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Economic Performance under NAFTA: A Firm-Level Analysis of the Trade-productivity Linkages

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Summary. — Did North American Free Trade Agreement (NAFTA) make Mexican firms more productive? If so, through which channels? This paper addresses these questions by deploying a robust microeconometric approach that disentangles the various channels through which integration with the global markets can affect firm-level productivity. The results show that NAFTA stimulated the productivity of Mexican plants via: (1) increase in import competition and (2) positive effect on access to imported intermediate inputs. Crucially, the impact of trade reforms was not identical for all integrated firms, with fully integrated firms (i.e., firms simultaneously exporting and importing) benefiting more than other integrated firms.

Key words — firm-level productivity, trade reforms, Latin America, Mexico

1. INTRODUCTION

In the past two or three decades most Latin American countries have redefined their development strategies, moving away from import-substitution regimes toward policies promoting integration with the global economy through exports and Foreign Direct Investments (FDI). This important shift has been accompanied by an intense academic debate regarding the relationship between integration with the international markets and domestic growth. Despite the general presumption of a positive impact of trade liberalization on economic growth, there is still disagreement among economists about the nature of this relationship (Baldwin, 2000). Most of the controversy is explained by the difficulty in identifying the underlying mechanisms driving this relationship (Winters, 2004). Furthermore, since trade liberalization is often just one element of a more comprehensive set of market-oriented reforms it is hard to disentangle its effect from the impact of other policies.

This paper contributes to this debate by developing a robust microeconometric approach that can disentangle the various channels through which integration with the global markets — via international trade — can affect firm-level productivity. Our empirical analysis is based on Mexican firm-level data covering 1993–2002, [1] a period of economic integration between Mexico, the US, and Canada within the North American Free Trade Agreement (NAFTA). The present study, defines NAFTA as a process of economic integration that goes beyond a simple tariff-reduction scheme and, instead, encompasses a set of institutional rules within which foreign trade and investment take place. The objective of this paper is to measure the impact of NAFTA on the productivity of Mexican plants.

The present study is related to various strands of literature. The pioneer set of studies collected in Roberts and Tybout (1996) analyzed the evolution of firm-level productivity dynamics in response to trade reforms and economic integration for various developing countries. More recently, the interest has moved toward the identification of the different channels and mechanisms behind the impact of trade reforms on productivity (Aghion, Burgess, Redding, & Zilibotti, 2004; Amiti & Konings, 2007; Fernandes, 2007; Girma, Greenaway, & Kneller, 2004; Pavcnik, 2002; Tybout, 2001). Our research also draws on the lessons learned from the industrial organization literature examining the impact of increased competition on industry dynamics (Olley & Pakes, 1996). Furthermore, the present study explicitly builds on the recent theoretical literature on trade models with heterogeneous firms. [2] All of these studies provide important theoretical underpinnings for understanding the mechanisms through which economic integration affects productivity dynamics at the firm-level. Finally, the present study complements the large body of research of NAFTA which has focused both on the firm-level impact of liberalization (Alvarez & Robertson, 2004; Lopez-Cordova, 2003), wages and income (Easterly, Fiess, & Lederman, 2003; Esquivel & Rodriguez-Lopez, 2003; Krueger, 2000; Lederman, Maloney, & Serven, 2003) and trade flows (Besedes, 2011; Romalis, 2007).

The present study builds a conceptual framework to analyze the relationship between economic integration and firm-level productivity distinguishing four transmission mechanisms: (1) enhanced competition, (2) access to intermediate inputs, (3) exports, and (4) FDI. Following a difference-in-difference estimation procedure, we are able to capture the productivity growth differentials between integrated and nonintegrated firms during a period before and after NAFTA. Contrary to previous studies, our approach allows for a heterogeneous productivity impact between firms with different integration status. In other words, the productivity effects of trade liberalization will be different between firms whose only link with the international markets is given via the import of intermediate inputs, firms whose link is though export of final goods, and

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firms that are importing inputs and exporting the final produce, that is, *fully integrated* firms.

Our results show that NAFTA stimulated the productivity of Mexican plants via: (1) an increase in import competition and (2) a positive effect on access to imported intermediate inputs. However, the impact of trade reforms was not identical for all integrated firms with fully integrated firms benefiting more than other integrated firms. Contrary to previous results, once self-selection problems are solved, we find a rather weak relationship between exports and productivity growth.

The paper is organized as follows: Section 2 briefly develops the conceptual framework describing the different trade-productivity transmission channels. The data used for the empirical analysis, Mexico's macroeconomic background, and trends in firm-level productivity are shown in Section 3. Section 4 describes our econometric approach and shows the results of various specifications. This Section also discusses potential endogeneity and selection problems, as well as the difficulties in isolating the impact of NAFTA from the peso devaluation of 1994. Finally, Section 5 concludes.

2. TRADE-PRODUCTIVITY LINKAGES

Economic theory predicts that trade reforms can affect firm-level productivity through several channels. Based on the existing literature, this section describes the theoretical linkages behind these channels, setting the basis for the subsequent empirical analysis. Overall, there is not a unique and well-defined model capturing the trade and productivity linkages, but rather a number of different approaches aimed at capturing different mechanisms through which economic integration can impact firms' performance. In the literature, we can identify four main channels through which trade reforms can influence productivity: competition, intermediate inputs, exports, and FDI. Each one of this channels can affect both internal restructuring, that is, productivity changes within the firm, and external restructuring, that is, productivity changes due to market shares reallocation between firms, exit, and entry. In the next sub-sections we discuss in detail each one of these channels, except the FDI one because, due to data limitations, we are unable to study this channel in our empirical analysis. [3]

(a) *Competition channel*

Trade liberalization and tariff reductions are expected to increase the competitive pressures to which domestic firms are exposed. This effect is expected to be stronger for import-competing firms and import-competing sectors than for export-oriented ones. In fact, while the reduction of Mexican tariffs under NAFTA increased the exposure to foreign competitors, by the same coin as for export-oriented ones the exposure to foreign competitors does not change, on the contrary, the reduction of US tariffs generates a competitive advantage equal to the additional tariff margins gained.

The first studies to formally explore this argument and relate the increase of the competitive pressures to an improvement of intra-firm efficiency were Martin (1978) and Martin and Page (1983). These authors argued that an increase in competitive pressures would reduce the "X-inefficiency", defined as the gap between actual productivity and the maximum productivity achievable (Leibenstein, 1966, 1978). The intuition behind their argument is that the efficiency of a firm is, *ceteris paribus*, a positive function of the managers' efforts and this, in turn, is triggered by the exposure to foreign competitors. Following Markusen (1981) who formalized the pro-competitive effect of trade liberalization, Melitz and Ottaviano (2008) is an excellent example of how to model such an effect in the context of an heterogenous-firm model by allowing markups to respond to import competition. Additionally, various empirical studies such as Pavcnik (2002) and Fernandes (2007) have focused on this channel pointing to substantial productivity gains as a consequence of exposure to foreign competition.

A second productivity effect of increased competition is given by its impact on firm size and size distribution; in fact, traditional trade models with homogeneous goods and identical firms assume that scale effects are the principal drivers of productivity changes following trade liberalization. [4] In a world where firms are heterogenous, the import-competing channel can explain changes in aggregate economics through "external restructuring", as less efficient firms are forced to contract or exit (Disney, Haskel, & Heden, 2003). This is shown clearly in Melitz and Ottaviano's (2008) and Bernard *et al.*'s (2007) models, where the increased competition leads to the exit and contraction of less productive firms, while more productive ones expand.

(b) *Intermediate inputs channel*

Economic theory suggests that liberalization of intermediate inputs will increase productivity levels of domestic firms due to an expansion in the menu of available intermediate inputs. This allows individual producers to match more appropriately their technology or product characteristics with the intermediate input used (Feenstra, Madani, Yang, & Liang, 1999). [5]

Another line of thought, linked to the endogenous growth models, suggests that the import of "tangible commodities facilitate the exchange of intangible ideas" (Grossman & Helpman, 1991a, 1991b). More specifically, learning from importing can occur through two distinct channels. First, by incorporating new intermediate products invented abroad into the local production processes (Keller, 2004). Second, the exposure to foreign technology allows for learning about new processes or products (Batiz & Romer, 1991). Related to this, Blalock and Veloso (2007) provide robust empirical evidence, for the case of Indonesian firms, how importing is a driver of international technology transfer.

In Bernard *et al.*'s (2003) model with heterogenous firms the impact of trade reforms on productivity is given via a reduction in the price of intermediate inputs (i.e., cheaper and technologically superior imported inputs replace domestic ones). All firms benefit from the intermediate inputs price reduction, and this effect goes in hand with market reallocation from less productive firms to more productive ones.

An empirical test of the importance of expanded access to imported intermediate inputs is provided by Amiti and Konings (2007) showing that a 10% point fall in input tariffs leads to a productivity gain of 12% for firms that import their inputs.

(c) *Exports channel*

The literature suggests that the expansion of exports could work as another channel explaining the positive influence of economic integration on firm-level performance. Grossman and Helpman (1991a, 1991b) assume that domestic entrepreneurs enlarge the stock of domestic knowledge by increasing their contacts with foreign buyers. Similarly, Fernandes and Isgut (2005), based on Arrow's (1962) learning-by-exporting model, show that exporting activities have learning externali-

ties that decrease over time and increase with the level of exports. Finally, at least three other hypotheses have been explored to explain productivity improvements as a consequence of export expansion. First, by having access to foreign markets, a firm can exploit economies of scale and increase its productivity. Second, relying on foreign markets can help firms to better absorb the negative shocks deriving from a contraction in domestic demand. Third, if the foreign markets are characterized by a higher degree of competition than domestic markets, then exporters will be under higher competitive ressures in those foreign markets increasing their incentives to innovate and become more efficient in order to access foreign markets. If the outlined mechanisms are valid, exporting firms will exhibit higher long-term productivity growth than nonintegrated firms (Wagner, 2002). The export channel will be particularly relevant when a country is granted additional market access as a result of a Regional Trade Agreement (RTA), such as NAFTA.

As we have seen in this section, economic theory identifies different channels of transmission between trade reforms and firm-level productivity. If these transmission mechanisms are at work, post-reform firm-level productivity performance will be a function of the firm's integration status. In other words, the productivity path followed by integrated firms will differ, *ceteris paribus*, from their nonintegrated counterparts. Furthermore, given the nature of the trade-productivity linkages, we would expect a heterogeneous post-reform productivity growth pattern even among integrated firms. For example, firms that are only exporting will bear directly the effects of the exports channel without experiencing, at least not directly, the positive effects of other trade-productivity linkages. In order to capture the different channels of transmission, in the following sections we will analyze the data categorizing firms into one of four groups based on their integration status: fully integrated, exporters, importers, and nonintegrated firms.

Many of mechanisms behind the various channels discussed above will affect all firms regardless of their integration status. For example, the enhanced market access abroad that stimulates the expansion of export-oriented firms has an indirect impact also on domestic firms through general equilibrium effects. Nevertheless, based on theoretical considerations, firm's integration status will determine the magnitude of its own trade-mandated productivity shock. In other words, *a-priori* a process of trade integration would have an asymmetric productivity impact on integrated versus nonintegrated firms, and perhaps this impact could differ between firms in different integration status.

3. DESCRIPTIVE ANALYSIS

(a) *Macroeconomic overview: NAFTA and the devaluation*

The present study covers the period from 1993 to 2002, a time characterized by major changes in the Mexican economy. In January 1994, NAFTA, a trilateral treaty between Canada, Mexico, and the US, was enacted. In December of that same year, as a consequence of a balance of payments crisis, the Mexican peso lost more than 60% of its value in terms of US dollars. This was the starting point of a profound economic crisis where GDP contracted by more than 8% and inflation passed from an annual rate of 7% in 1994 to 41% in 1995. The huge devaluation together with the contraction of the domestic market stimulated exports of Mexican produce. As we can see from Figure 1, during 1994–96, the importance of international trade in the Mexican economy (measured as the ratio of exports plus imports to GDP) almost doubled, passing from a pre-crisis/NAFTA level of 38% to 63% in 1996. The export boom during the period 1994–2002 was led by manufacturing exports, which accounted for 95% of the total exports.

Some important elements emerge from Figure 1. First, the process of trade liberalization in Mexico started in the 1980s. When trade liberalization is measured as a reduction in tariffs, the most important reforms were undertaken during the second half of the 1980s (Peters, 2000). A second interesting point, is that the response of the economy to this first wave of liberalization was rather slow, with trade volumes showing only a modest increase after large tariff reductions. On the other hand, the relatively small reduction in tariffs observed after NAFTA was followed by a substantial increase in the importance of trade volumes in the Mexican economy. These facts suggest that the substantial increase in economic integration between the Mexican and the US economies is explained by a *combination* of NAFTA and the peso devaluation. In other words, the peso devaluation *pushed* Mexican firms into the foreign markets that were opened via the window of NAFTA; once many of the Mexican manufacturers had absorbed the sunk costs of entering foreign markets, they remained integrated despite the revaluation of the Mexico peso during the late 1990s. This may explain the significant increase in the degree of openness that occurred after the devaluation, which was not reversed even when the real exchange rate was revalued. A second complementary explanation behind the pattern followed by openness is that NAFTA implied much more than a tariff reduction scheme, involving deep regulatory and institutional changes, representing a successful case of *deep integration*. [6]

(b) *Firm size and integration status*

In order to see how the post NAFTA/devaluation affected the performance of Mexican manufacturing firms, we use firm-level data from the Annual Industrial Survey (EIA) covering the period from 1993 to 2002. EIA surveys more than 5,000 firms covering 85% of total industrial production. The survey provides plant-level information on characteristics such as number of employees, hours worked, wages, value of production and sales, exports, value of intermediate inputs, inventories, investment, etc. (for more detail see Iacovone (2008)). It is important to stress that the EIA, while covering 85% of Mexican industrial output, it does not include *maquiladoras*. Therefore, despite their importance (Feenstra & Hanson, 1997) it is not possible to include in our analysis the responses of maquiladoras plants to the NAFTA liberalization nor it is possible to account for the impact of the US Offshore Assembly Program as this would require having data on the maquiladoras (Robert & Gordon Hanson, 2000). [7] Table 1 reports some descriptive statistics of the main variables used in the subsequent empirical analysis.

As we have mentioned before, using the theoretical considerations discussed in Section 2 we allocate firms into one of the following four mutually exclusive groups according to their integration status: (1) exporters, (2) importers, (3) fully integrated, and (4) nonintegrated firms. The first group consists of firms that are exporting into the foreign markets without importing intermediate goods; the second group is made up of firms whose only link with the global markets is via the import of intermediate inputs. The third group is formed by all those firms that sell part of their final production in the foreign markets while importing part of their intermediate inputs. Firms are allocated to their respective "integration group" irrespective of the level of their exports/imports. In a robustness check we use alternative definition for the "integration

dummy" and the results, reported in Table 6 in Appendix B, are robust to the use of alternative definitions for the "integration treatment". [8] Finally, the last group consists of firms that do not have any direct link with foreign markets. [9]

Figure 2 shows information regarding the number of firms and their size by integration status for a given year (1997). [10] In 1997, 2372 firms, representing more than 40% of the total manufacturing firms in Mexico, had no direct linkage with the international markets. In that same year, 10% of Mexican manufacturing firms were integrated to international markets via exports, 19% via imports, and 28% were importing intermediate inputs and exporting their final product (fully integrated).

In 1997, the great majority of the numerous nonintegrated firms were micro or small plants. [11] Both exporters and importers have a similar composition in terms of firm size, with around 40% being small and 30% being medium firms. Finally, the fully integrated firms, that simultaneously export and make use of imported intermediate inputs, are the largest ones, with virtually no micro firms being part of this category. In 1997, three and four out of 10 firms had a medium or large size, respectively.

(c) *Trade shock, integration status, labor productivity*

As we mentioned above, integration was mainly brought about by a combination of NAFTA and the peso devaluation. We have also shown that nonintegrated and exporting firms tend to be smaller than importing and fully integrated ones. In order to explore how the patterns of integration may have affected the size of the firms, Figure 3 shows the time trend in the proportion of integrated firms (all three integration status groups) and their average size (measured as total employees). According to Figure 3, the proportion of integrated firms increased steadily from 1993 to 1997 (continuous line). Regarding the size of the firm (measured as the number of employees), apart from the change occurring during 1993–95, the average size of integrated firms increased throughout the period. It is interesting to note that 1994 is the only year when NAFTA was at work in the absence of a devaluation effect. [12] During 1993–94, the average size of integrated firms remained constant, while the proportion of integrated firms increased. Therefore, NAFTA (in the absence of a devaluation) helped relatively small firms to incorporate into the global markets. [13] After 1995, when the devaluation effect was very strong, even smaller firms where *pushed* into the global markets, hence explaining the increase in the proportion of integrated firms and the reduction in their average size. After 1995, the changes in the distribution of size among integrated firms in the market can be attributed to a combination of NAFTA and the peso devaluation. The simultaneity of these two events resulted in an expansion of integrated firms but this time the small ones (many of the exporters and to a lesser extent the importers) were not able to survive the crises. Therefore, the average size of the integrated firms increased after 1995. This increase in the average size among integrated firms after the trade reforms is consistent with trade models à la Melitz (Bernard *et al.*, 2007; Melitz, 2003; Melitz & Ottaviano, 2008).

Figure 4 shows the performance in value added labor productivity per hour by integration status. During 1993–94 (the period of NAFTA without a peso devaluation), average productivity in all integration groups rose, with the fully integrated firms benefiting most. After the peso devaluation and until 1996, labor productivity of integrated and nonintegrated firms decreased with the nonintegrated firms experiencing the largest negative shock. During 1996–2000, all integrated firms experienced a reduction in labor productivity as opposed to the nonintegrated firms, that were catching up. This strongly suggests that the post NAFTA/devaluation trade expansion had asymmetric effects on firms based on their integration status, in particular in terms of their productivity performance.

This section shows that there is a great degree of heterogeneity in size, sector of specialization, and productivity between firms with a different integration status. Exporting firms are similar in size to nonintegrated firms although their level of labor productivity is higher with a level closer to the one exhibited by importing firms. Descriptive statistics also show that importers, as well as fully integrated firms, are concentrated in two capital intensive sectors: "machinery and equipment" and "chemical products". Finally, the labor productivity trends show that NAFTA marked a change in the slope of productivity paths between firms with different integration status, especially between fully integrated and nonintegrated plants.

The rest of this paper will try to explore how much of the differential in labor productivity shown in Figure 4 is attributable to the increase in trade integration observed during 1993–2002. In our empirical strategy we take 1993 as the base year (period before NAFTA), compare the productivity growth rate between integrated and nonintegrated firms (controlling for firm-level characteristics and allowing for heterogeneous effects across integration status) and attribute these difference to the reforms. Since many other factors can influence the productivity growth rate differentials, a formal econometric analysis is needed to control for other variables potentially influencing the patterns observed in Figure 4.

4. EMPIRICAL STRATEGY

In this section we formally evaluate the impact of NAFTA on firm-level productivity. There are two possible approaches that we can follow to disentangle the relationship between trade integration and firm-level productivity: (1) link tariff reductions with firm-level productivity while controlling for other possible effects; or (2) compare the differential of productivity growth rates between integrated and nonintegrated firms before and after the reforms controlling for observables and unobservable fixed effects. Both approaches have their advantages and limitations hence, in this study, we combine both of them in order to identify separately all the channels discussed in Section 2.

It should be stressed that during the mid-80s Mexico already went through a serious of liberalization reforms. [14] Some of these reforms involved expanding access to foreign investments. [15] These reforms, in particular the investment reforms can possibly have a delayed effect and result in significant increase in capital inflows which may compound our results. For this reason, given our focus on labor productivity which is sensitive to changes in the capital stock, in all our regressions we will control for capital per worker hence our results should be interpreted net of any "capital stock changes" due to investment reforms. [16]

Identifying the impact of trade reforms exploiting tariff reductions has one important advantage but also some serious drawbacks. On the positive side, this approach is able to isolate neatly the impact of an important element of trade reforms, such as tariff reductions, from all other trade-related exogenous shocks. However, this advantage can also be a source of weakness. If we believe that trade reforms involve much more than just a reduction in tariff rates, focusing solely on tariff variations will lead to an *under-estimation* of the impact of trade reforms. This appears to be a very important issue in the case of NAFTA since, as discussed in Section 3, the changes in tariff rates were relatively modest. [17] In fact, as it is

argued in Kose, Meredith, and Towe (2004) and Lederman *et al.* (2003), the major changes introduced by NAFTA took the form of new rules and institutions to promote integration among the trade partners.[18] Exploiting tariff reductions to identify the productivity impact of trade reforms introduces a further technical problem involving the identification of the impact of tariffs on intermediate inputs.

Although it is virtually impossible to identify NAFTA's full productivity impact by focusing only on tariff variations, the information contained in the post-reform reductions in import tariffs is enough to identify the effect of the reforms via the import-competing channel. As mentioned in Section (a), controlling for everything else, a reduction in import tariffs is expected to increase foreign competition for Mexican plants, pushed to contract or close down, and hence boost labor productivity. The present study uses tariff variations to identify the link between NAFTA and labor productivity via the import-competing channel. Nevertheless, we complement this approach with a pseudo-experimental procedure that identifies all other trade-productivity channels discussed in Section 2.

As discussed in Section 2, theoretical models with heterogeneous firms suggest that trade reforms will impact asymmetrically on different types of firms. We expect *integrated* firms to be positively affected by the reforms *relative* to *nonintegrated* firms. Moreover, the impact within integrated firms could be different depending on a firm's integrated status. This idea is not only based on theoretical considerations but also appears to emerge from the descriptive statistics presented in Section 3 suggesting that plants within different "integration status" show a different productivity evolution over time. Hence, a crucial identifying assumption behind the pseudo-experimental approach adopted in this paper is that the reforms introduced by NAFTA had a different effect on pre-reform integrated and nonintegrated firms.

Our strategy builds on the previous work by Pavcnik (2002) and Lopez-Cordova (2003) analyzing the impact of trade reforms in Chile and Mexico, respectively. While Lopez-Cordova (2003) exploits tariff variations Pavcnik (2002) uses a quasi-experimental approach (i.e., treatment versus control group). The mayor difference between these two closely related studies and the empirical approach followed in this paper are the following:

1. Pavcnik (2002) defined a firm as being *integrated* when it belonged to a "integrated" sector—at 4 digits of the ISIC classification—regardless of the firm's integration status. Thanks to data availability, in this paper we define the integration status at the firm level.[19]
2. Within integrated firms, our approach allows for a heterogeneous impact of the reforms among firms with different integration status, that is, exporters, importers or fully integrated.
3. Our econometric approach controls for possible endogeneity problems related to a firm's decision to change integration status; and it also attacks the attrition problem present in the Mexican industrial survey (EIA).

(a) *Econometric approach*

The objective of the econometric strategy is to understand the impact of NAFTA on firm-level productivity. For this purpose we use the value-added per unit of hourly labor as the productivity index.[20] The reason of our choice lies in the simplicity in the interpretation of this index and in its transparency. Moreover, the direct link between value-added labor productivity and national welfare makes this index attractive from a policy perspective. However, this index also has some drawbacks, the principal one being that two firms may differ in their value-added labor productivity based solely on differences in their capital intensity. In order to address this issue, in our regressions we control for the stock of capital per worker.

Let us define φ_{it} as the log of the value-added per hourly worker in firm i at time t. Similarly, let $\mathbf{X}_{ijt}$ be a vector containing a set of firm-level characteristics, as well as industry and location fixed effects. Let τ_{it} be the domestic import tariffs under NAFTA; in other words, τ_{it} are the tariffs faced by foreign competitors of firm i in time t. Productivity is assumed to be a function of a constant, time and integration status, the interaction between the former and the latter, import tariffs, and the vector with covariates $\mathbf{X}_{ijt}$:

$$\varphi_{it} = \alpha + \sum_{t=94}^{2000} \delta_t Time_t + \sum_{s=2}^{4} \beta_s Integration_{i,t}^{s} + \sum_{t=94}^{2000}\sum_{s=2}^{4} \delta_{t,s} \cdot Integration_{it}^{s} \times Time_t + \theta \cdot \mathbf{X}_{ijt} + \psi\tau_{it} + \varepsilon_{it} \quad (1)$$

where $Time_t t = (1994, \ldots, 2000)$, are year dummies capturing economy-wide macroeconomic shocks; $Integration_{it}^{s} s = (2, 3, 4)$, are a set of binary or dummy variables taking zero/one values depending on the integration status of the firm. The reference category is the group of nonintegrated firms in the pre-NAFTA year 1993. Therefore, the year dummies will capture overall trends affecting productivity with respect to the base year, 1993. On the other hand, the integration status dummies will pick up the differences between firms that are integrated versus nonintegrated firms (the excluded category). The interaction term between these two sets of dummy variables is what is known in the literature as the Difference-In-Difference (DID) estimator capturing the treatment effect, in our case the impact of NAFTA. Finally, all the continuous variables are expressed in logs.

The flexibility of specification (1) allows the impact of NAFTA to be different across integration status and these effects are allowed to vary over time. The coefficients of interest are the treatment effects $\hat{\delta}_{t,s}$ and, if correctly estimated, they capture the differences in productivity *growth* between treated (integrated firms) and controls (nonintegrated firms). The treatment effect is capturing what is known in the literature as ATT or "average treatment on the treated", that is, the impact of NAFTA on those firms that are already integrated and hence are being directly affected by the agreement. Note that, as we mentioned before, NAFTA is likely to have some general equilibrium effects on all Mexican firms, including those that are not integrated. Nevertheless, these are not identified by our DID coefficient. Similarly, our estimates cannot be used to quantify the impact of NAFTA on nonintegrated firms had they been integrated unless we are willing to accept the assumption that the "average treatment on the nontreated" is equal to the ATT.

If trade reforms had a positive effect on the productivity of integrated firms the difference-in-difference coefficients should be positive. Therefore, exploiting the heterogeneous impact introduced by NAFTA (both across firms with different integration status and over time), our coefficients, $\hat{\delta}_{t,s}$, capture the impact of the reforms on productivity separating the various trade-productivity channels without restricting the effect to take place only via tariff reduction. Analytically, the treatment effects are defined by the following equation:

$$\begin{aligned}\delta_{DID}^{Int} &= \Delta\bar{\varphi}_{Int} - \Delta\bar{\varphi}_{NInt} \\ &= \left(\bar{\varphi}_{Int}^{after} - \bar{\varphi}_{Int}^{before}\right) - \left(\bar{\varphi}_{NInt}^{after} - \bar{\varphi}_{NInt}^{before}\right) \\ &= \left(\bar{\varphi}_{Int}^{after} - \bar{\varphi}_{NInt}^{after}\right) - \left(\bar{\varphi}_{Int}^{before} - \bar{\varphi}_{NInt}^{before}\right)\end{aligned} \quad (2)$$

The DID approach makes two important assumptions that need to hold in order to properly identify the treatment effect (Blundell & Costa Dias, 2000; Wooldridge, 2002). The first assumption is that the treatment is not correlated with time-varying unobservables. The second assumption is that the macroeconomic shocks affect all firms in a similar fashion. The time dummies capture economy-wide macroeconomic changes, such as the sharp devaluation of the Mexican peso in December 1994. Intuitively, it is plausible that exchange rate movements will have different impacts on firms with different integration status. Hence, this could potentially introduce a bias into our treatment estimates.[21] Assessing the plausibility of the underlying assumptions is complex and we will discuss this further when presenting our results.

Bearing all the assumptions and limitations in mind, the DID is a powerful tool able to identify the impact of a particular policy on a specific outcome variable. The DID framework captures the impact of policy interventions controlling for status-specific characteristics that are time-invariant (see Eqn. (2)). Therefore, all the time-invariant initial firm characteristics that may have influenced the selection of the firm into a specific integration status will not influence our results.

As is clear from Eqn. (1), the DID framework is complemented with a tariff reduction approach capturing the impact of import competition via coefficient ψ. If lowering import tariff rates increases domestic competition and this, in turn, has a positive effect on productivity, then coefficient ψ should be negative.

(b) *Results and robustness tests*

(i) *Results*

The first set of models use all the firms in our sample to run OLS for four different specifications of Eqn. (1). All the results presented here correct for potential autocorrelation across firms using clustered-robust standard errors at the firm-level. The results are presented in columns (1)–(4) in Table 2. We start off with a parsimonious version of Eqn. (1), which includes only the treatment effects with no other controls (specification (1) in Table 2). In the second column sector-specific Mexican tariffs under NAFTA are added to capture the competition channel. In the following two specifications we respectively add industry and location fixed effects — column (3) — and also plant-level controls in column (4).[22]

A first remark when comparing these four specifications is that, as we would expect, the inclusion of fixed effects and extra controls tends to decrease the size of the DID estimates.

According to our parsimonious specification (column (1) Table 2), in 1993, integrated firms (regardless of their integration status) had an average productivity higher than nonintegrated firms. This result contrasts with the parameter estimated from the full specification with all the controls (specification (4)). Once all the control variables are included in the regression, the results show that the initial *integration premium* is explained by differences in the values of the plant-level characteristics between integrated and nonintegrated firms and not by integration *per se*. Plant characteristics such as size, capital per worker, investment in research and development, and foreign participation are all positively correlated with productivity, however, notice that these variables may be endogenous and are hence not the main focus of this study. These controls are included to avoid an omitted variable bias on our main coefficient of interests which are the δs of the treatments.[23]

Although a firm's integration status cannot account for initial productivity differentials, it might still explain differences in productivity *growth* across firms, which is our variable of interest. In order to concentrate our discussion on the coefficients capturing the heterogeneity in productivity performance across integration status, that is, the treatment effects, in Figure 5 we plot the evolution of $\delta_{t,s}$ over time.[24] Although we do not report confidence intervals for the plotted coefficients (the significance of the parameters is reported in Table 2), Figure 5 captures the trends followed by the treatment effects. Figure 5 shows that the treatment effects for importer and fully integrated firms are positive and significantly different from zero in all post-NAFTA years, except 2000–01 for the importers. On the other hand, the effect of NAFTA on productivity growth of exporters was not significantly different from the effect it had on nonintegrated firms' productivity performance, the control group, in most years. Note that the coefficients for "fully integrated firms" are in general larger than those for other integration status suggesting a complementarity between export and import activities as channels to promote productivity growth.[25]

In order to put the treatment effects into context, our results show that during the post-NAFTA period, annual labor productivity of fully integrated plants grew between 10% and 25% *faster* than labor productivity of nonintegrated ones. The treatment effect was somehow smaller for importers, with an annual growth differential between 12% and 20% with respect to nonintegrated firms. The results from the full specification highlight important elements of heterogeneity related to the integration status of the firm. Hence splitting integrated firms in different groups taking into account their integration status (i.e., exporter, importer, or fully integrated) allows us to capture heterogenous treatment effects that would otherwise be ignored if we were lumping together all integrated firms regardless of their integration status as some previous studies did (Lopez-Cordova, 2003; Pavcnik, 2002).

Regarding the import-competing channel, as expected *a priori*, the coefficient on the log of import tariffs (ψ in Eqn. (1)) is negative. Everything else constant, a firm facing a tariff reduction equal to, say, 10% tends to increase its productivity by 1%. Under NAFTA, Mexican tariffs were reduced from an average of 16% to 5%, or 11% points, representing a reduction of almost 69% on average tariff. According to our results, this policy decision fostered competition and increased firm-level productivity by 6.8% ($69 * 0.099$).

(ii) *Robustness analysis: Addressing potential endogeneity*

Every year about 5–10% of plants exit the sample because of attrition and not taking this into account may generate a bias. In order to control for this we follow Amiti and Konings (2007) and re-estimate our equation by adding a dummy that is equal to one in time t when the plant is going to exit in $t + 1$ and zero otherwise. The results, shown in column (5) of Table 2, confirm that plants that are to exit the market the following year have a significantly lower productivity. NAFTAs treatment effects are remarkably robust to this new specification.

As it was mentioned before, an important methodological difference between the present study and that of Pavcnik (2002) is that the treatments here are identified at the firm-level as opposed to Pavcnik (2002) who identifies it at the sector-level. What kind of bias was imposed in Pavcnik (2002) while aggregating different firms in the same sector? Estimating a specification including Mexican import tariffs as controls, similar to (2) in Table 2, but identifying treated firms at the four-digit sector level, shows that sector-level identification leads to *significantly smaller treatment effects* suggesting that productivity effects of Chilean integration might have been higher than what was originally found.

As mentioned before, if the assumption of exogeneity of the treatment (being integrated within a trade liberalization period) is violated and our treatments are correlated with some unobservable characteristics, the OLS estimated coefficients will be biased. So far we have tried to alleviate this endogeneity problem by including firm-level variables as controls. If the decision to become integrated (treatment) is correlated with any of the observable characteristics used as controls, our results are still consistent. However, the problem of endogenous treatment is especially acute in our case because we have to deal with what is an established finding in the literature: most efficient (and productive) firms *self-select* into export markets (Bernard & Bradford Jensen, 1999; Melitz, 2003). It is therefore reasonable to expect a causal relationship from productivity levels to integration status. If this is true, the treatment effects presented so far may be biased.

Table 4 presents the number of firms that change status every year distinguishing between those that begin importing or exporting and those that stop importing or exporting. We can see that there is a substantial number of plants, about 20%, that switch integration status every year.

In order to tackle this potential endogeneity problem, four additional specifications are estimated. The first two specifications impose the rather strong assumption that the characteristics shared by "switchers are fixed over time. Hence if a plant decides to switch integration status in, say, time t it will be treated as a "switcher throughout the period of analysis. Under this assumption, a crude and artificial way of eliminating the endogeneity bias is by simply eliminating all plants identified as "switchers in the sample. The results of this specification are reported in column (1) of Table 3 and are qualitatively similar to the results of our basic model discussed previously.[26] The fact that our results are robust to switchers exclusion is encouraging and seems to point toward the idea that our findings are indeed not driven by endogenous treatments. However, since switching integration status is not a random process, the results obtained using the restricted sample of nonswitchers are valid only for nonswitching plants and biased estimators of the true population parameters. To get unbiased point estimators of the productivity effects of NAFTA on all plants in Mexico, it is necessary to account for the plants decision to switch (or not) integration status. This is done using a Heckman selection model where the probability of being a nonswitcher is instrumented. For all "switchers — as defined above — we impose the condition that the outcome variable (productivity, φ_{it}) is unobserved and estimate the following model:

$$\varphi_{it} = \alpha' + \beta' \cdot \mathbf{X}'_{ijt} + \psi' \tau_{it} + \lambda' \left(\hat{\gamma}' Z'_{ijt} \right) + \varepsilon'_{it} \tag{3}$$

$$P\left(Y'_{it}\right) = \kappa' + \gamma' \cdot \mathbf{Z}'_{it} + \mu'_{it} \tag{4}$$

Where $Y'_{it} = 1$ if firm i is not a switcher

or $Y'_{it} = 0$ if firm i is a switcher

Following Heckman (1979) we proceed in two steps. First, we estimate Eqn. (4) using a probit model. In the second step, we estimate our main equation (3) using the $\hat{\gamma}$ obtained from the first step to construct the inverse Mills ratio. Eqn. (4) is the selection equation where $\mathbf{Z}'_{it}$ includes all the explanatory variables in the primary equation, the domestic tariffs (τ_{it}) plus the exclusionary restriction. Melitz's (2003) model suggests that a firm will produce solely for the domestic market if its productivity is under certain threshold and will engage in exporting if its productivity is above that threshold. In general, a plant will be in a specific integration status to the extent that its productivity falls within a certain range. We re-interpret Melitz model by arguing that a plant is more likely to be a change in integration status (switcher) if its productivity is "significantly different" from the productivity of those plants in the same sector and with the same integration status. Following this argument we calculate the absolute value of the difference between the productivity of a given plant and the median productivity within the same integration status and sector. Since the relationship between the productivity dissimilarity index and the probability of switching could be nonlinear, a squared term of this index is also included as a regressor in the probit model. Therefore, the exclusionary restriction (instrument) in system (3) and (4) is a dissimilarity index (and its square) which measures the absolute productivity distance between any given plant and "similar plants".

The results of this second specification are reported in column (2) of Table 3. The results show evidence of a selection bias as λ, the coefficient of the Mills Ratio, is statistically significant. The coefficient results reported in column (2) Table 3 show that, accounting for selection bias reduces significantly the productivity effects of NAFTA on firms integrated to the international markets via imports. In only 2 out of 8 years-integration status included, importers-only plants increased their productivity at a faster rate than the controls. Interestingly, the treatment effects for both exporters and fully integrated, increased in size and significance as compared with the results from the specification that includes switchers but does not account for self-selection (column (5) in Table 2).

As it was mentioned above, the results presented in columns (1) and (2) of Table 3 rely on the rather restrictive assumption that being a "switcher" is a firm-specific attribute that is constant over time. This assumption is relaxed in the third and fourth specifications shown in Table 3. The "switching" status is defined as an attribute that varies over time therefore the same plant can transit from nonswitcher to switcher one. Empirically, the dummy variable defining switcher is equal to 1 the moment a plant changes integration status and zero otherwise. However, notice that, once a plant is defined as a switcher it will always remain as such. For the sake of comparison with specification (1) in Table 3, specification (3) runs an OLS where all switchers are eliminated.[27] The results of specification (3) are qualitatively similar as the ones shown by specification (1) in Table 3 and the full model (specification (5)) in Table 2.

Finally, column (4) of Table 3 contains the results of our preferred specification, with all the set of controls and accounting for selection bias. Under this specification, most treatment effects are positive and significantly different from zero. Domestic tariffs remain negative and firms that are going to exit in the following period are, on average, less productive that those that stay in the market.

At this point a caveat is needed. Modeling adequately the firms' switching process is extremely complex due to the difficulty to adequately capture, with a single reduced-form model, all the twelve different possible processes of switching. Second, even within a single switching process (e.g., switching from domestic to importer), there are different types of switchers. There are firms that change status and remain stably in the new status ("stable switchers") and there are firms that only temporary switch status before returning to their original status after 1 or 2 years. In fact, in Table 5 we can see that if we adopt a relatively liberal definition of "stable switchers" by imposing the condition that they remain for at least 2 years in the new status, including the year of switching, we see that about 25% of plants are temporary switchers. If we impose the condition that to be defined as "stable switcher" a plant needs to remain at least 3 years in the new status, including the year

Table 1. *Descriptive statistics*

	Average	Standard Deviation
NAFTA Tariff on US Goods (%)	6.095808	7.036941
Age (Years)	25.35733	15.49911
Total sales (thousands of Pesos)	68172.56	344668.9
Capital stock per worker (thousands Pesos)	241.3503	2984.742
Investment in R& D (thousands of Pesos)	108.0089	2397.445
Investment in tech transfers (thousands of Pesos)	536.6467	5759.899
Imports + exports over sales (%)	19.40678	30.26798
Imports over sales (%)	10.42703	17.69626
Exports over sales (%)	9.260403	21.0511
Share of FDI in 1993 (%)	9.690506	27.40694

Table 2. *Estimations of DID model*

	(1)	(2)	(3)	(4)	(5)
DMX	0.414***	0.398***	0.412***	−0.147***	−0.140***
DnMX	0.274***	0.273***	0.237***	−0.02	−0.015
DMnX	0.284***	0.280***	0.258***	−0.095***	−0.090***
DMX1994	0.254***	0.261***	0.254***	0.128***	0.129***
DMX1995	0.463***	0.469***	0.489***	0.255***	0.257***
DMX1996	0.468***	0.479***	0.503***	0.226***	0.229***
DMX1997	0.300***	0.312***	0.354***	0.183***	0.187***
DMX1998	0.247***	0.263***	0.309***	0.194***	0.192***
DMX1999	0.232***	0.249***	0.297***	0.173***	0.161***
DMX2000	0.118***	0.136***	0.184***	0.100***	0.089**
DMX2001	0.096**	0.107**	0.154***	0.097**	0.089**
DMX2002	0.227***	0.244***	0.281***	0.138***	
DnMX1994	0.077*	0.078*	0.06	−0.053	−0.053
DnMX1995	0.294***	0.297***	0.333***	0.083*	0.085*
DnMX1996	0.240***	0.243***	0.292***	0.027	0.03
DnMX1997	0.115**	0.118**	0.162***	0.007	0.011
DnMX1998	0.173***	0.177***	0.197***	0.059	0.059
DnMX1999	0.164***	0.169***	0.180***	0.042	0.033
DnMX2000	0.137**	0.140**	0.155***	0.036	0.025
DnMX2001	0.186***	0.189***	0.211***	0.133**	0.124**
DnMX2002	0.238***	0.247***	0.257***	0.110*	
DMnX1994	0.186***	0.188***	0.188***	0.132***	0.133***
DMnX1995	0.338***	0.339***	0.337***	0.198***	0.201***
DMnX1996	0.343***	0.346***	0.348***	0.144***	0.148***
DMnX1997	0.146***	0.153***	0.162***	0.072**	0.076**
DMnX1998	0.193***	0.202***	0.203***	0.140***	0.140***
DMnX1999	0.169***	0.178***	0.194***	0.116***	0.116***
DMnX2000	0.075*	0.082*	0.097**	0.028	0.022
DMnX2001	0.081*	0.077*	0.102**	0.062	0.056
DMnX2002	0.163***	0.161***	0.177***	0.092**	
TariffsMXNafta		−0.032*	−0.127***	−0.099***	−0.101***
Exit in $t+1$					−0.811***
Plant controls	No	No	No	Yes	Yes
Industry FE	No	No	Yes	Yes	Yes
Location FE	No	No	Yes	Yes	Yes
Clustered SE	Yes	Yes	Yes	Yes	Yes
N	52621	52151	52151	37825	34634
r^2	0.081	0.08	0.152	0.341	0.347

Notes: (1) The plants control include age, sales, capital per worker, R & D, payments for technology transfers, foreign ownership. (2) DNMX = dummy variable for "fully integrated" plants; DnMX = dummy variable for "export only" plants; DMnX = dummy variable for "import only" plants.

of switching, then we see that about one third of switchers do so only temporarily. However, modeling the process of switching goes certainly beyond the scope of this paper.

One final point that we need to tackle is the extent to which our results are driven by NAFTA or by the 1994 peso's devaluation. Unfortunately, the timing of the devaluation is particularly bad from the perspective of a study analyzing the impact of NAFTA, because NAFTA was enacted on January 1, 1994 and the devaluation occurred in December 1994. It is reasonable to expect that the exchange rate devaluation can affect firms with different integration status differently. In particular, we would expect that the first order impact on firms that just export will be positive, while the impact on firms that just import will be negative. The first order effect

Table 3. *Controlling for switchers*

	Switchers — identified as such always (from beginning)		Switchers — identified from the moment firms switch	
	OLS (1)	Heckman (2)	OLS (3)	Heckman (4)
DMX	−0.078**	−0.159**	−0.097***	−0.011
DnMX	0.011	0.546**	0.003	0.191**
DMnX	−0.058**	0.457*	−0.066**	0.017
DMX1994	0.139***	0.198**	0.139***	0.141**
DMX1995	0.290***	0.475***	0.287***	0.380***
DMX1996	0.253***	0.521***	0.245***	0.368***
DMX1997	0.210***	0.553***	0.223***	0.400***
DMX1998	0.178***	0.453***	0.218***	0.294***
DMX1999	0.183***	0.497***	0.196***	0.295***
DMX2000	0.060	0.392**	0.090*	0.200**
DMX2001	0.048	0.304**	0.042	0.132*
DnMX1994	0.089	0.062	−0.015	0.073
DnMX1995	0.290**	0.364**	0.139**	0.384***
DnMX1996	0.246**	0.407**	0.129**	0.387***
DnMX1997	0.226	0.421**	0.097	0.436***
DnMX1998	0.433***	0.580***	0.176**	0.481***
DnMX1999	0.185	0.350*	0.065	0.405**
DnMX2000	0.251*	0.368**	0.147	0.480***
DnMX2001	0.247**	0.301*	0.159	0.549***
DMnX1994	0.244***	0.243**	0.135***	0.296***
DMnX1995	0.380***	0.276***	0.218***	0.377***
DMnX1996	0.212***	0.124	0.149***	0.251***
DMnX1997	0.207***	0.133	0.133***	0.349***
DMnX1998	0.231***	0.054	0.194***	0.316***
DMnX1999	0.255***	0.105	0.201***	0.394***
DMnX2000	0.114	−0.024	0.036	0.307***
DMnX2001	0.050	−0.118	0.019	0.281***
halfline				
TariffsMXNafta	−0.086***	−0.064***	−0.092***	−0.078***
firmwillexitDUMMY	−1.031***	−1.028***	−0.906***	−1.009***
Lambda		−0.811*		−0.661***
First stage — LHS: Firm is no Switcher (=Firm Select into the sample)				
Distance from Avg Prod		0.040		0.032
Distance squared		−0.016		−0.020**
N	14840	34459	20146	34634
r^2	0.362		0.356	

Notes: DNMX=Dummy variable for "fully integrated"plants; DnMX=Dummy variable for "export only" plants; DMnX=Dummy variable for "import only" plants.

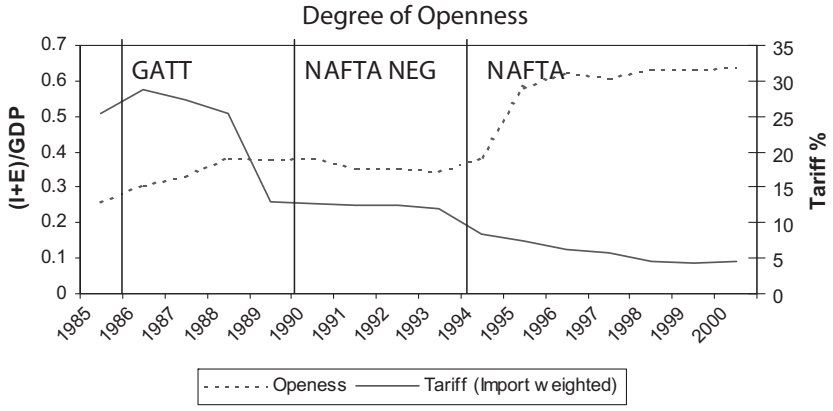
Table 4. *Number of "switchers"*

Year	Begin import	Begin export	Stop import	Stop export
1994	341	355	336	343
1995	291	566	432	186
1996	321	399	340	224
1997	359	346	278	249
1998	208	196	404	329
1999	295	296	216	251
2000	220	237	191	277
2001	172	182	277	322
2002	114	128	250	286
Total	2321	2705	2724	2467

on fully integrated firms is harder to predict *a priori*. Based on this reasoning, we can expect that the coefficients for firms that just export (import) could be upward (downward) biased, in particular during the period 1995–98 with this bias decreasing over time once the exchange rate appreciates. The results from the preferred specification (column (4) of Table 3) show a positive trend in the case of exporters-only and no apparent trend in the case of importers-only. Therefore, the trends followed by the coefficients capturing the treatment effects appear to be inconsistent with what one would expect if the bias arising from the devaluation was driving our results.

Table 5. *Switchers: stable vs. temporary*

Year	All	At least 2 years in new status (including year of switching)		At least 3 years in new status (including year of switching)	
		Stable	Temp	Stable	Temp
1994	1290	984	306	860	430
1995	1356	1051	305	909	447
1996	1176	901	275	759	417
1997	1133	847	286	714	419
1998	1050	776	274	670	380
1999	958	739	219	628	330
2000	857	636	221	555	302
2001	858	681	177		
2002	701				
Total	9379	7316	2063	6477	2902



Q8 Figure 1. *Mexico – economic integration. Source: Nicita (2004).*

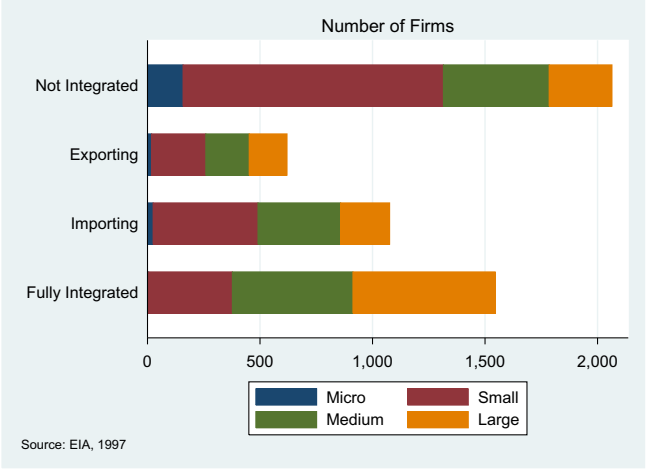


Figure 2. *Size distribution by integration status.*

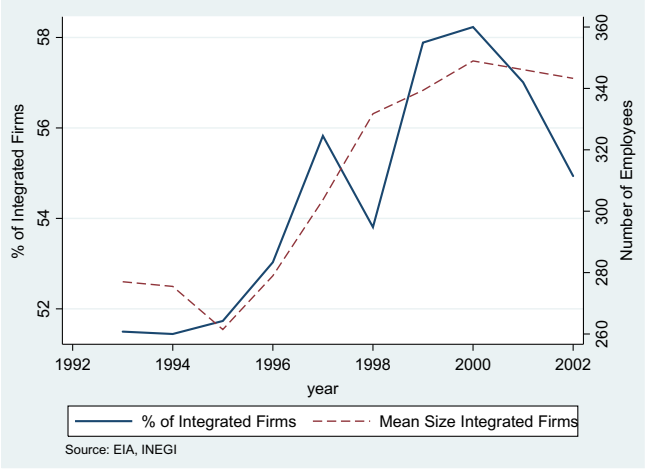


Figure 3. *Patterns of integration and firm size.*

5. CONCLUSIONS

This paper answers two questions: (1) Did NAFTA reforms make Mexican plants more productive? (2) If so, through which channels? As opposed to previous studies, we have been able to identify the trade integration status at the firm level and not at the sectoral level (Pavcnik, 2002). Also, improving on previous studies that analyze the impact of NAFTA, we have attempted to identify an "overall NAFTA impact" (through the various channels) and not just the impact of tariff changes (Lopez-Cordova, 2003). Furthermore, our empirical analysis overcomes two principal hurdles: endogeneity and potential sample selection bias. A further complication was generated by the timing of the peso's devaluation, which occurred in December 1994 and overlapped with the period of implementation of NAFTA enacted in January 1994. The papers tries to tackle all these empirical issues and our results appear to be robust and not driven by these issues.

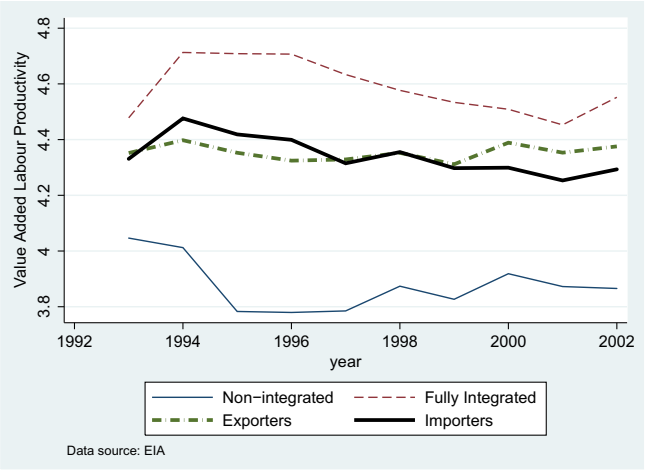


Figure 4. *Labor productivity performance by integration status.*

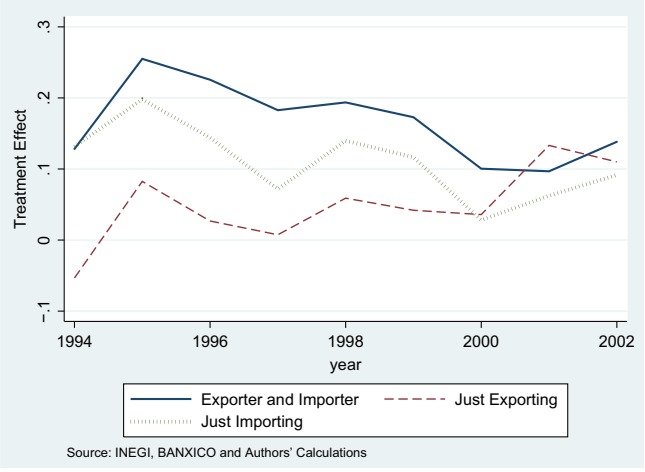


Figure 5. *Impact of NAFTA on productivity by integration status for all firms.*

The results of this paper confirm the importance of the import-competition channel. As previously suggested in various empirical studies (Fernandes, 2007; Pavcnik, 2002; Tybout & Westbrook, 1995), an increase in import competition, measured by a reduction of import tariffs under NAFTA, had a positive effect on stimulating the productivity of Mexican plants. We also found that the impact of trade reforms is not identical for all integrated plants. Consequently, it is important to distinguish between firms based on the way these are actually integrated to the international markets. In fact, we found that the benefits to firms that are fully integrated are normally larger than the benefits accruing to other types of integrated firms. In contrast with the findings of Lopez-Cordova (2003) but in line with some more recent studies (Amiti & Konings, 2007; Blalock & Veloso, 2007), our results suggest that imported intermediate inputs can be a crucial source of productivity growth for firms, and trade reforms that enhance access to these inputs can be an important source of a country's competitiveness. As it was the case in (Bernard & Bradford Jensen, 1999; Pavcnik, 2002), we cannot find evidence that exporting is a channel of productivity growth. However, a possible explanation for the lack of evident improvements in the productivity growth of exporters, as opposed to importers, could be that the extra market access for Mexican exporters after NAFTA has been modest given that US tariffs were already low. In contrast, the changes for importers have been more substantial. Furthermore, with the boom in FDI and the expansion of exports after NAFTA, many of the importers may have found themselves in the new situation of having to supply MNCs or exporters with far higher demand standards. The process of catching up with these new demands may be an important explanation behind the significant productivity growth of importers. Unfortunately, we have no hard evidence to support this hypothesis except some facts presented in our descriptive analysis (Section 3).

Finally, consistent with various previous studies (Djankov & Hoekman, 2000; Evenett & Voicu, 2001), the FDI channel also appears to be an important source of productivity growth for plants acquired, or with participation shares, by MNCs. However, data limitations do not allow us to investigate this channel in more detail because the data only allow us to identify the foreign ownership of Mexican plants in 1994. For this reason, we decided not to pursue further the study of the impact of FDI and the potential vertical and horizontal spillovers in this study, even if we are aware of their importance as drivers of productivity changes in Mexico during the period under analysis.

NOTES

1. In the paper we refer interchangeably to firm or plant to identify the unit of observation of our study, however this refers to the unit of observation of our data that is "the manufacturing establishment where the production takes place".

2. Among the most influential studies in this field include the following contributions: Melitz (2003), Bernard, Eaton, Jenson, and Kortum (2003), Bernard, Redding, and Schott (2007), Yeaple (2005), Verhoogen (2008), and Bustos (2007).

3. Despite the fact that the EIA includes foreign owned firms, because of its questionnaire this survey did not collect information about foreign ownership. The only information on foreign availability is derived from the 1993 Industrial Census hence is a time-invariant firm characteristic and is used as a control in our empirical analysis.

4. See for example Markusen (1981).

5. Formally, economic theory provides us with models where specialized inputs are characterized by increasing returns (i.e., high initial capital and learning costs) and consequently the degree of differentiation is limited by the size of the market. In this model, the liberalization of intermediate inputs will increase the varieties of available inputs, some of them more specialized and closer in terms of complementarity to the domestic ones.

6. By means of an explicit econometric model linking tariff reduction and household real income, De Hoyos (2005) finds that measuring NAFTA just as the reduction in tariff brought about by the agreement would lead to the conclusion that the agreement had almost no impact on real household incomes in the economy.

7. The "maquiladoras" data are collected following a separate protocol and by a separate department hence the data of EIA and those of "maquiladoras" are maintained in separate location and cannot be easily merged for confidentiality reasons.

8. First, in column one, we define the integration treatment using a continuous variable defined as the value of trade normalized by revenue. Second, following the threshold used by Pavcnik (2002), we set a minimum threshold of 15% for the share of trade normalized to revenues. In this way, a fully integrated firms is one which value of exports plus imports over sales is above 15%, an importer only is a firm which only imports intermediate inputs and for a value that is above 15% its sales, and exporter only is a firm which only exports and does not use imported intermediate inputs with its exports being at least 15% of its total sales.

9. Note that this is not entirely correct. In fact, for nonintegrated firms to be completely isolated from direct linkages with foreign markets they would have to be part of a sector that does not suffer from import-competition and at the same time is not receiving FDI. Even using detailed data such as EIA, it is impossible to define if and to what degree a firm is in an "import-competing" sector. Hence the import competition channel will have an effect on integrated and nonintegrated firms according to our definition. Nonetheless, *a-priori*, trade reform will have a smaller impact on nonintegrated firms *relatively* to integrated firms.

10. No particular reason is behind our decision to use 1997 to show the percentages of plants under the different integration status. None of the messages based on Figure 3 would change if another year were chosen.

11. Micro firms are defined as plants with less than 16 employees, small plants have between 16 and 100 employees, medium are those firms with more than 100 but less than 250 employees, while large have more than 250 employees.

12. Given that the peso crisis took place on December 20, 1994, the effect of the devaluation is not captured by the data from year 1994.

13. Yet another way of interpreting the increase in small integrated firms during 1993–94 is by assuming that larger firms had a better chance of anticipating NAFTA, therefore integrating before the agreement was enacted.

14. These were centered around the GATT accession in 1986.

15. First, in November 1987, the United States and Mexico entered into a bilateral understanding on trade and investment called the *Framework of Principles and Procedures for Consultation Regarding Trade and Investment Relations*, second in October 1989, the two countries entered into a second trade and investment understanding called *The Understanding Regarding Trade and Investment Facilitation Talk*. Third, in 1989 and 1995 and the restrictive Mexican Law of Foreign Investment was substantially relaxed.

16. In this sense our results represent a lower bound of the liberalization reforms.

17. During direct interviews conducted with entrepreneurs, academics and policy-makers in Mexico, the argument that NAFTA's changes were much larger than those that could be measured by the change in tariffs came out as a consensus.

18. An argument supporting the tariff-reduction approach would state that a small tariff change that is perceived as permanent can have a larger impact than a larger change that is perceived as unstable. The "bilateral nature" of NAFTA made the tariff change much more credible than the unilateral tariff liberalization that took place during the second half of the 1980 s. Furthermore, NAFTA is considered by some scholars "as a way of locking in previous policy reforms" (Tomz, 1997; Whalley, 1993). Therefore, one can argue that the reduction in trade barriers could serve as a proxy for the legal and institutional change. Nevertheless, the nature of the exact relationship between changes in tariffs and changes in institutions is not clearly defined.

19. We evaluated the correlation between the definition used by Pavcnik (2002) and our definition and found out this is only about .30.

20. In our empirical analysis we focus on labor productivity because of two main reasons. First, conditional on capital per worker, we consider this a very good proxy of overall productivity which is at the same time simple, transparent to calculate and relevant to policy makers. Second, the in a context where our plants are multi-product and multi-inputs, it is very difficult to correctly estimate TFP even using sophisticated approaches such as in Olley and Pakes (1996). However, for robustness check, we have also estimated a similar model using as outcome variable a TFP index, not estimated but calculated as in Aw, Chen, and Roberts (2001) and Caves, Christensen, and Diewert (1982), and our main results, available upon request, are qualitatively robust.

21. Formally, as explained by Blundell and Costa Dias (2000), if the macro trends captured by the year dummy impacts asymmetrically "treated" and "nontreated" firms our estimated difference-in-difference coefficients, $\hat{\delta}^{Int}_{DID}$, recovers not only the effect of the treatment on integrated firms but also the differential effect of the macro-trend across the two groups. If we define this differential effect of the macro trend as $(k^{\text{int}} - k^{\text{Nint}})$ our estimates may be biased in the following way:

$$\hat{\delta}^{Int}_{DID} = \delta^{Int}_{Treatment} + \underbrace{(k^{\text{int}} - k^{\text{Nint}})(Time_{after} - Time_{before})}_{Bias}$$

22. The control variables included in the regression area displayed in Table 7.

23. These results are reported in Table 7 in online Appendix B.

24. The coefficients are taken from the full model, that is, those reported in column (4) of Table 2.

25. In Table 6 of online Appendix B we report the formal tests that the estimates of beta coefficients are statistically different. We confirm that the betas of "fully integrated firms" are nearly always statistically different from those of "exporters only", 80% of the time at the 5% significance level, while not always larger than "importers only", just 20% of the time at the 5% significance level.

26. Notice that eliminating the "switchers in this way reduces the sample from 34,634 observations to little more than 14,840.

27. Notice that under specification (3) the reduction in the number of observations included in the estimation is not as acute as in specification (1) since some of the switchers are identified as such for only a fraction of the time period under analysis.

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APPENDIX A. TABLES AND FIGURES

Tables 1–5 and Figures 1–5.

APPENDIX B. SUPPLEMENTARY DATA: ADDITIONAL ROBUSTNESS TABLES

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.worlddev.2012.09.008.