–White standard errors in parentheses

Standard errors corrected for clustering at the plant level

*, **, *** denote significance at the level of 1, 5, and 10%, respectively

Table 14 Trade policy instruments

Year	Trade policies
1975	National Agency for Export Promotion: to promote Chilean's exports by improving the international insertion of Chilean's firms
1976	Elimination of all non-tariffs barriers
1979	Uniform import tariff of 10%
1980	Economic complementation agreements: Latin American Integration Association (ALADI)
	Export Promotion Programme: to supply information on foreign markets and customers, promoting Chilean exports through generic publicity and targeted missions, and working to resolve the administrative problems faced by exporters
1983	Increase import tariff to 20%
1984	Increase import tariff to 35%
1985	Reduction of import tariffs to 20%
	Economic Positioning Campaign: to diffuse the country image in external markets. The programme is financed and organized jointly by PROCHILE and other organizations
1988	Reduction of import tariffs to 15%
1991	Reduction of import tariffs to 11%

Table 14 continued

Year	Trade policies
1992	Bilateral FTA (ECA No. 17) with Mexico: 2 programes of linear tariff reduction lasting 4 and 6 years. Establishment of NTB
	Rules of Origin: Based on modified LAIA and NAFTA
	Commercial Information System (CIS): PROCHILE provides information to firms about international markets (prices, transport costs, entrance regulation and trade barriers.)
1993	Bilateral FTA with Venezuela (ECA No. 23): Tariff elimination programme to be completed by 1999
1993	Bilateral FTA with Bolivia (ECA No. 22): Tariff elimination programme to be completed by 1999
1994	Bilateral FTA with Colombia (ECA No. 24): Tariff elimination programme
1995	Bilateral FTA with Ecuador (ECA No. 32): Tariff elimination programme to be completed by 2000
1996	FTA with MERCOSUR (ECA No. 35): Tariff elimination programme under way; completed by January 2014
	Participation in institutional structure of MERCOSUR
1997	Bilateral FTA with Cananda. Tariff elimination programmes under way as scheduled; process will be completed in 2014. Opening of negotiations on financial services. Scheduled for 1999
1998	Bilateral FTA with Peru (ECA No. 32): Tariff elimination programme under way; to be completed by 1 January 2012
2002	Bilateral FTA with the US
2003	EU grants immediate tariff-free access for 85% of Chilean exports to the EU and provides for annual reductions in import tariffs on the remainder, culminating in zero tariffs for 96 percent of exports by 2007 and 100 percent tariff-free access by 2013
2004	Bilateral FTA with Korea

Source ECLAC

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