ERNESTO LÓPEZ-CÓRDOVA

NAFTA and Manufacturing Productivity in Mexico

Mexico's negotiation and implementation of the North American Free Trade Agreement (NAFTA) represent a watershed in the country's economic history. The agreement will eventually open up most sectors of the Mexican economy to its largest trading partner, the United States, thereby buttressing the liberalization reforms implemented since the mid-1980s. The implications for the country's welfare are hard to understate. Until very recently, however, there has been little hard evidence on how the agreement has affected the Mexican economy.

This paper contributes to a better understanding of NAFTA's economic implications for Mexico by studying the degree to which the agreement has affected total factor productivity in the manufacturing sector. Economists view productivity as the main engine for economic growth. As in most of Latin America, Mexico's overall total factor productivity performance from the early 1980s through the mid-1990s was rather disappointing, with average annual growth between –1 and –2 percent.[1] An understanding of the factors that hamper productivity in Mexico is crucial for the design of appropriate economic policies conducive to higher living standards.

The experience under NAFTA is interesting in itself. First, the Mexican case is particularly relevant for countries participating in the ongoing

López-Córdova is with the Inter-American Development Bank.

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1. World Bank (2000).

negotiation of the Free Trade Agreement of the Americas (FTAA) or other regional trading arrangements (for example, between the United States and Chile or the United States and Central America). Some of the findings in this paper may offer important insights to the rest of the hemisphere. Second, while there have been several contemporaneous events that may confound studies on NAFTA (such as the devaluation of 1994), the agreement allows researchers to disentangle the different forces that have shaped the Mexican economy in recent years. For example, the present study exploits the fact that the tariff elimination calendar in NAFTA was put in place in 1992 to correct for the potential endogeneity of actual tariff levels.

In the paper I measure total factor productivity (TFP) using a panel of manufacturing plants spanning the 1993–2000 period. I apply an algorithm proposed by Olley and Pakes to address the possibility of sample selection and simultaneity problems in estimating a production function using panel data.[2] With the TFP estimates in hand, I assess the impact that the dismantling of protectionist barriers and the rise in foreign manufacturing operations in Mexico have had on plant performance. I also look at the role of the reallocation of resources in explaining productivity improvements.

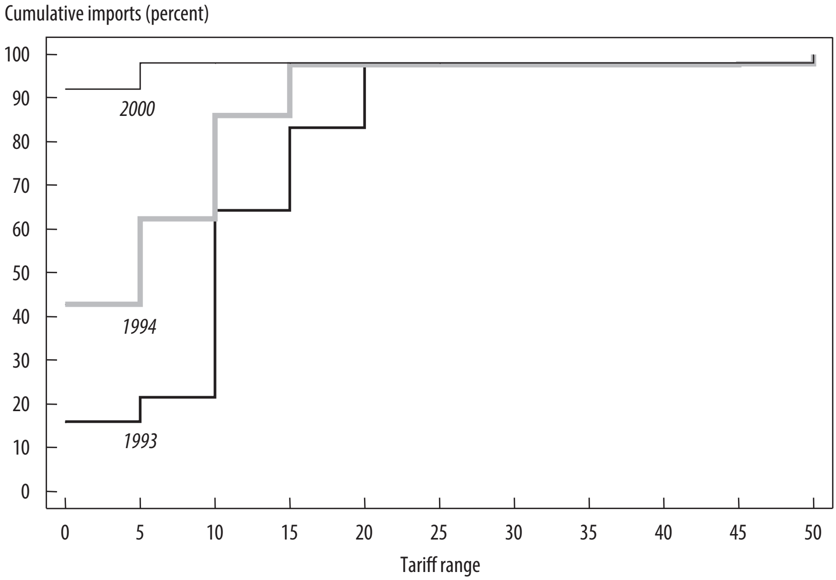
The paper is organized as follows. The next section provides background on the liberalization strategy followed by Mexico since the mid-1980s. It shows the substantial reorientation of the Mexican economy to the global and North American markets. The subsequent section reviews the theoretical and empirical literature on the relationship between openness and productivity. The paper then describes the methodology used in measuring total factor productivity in Mexican manufacturing and discusses the behavior of aggregate productivity. The following section explores NAFTA's impact on productivity at the plant level based on an econometric exercise that isolates the plant-specific, industry-wide, and macroeconomic forces that influence manufacturing efficiency. The paper concludes with final remarks.

Trade and Investment Liberalization in Mexico

Trade liberalization in Mexico began with the gradual elimination of import and export licenses and a simplification of tariffs between January 1983 and July 1985. During this period, the fraction of imports subject to

2. Olley and Pakes (1996).

FIGURE 1. Mexican Tariffs on U.S. Manufacturing Goods, by Tariff Range

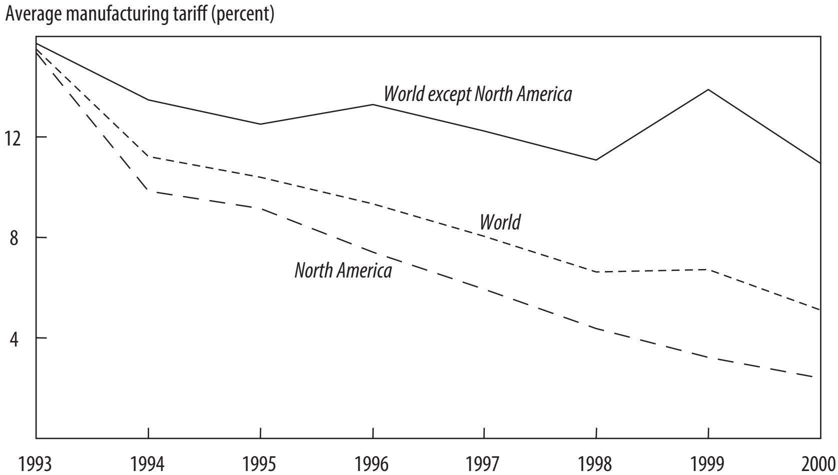


licensing requirements fell from 100 percent to 36 percent. After joining the General Agreement on Tariffs and Trade (GATT) in 1986, Mexico agreed to bind tariffs at a 50 percent level, to eliminate reference prices, and to continue eliminating import licenses. In December 1987 Mexico consolidated tariffs on industrial imports to five levels: 0, 5, 10, 15, and 20 percent ad valorem. Only 192 tariff-lines were subject to licensing requirements by 1993, and the average ad valorem tariff was 11.4 percent.[3]

NAFTA consolidated the liberalization of the Mexican economy and opened up the Canadian and U.S. markets to Mexican producers. In the agreement, the three countries agree to liberalize trade on most products by 2008. Regarding manufacturing trade, Mexican import duties on North American products experienced a rapid decline since 1994, the year in which the agreement came in effect. As figure 1 illustrates, in 1993 only around 10 percent of all Mexican manufacturing imports from the United States paid duties smaller than 5 percent ad valorem and 15 percent of imports paid duties less than 10 percent. In 1994 NAFTA's first tariff cut

3. López-Córdova (2001); Ten Kate (1992).

FIGURE 2. Mexican Tariffs on Manufacturing Imports, by Region of Origin, 1993 to 2000



increased the fraction of imports in these tariff categories to 40 percent and 60 percent, respectively. By 2000, around 93 percent of all manufacturing imports paid duties under 5 percent, and less than 1 percent of imports faced duties 10 percent or higher.

The elimination of tariffs on Canadian and U.S. goods explains most of the downward trend in average manufacturing tariffs on world imports depicted in figure 2, since North American goods represent the bulk of all Mexican imports. Mexican tariffs on the rest of the world have also fallen since 1993, albeit more moderately, thanks in part to the subscription of other preferential trading arrangements such as the free trade agreement with the European Union.[4] Despite these reductions, most-favored-nation tariffs have actually increased in a number of industries (such as apparel), although the number of affected trading partners has fallen.

4. To date Mexico has subscribed to eleven free trade agreements with thirty-two countries. In addition to Canada and the United States, trading partners include Bolivia, Chile, Colombia, Costa Rica, Honduras, El Salvador, Nicaragua, and Venezuela; the members of the European Union and of the European Free Trade Area (Iceland, Liechtenstein, Norway, and Switzerland); and Israel. Mexico is also currently engaged in trade talks with Ecuador, Japan, Panama, Peru, Singapore, the members of the Southern Common Market (MERCOSUR—namely, Argentina, Brazil, Paraguay, and Uruguay), and some countries in Central Europe.

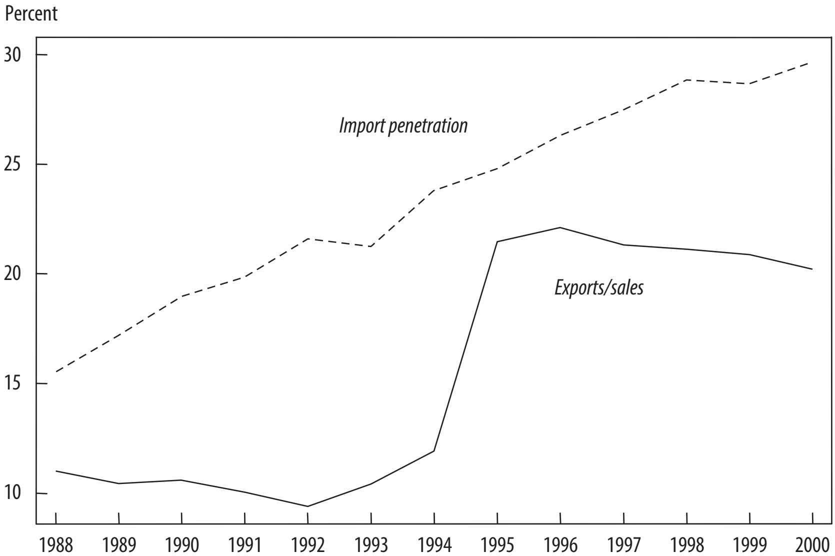
The immediate result of the rapid dismantling of trade barriers has been a remarkable increase in Mexico's world trade. Total imports and exports increased more than fourfold from 1990 to 2000, reaching 174 billion and 166 billion, respectively. While the share of imports coming from North America remained constant at around 75 percent, Mexico's exports to the region went from 80 to 91 percent of all exports. As a result, Mexican manufacturing producers now face fiercer competition in their home market and send a greater fraction of their output overseas (see figure 3). Import penetration—that is, imports as a share of apparent consumption—rose from 19 to 30 percent in the 1990–2000 period for the sector as a whole. While import penetration levels vary widely across manufacturing industries, an upward trend is observed across the board. The exposure to foreign competition has increased dramatically in some industries: import penetration jumped from 9 to 20 percent in the textile and apparel industry, for example, which has traditionally been protected in Mexico. Similarly, the share of manufacturing output being exported rose from 11 to 20 percent over the same period, with exports in the metal goods, machinery and equipment industry reaching 32 percent.

Trade liberalization, and NAFTA in particular, have solidified the orientation of the Mexican economy toward the North American market.[5] Mexico-U.S. trade integration, defined here as the ratio of bilateral trade to the sum of each country's total trade, has more than doubled since the mid-1980s, and it stood at over 10 percent in 2000. Such behavior contrasts with the steady decline in U.S.-Mexico trade integration from 1950 to the mid-1970s.

Just as Mexico became more open to trade flows, the country revamped its legal framework regulating foreign investment. Previous legislation, enshrined in the 1973 Law to Promote Mexican Investment and Regulate Foreign Investment, granted discretionary powers to the Mexican government to limit foreign ownership to no more than 49 percent of a firm's equity. It further reserved some industries to ownership by the state or Mexican nationals (including petrochemicals and mining) and imposed performance requirements on foreign producers located in the country.

5. There is some disagreement as to whether NAFTA does, in fact, explain the growth in U.S.-Mexico trade in the second half of the 1990s. Alternative explanations are the booming U.S. economy of the period and the initial trade liberalization of the Mexican economy in the mid-1980s. For views on this issue, see CBO (2003); Garcés-Díaz (2001); Gould (1998); and Romalis (2002).

FIGURE 3. Manufacturing Import Penetration and Export Ratios, 1988 to 2000

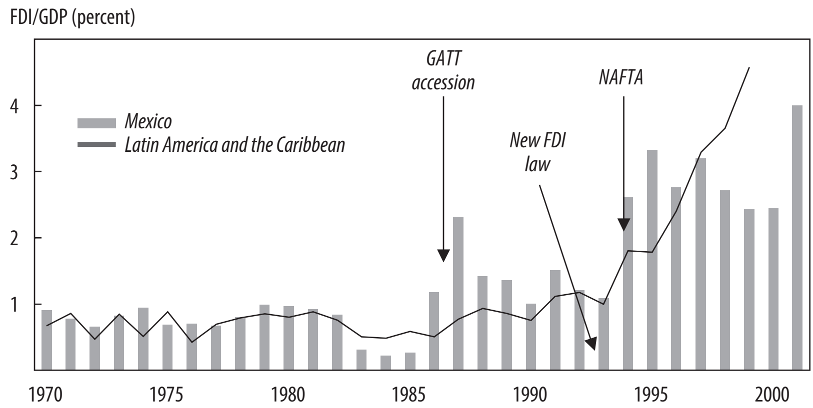


In the second half of the 1980s, Mexico's initial trade liberalization led to the introduction of reforms allowing foreigners 100 percent participation in certain previously restricted industries (namely, glass and iron) and facilitating in-bond assembly, or *maquiladora*, operations. The new foreign investment law introduced in 1993 eliminated most restrictions on foreign direct investment (FDI). This legislation was intimately related to the disciplines negotiated by Mexico under NAFTA. The agreement guaranteed national treatment to foreign investors, eliminated performance requirements and controls, and established a dispute settlement mechanism.[6]

These reforms substantially opened the Mexican manufacturing sector and the economy as a whole to foreign investors. Foreign direct investment flows thus mirrored changes in the restrictiveness of Mexican legislation and the overall trade regime (see figure 4). Whereas FDI as a percent of gross domestic product (GDP) remained below one percent over the

6. For a discussion of Mexico's FDI regime, see Dussel Peters (2000); Dussel Peters, Galindo Paliza, and Loria Díaz (2003); and García Fernández (2001).

FIGURE 4. FDI Flows, 1970 to 2001



1970–85 period, it rose to between one and two percent from 1986 to 1993, and it has remained above two percent since 1994. This performance was not exclusive of Mexico, however: Latin America as a whole has seen a similarly heightened importance of FDI, suggesting that several factors in addition to NAFTA and a more liberal FDI legislation might help explain capital flows to Mexico.

Despite such regional evidence, economic integration with the North American economy has been a major factor explaining capital flows to Mexico.[7] FDI inflows from the United States amounted to U.S.$18.4 billion (in 1995 prices) from 1994 to 2000, of which U.S.$10.3 billion went to the manufacturing sector. FDI flows in Mexican manufacturing increased from 6.4 to 7.2 percent of U.S. manufacturing investment overseas. Moreover, Mexico's share in U.S. total assets overseas rose from 2.16 in 1989 to 2.77 in 1993 and 2.85 in 2000, whereas in manufacturing the corresponding figures are 4.33, 4.80 and 5.92.[8]

7. As in the case of trade flows, authors disagree about NAFTA's impact on FDI. Levy Yeyati, Daude, and Stein (2002) show that preferential trading arrangements positively affect bilateral capital flows across countries. In the case of NAFTA, Cuevas, Messmacher, and Werner (2002) suggest that NAFTA might have increased FDI in Mexico by as much as 70 percent; they further add that the inability to continue with the structural reform process probably held back that figure.

8. Figures are based on information from the Bureau of Economic Analysis.

Trade, FDI, and Productivity: Existing Literature

Given the substantial liberalization of trade and investment flows in the 1990s, which was largely driven by the implementation of NAFTA and Mexico's integration with the North American economy, the question arises as to how the manufacturing sector has performed under the new policy environment. Before addressing this issue, I want to briefly outline the works that serve as the basis of my argument. This section thus surveys the existing theoretical and empirical literature linking trade and investment to productivity.

Theoretical Predictions

The theoretical literature predicts that trade policy may have an impact on manufacturing productivity through different channels.[9] First, there may be an import discipline effect as trade liberalization exposes domestic producers to greater competitive pressures. Second, producers may have improved access to state-of-the-art machinery and intermediate goods, which allows them to reach higher efficiency levels. Third, plant turnover may increase, with less productive plants exiting the market, which would raise average productivity in the sector.

The import discipline effect, "the oldest insight in this [trade policy] area," influences productivity in at least three ways: by reducing the slack in firm management (so-called *X*-efficiency); by forcing firms to increase their output and thus improve their scale efficiency; and by increasing firms' incentive to innovate.[10] The gains accruing from better firm management are quite intuitive, but economists have problems putting a solid theory behind it since it goes against one of the main pillars of modern microeconomic theory: the assumption that firms maximize profits. The scale efficiency gain is basically the result of competition, which prevents firms from restricting output and raising prices. Lower prices are followed by higher output and, in turn, lower average costs. This result depends heavily on the assumption that firms easily enter and exit markets.[11] Finally,

9. The following discussion relies on Tybout (2000, 2001) and López-Córdova and Moreira (2003).

10. Helpman and Krugman (1989).

11. See Tybout (2001).

the argument about the incentives to innovate, which is key in linking trade to long-term productivity growth, is also quite intuitive, but its theoretical foundations are somewhat shaky. Rodrik and Goh, for instance, both model the impact of protection on innovation and reach totally different results.[12] The former argues that trade might reduce the firms' incentive to innovate if imports reduce their market shares, whereas the latter says that protection reduces innovation because it raises the opportunity cost of technological effort.

Trade liberalization may also expand the menu of intermediate inputs and capital available to firms and facilitate access to world-class technologies. That is, technology transfer may increase with the removal of trade barriers.

Trade may affect productivity at the aggregate level by inducing higher plant turnover. The argument is that "trade can promote industry productivity growth without necessarily affecting intrafirm efficiency."[13] The simultaneous expansion of imports and exports would force the least efficient firm to contract or exit and the most efficient to expand. This share effect is basically a one-time gain.

With regard to FDI, foreign capital participation may affect productivity through the increased presence of world-class competitors that raise average productivity in the industry. As in the case of trade, FDI is expected to improve firm management, raise scale efficiency, and provide more incentives to innovate. Nonetheless, the entry of large multinational firms in limited domestic markets raises the possibility of collusion and makes the results difficult to pin down.

Knowledge spillovers and linkage effects are the most likely channels to have long-term implications for productivity growth, since they improve the firms' ability to innovate. FDI knowledge spillovers are said to take place when local firms increase their productivity by copying the technology of affiliates of foreign firms. Although widely believed to be an important source of technology diffusion, particularly for developing countries, this mechanism has its limitations. First, there is the issue of the absorptive capacity: spillovers from FDI are unlikely to occur in the absence of a qualified work force or investments in R&D. Second, given the foreign

12. Rodrik (1992); Goh (2000).
13. Melitz (2002).

firms' strong interest in protecting their competitive edge and, therefore, in minimizing technology transfer, spillovers are more likely to be vertical (among foreign firms' clients and suppliers) than horizontal (among their competitors).[14]

The rationale behind the linkage effects is similar to the input availability channel in the new growth theories. FDI is believed to generate positive pecuniary externalities to local firms by improving the quality and variety of the local supply of intermediate goods.[15] This could happen both directly, through investment in these industries, and indirectly, through investment in final (consumer) goods, which could create enough demand and technology spillovers for the establishment of intermediate industries.

Empirical Studies

Most empirical studies concentrate on the trade channel and, more specifically, on the import discipline, scale, and turnover hypotheses. Several authors find evidence of a strong import discipline effect, including Pavcnik for Chile (1979–86), Fernandes for Colombia (1977–91), Tybout and Westbrook for Mexico (1986–90), and Muendler for Brazil (1986–98).[16] There is little evidence of important turnover or scale-related gains, although Pavcnik's estimates suggest that import discipline would have been dwarfed by the turnover effect and Muendler finds that the elimination of trade barriers increases the likelihood that low-efficiency firms will shut down, which in the long run would have a positive impact on aggregate productivity.[17]

Evidence on the other trade effects, particularly those that are believed to affect not only the level but also the rate of productivity growth, is more limited. On the availability of world-class inputs and related technology acquisition effects, Muendler's work on Brazil finds a positive but relatively

14. Kugler (2000).
15. See, for example, Markusen and Venables (1999).
16. Pavcnik (2002); Fernandes (2001); Tybout and Westbrook (1995); Muendler (2002).
17. Pavcnik (2002); Muendler (2002).

unimportant impact on productivity.[18] Alvarez and Robertson, however, who work with plant-level data from Chile and Mexico, detect a significant and positive relationship between importing intermediate inputs and innovation in the latter country.[19]

Evidence based on country- and sectoral-level data also points to a positive input effect. For instance, Blyde finds that technological spillovers diffused through imported machinery have a positive impact on productivity, and Schiff, Wan, and Olarreaga uncover north-south and south-south technological spillovers, diffused through imports.[20] North-south spillovers are higher and affect mainly R&D–intensive industries, whereas south-south spillovers are relevant mostly for other types of industries.

The acquisition of knowledge through exports is also the subject of a few studies, but the evidence is mixed. Clerides, Lach, and Tybout find no evidence of learning-by-exporting processes at the plant level using data for Colombia (1981–91) and Mexico (1984–90).[21] The Alvarez and Robertson results cited above, however, point to a strong link between exporting and investment in innovation in both Mexico (1993–95) and Chile (1993–95). The World Bank similarly finds suggestive signs of learning-by-exporting processes based on plant-level data for Mexico (1990–98).[22]

Finally, the scarce evidence on the FDI channel tends to support the prevalence of vertical (interindustry) over horizontal (intraindustry) spillovers and to highlight the importance of the countries' absorptive capacity. For instance, Aitken and Harrison find that foreign equity participation raises plant productivity in Venezuela (1976–89), while horizontal spillover are negative.[23] Likewise, Kugler reports limited horizontal spillovers for Colombian manufacturing plants in 1974–98, but finds evidence of "widespread interindustry spillovers from FDI."[24]

18. Muendler (2002).

19. Roberto Alvarez, and Raymond Robertson, "Exposure to Foreign Markets and Firm-Level Innovation: Evidence from Chile and Mexico" (www.macalester.edu/~ robertson/ [25 March 2002]).

20. Blyde (2002); Schiff, Wan, and Olarreaga (2002).

21. Clerides, Lach, and Tybout (1998).

22. World Bank (2000).

23. Aitken and Harrison (1999).

24. Kugler (2000).

Total Factor Productivity in Mexico

This section estimates total factor productivity at the plant level using microeconomic data covering the 1993–2000 period. Traditional approaches that use ordinary least squares (OLS) estimation on panel data suffer from simultaneity and selectivity problems. To avoid such shortcomings, the results presented herein rely on a methodology proposed by Olley and Pakes; the details appear in an earlier paper.[25]

Empirical Strategy

Output is produced in each plant, i, in a given industry during year, t, according to a Cobb-Douglas production function (all variables ar, expressed in natural logarithms):

$$y_{it} = \beta_0 + \beta_u l_{it}^u + \beta_s l_{it}^s + \beta_m m_{it} + \beta_k k_{it} + p_{it} + \varepsilon_{it}, \quad (1)$$

where y_{it} is output; l_{it}^u and l_{it}^s represent unskilled- and skilled-labor work hours, respectively; m_{it} is total material inputs; k_{it} represents capital inputs; p_{it} is total factor productivity; and ε_{it} is an error term. Both p_{it} and ε_{it} are unobservable to researchers.

There are two problems in estimating equation 1 using plant-level data. First, attrition in the plants included in manufacturing surveys typically results in a sample selection bias. The reason is that less productive plants are more likely to exit the sample, leaving only the most productive plants in the estimation sample and resulting in biased productivity estimates. Second, even though productivity, p_{it}, is unobserved by researchers, plant managers might observe p_{it} or make inferences about the plant's productivity level, and they then choose their inputs based on the inferred productivity level. This creates a simultaneity problem that biases the coefficient estimates in equation 1.

Olley and Pakes propose an estimation procedure that addresses both issues.[26] They present a model in which plants choose whether to exit the market after observing a productivity shock. If a plant decides to continue in the market, it then chooses next year's capital stock through investment

25. Olley and Pakes (1996); López-Córdova (2003).
26. Olley and Pakes (1996).

and other inputs, considering the plant's productivity level. Productivity is a function of the plant's age and capital stock and, therefore, of investment. Information on a plant's investment decisions thus serves as a control for the impact of the unobserved productivity shock on the choice of inputs.[27]

In an earlier work, I apply the Olley-Pakes algorithm to a panel of Mexican manufacturing plants in the period 1993–2000.[28] The panel starts with 6,800 plants, although plant exit and data problems limit the sample used in this study to around 5,700 plants. The data come from the Annual Industrial Survey (EIA) carried out by Mexico's National Institute of Statistics, Geography, and Information (INEGI). The survey contains information on employment, input use, shipments, production, and investment at the plant level. These data were complemented with information from various other INEGI sources.[29]

The analysis further relies on a database of several economic integration indicators in North America from official sources. The database contains import and export figures by trading partner in Mexico and the United States, as well as both preferential (that is, NAFTA) and most-favored-nation import duties and FDI flows. The database covers, but is not limited to, the period of analysis. It has a high degree of industry disaggregation, which allows me to consider variation in the NAFTA trade liberalization commitments as a means of studying the agreement's implications.

Total Factor Productivity Estimates

Table 1 shows the Olley-Pakes estimates of the production function parameters in equation 1. The algorithm was applied to nine different manufacturing industries. With these estimates, TFP (in logs) is defined as the residual,

$$\hat{p}_{it} = y_{it} - \hat{\beta}_u l_{it}^u - \hat{\beta}_s l_{it}^s - \hat{\beta}_m m_{it} - \hat{\beta}_k k_{it},$$

where a hat designates a coefficient's estimated value.

27. The Olley-Pakes algorithm imposes stringent requirements on the data—for example, by requiring that investment is strictly positive. Levinsohn and Petril (2000) propose an alternative methodology that relies on intermediate input usage, instead of investment, as a means of correcting the simultaneity problem.

28. López-Córdova (2003).

29. INEGI has strict confidentiality standards that made it necessary to work at its headquarters in Mexico and obtain special permission for performing the econometric exercises used in this paper. See López-Córdova (2003) for more detail on the data.

TABLE 1. Production Function Estimation Results[a]

	Manufacturing division								
Variable	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*
Unskilled labor	0.093	0.246	0.060	0.140	0.054	0.102	0.126	0.101	0.090
	(0.008)***	(0.009)***	(0.033)*	(0.016)***	(0.010)***	(0.018)***	(0.040)***	(0.009)***	(0.032)***
Skilled labor	0.061	0.094	0.162	0.088	0.151	0.136	0.066	0.123	0.159
	(0.007)***	(0.008)***	(0.022)***	(0.010)***	(0.010)***	(0.015)***	(0.014)***	(0.007)***	(0.028)***
Materials	0.826	0.652	0.747	0.732	0.763	0.781	0.809	0.777	0.724
	(0.008)***	(0.010)***	(0.024)***	(0.014)***	(0.011)***	(0.015)***	(0.035)***	(0.007)***	(0.024)***
Capital	0.049	0.077	0.059	0.072	0.084	0.013	0.027	0.041	0.007
	(0.004)***	(0.006)***	(0.005)***	(0.006)***	(0.004)***	(0.005)***	(0.008)***	(0.005)***	(0.003)**
No. observations	4,639	4,052	780	1,362	4,720	1,325	497	5,603	57

* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level; *** statistically significant at the 1 percent level.

a. Bootstrapped standard errors are in parentheses.

From 1993 to 2000, annual average plant productivity in Mexican manufacturing grew at a rate of 1.2 percent. Manufacturing industries exhibited wide differences in productivity performance, as shown in figure 5. Whereas plant TFP in the apparel industry fell by 4.3 percent per year, it rose in the machinery and equipment, computing equipment, and precision instruments industries at yearly rates of 5.0, 7.3, and 5.5 percent, respectively.

Although such changes coincided with NAFTA's first eight years, the above figures do not establish a causal relationship between the agreement and productivity performance. Indeed, distinguishing between NAFTA's contribution to productivity performance proves rather challenging, since a number of events affected Mexico's economy during the same period—from the devaluation of the peso in December 1994 and the ensuing banking crisis in Mexico, to rapid U.S. productivity growth and the Asian financial crisis in the second half of the decade. Figure 6 shows that productivity performance varied significantly across industries according to their degree of technological sophistication or skill intensity; it also varied across plants according to their size or geographical location.[30]

The evidence strongly suggests, however, that the greater integration of the Mexican economy to North America and the world economy at large had a substantial impact on productivity performance. Figure 7 classifies Mexican manufacturing industries as traded or nontraded, with the former category encompassing industries in which either import penetration or the ratio of exports to output are in the top quartile of all industries, while the latter covers all remaining industries. It further identifies traded and nontraded industries oriented specifically to the North American market. Plant productivity in traded industries grew, on average, at an annual rate of 2.0 percent, or 1.7 percent if one considers only those industries with strong trade links with North America. In stark contrast, plant productivity stagnated in nontraded industries, which have few trade links with North American or world markets.

Figure 7 also illustrates other plant characteristics that reflect close links to the world economy. Exporters outperformed nonexporters, and

30. Technological sophistication is defined following the OECD (2001) classification.

FIGURE 5. Average Plant TFP Growth, 1993 to 2000

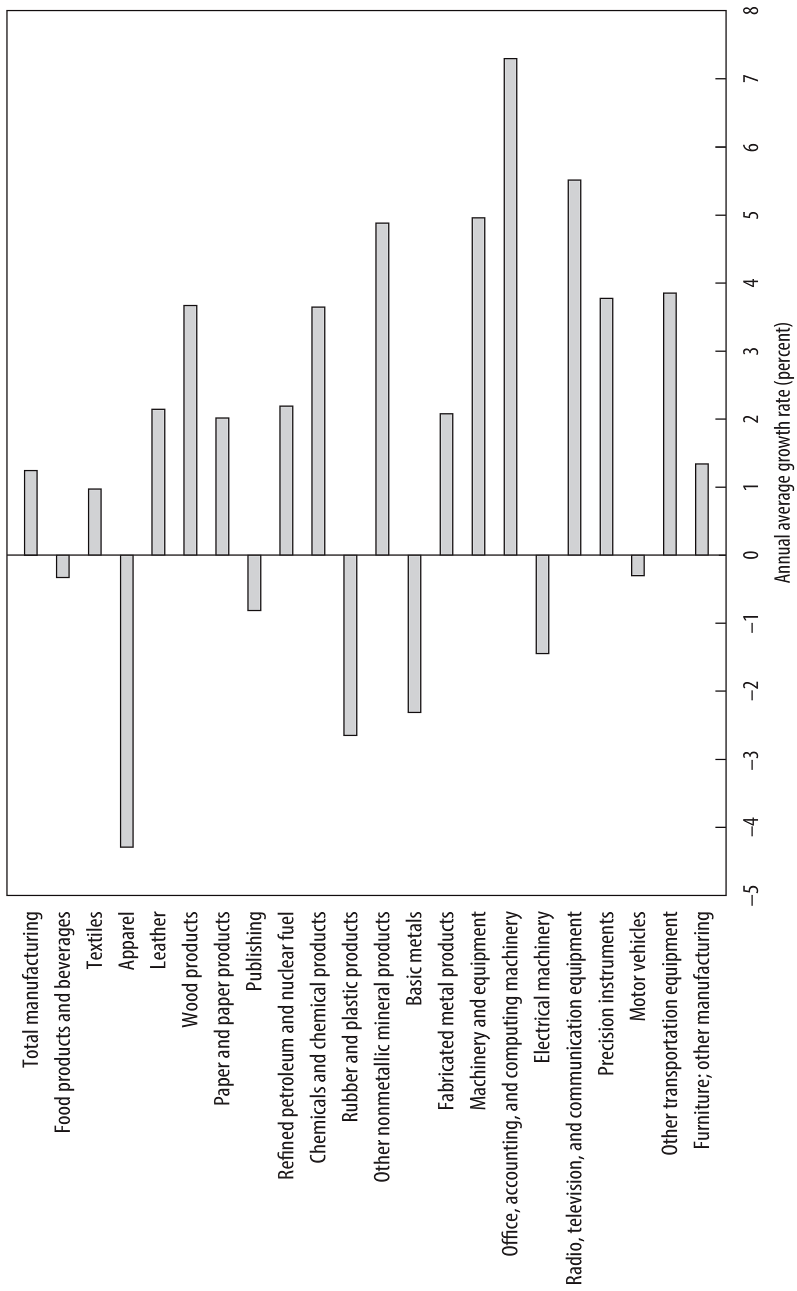
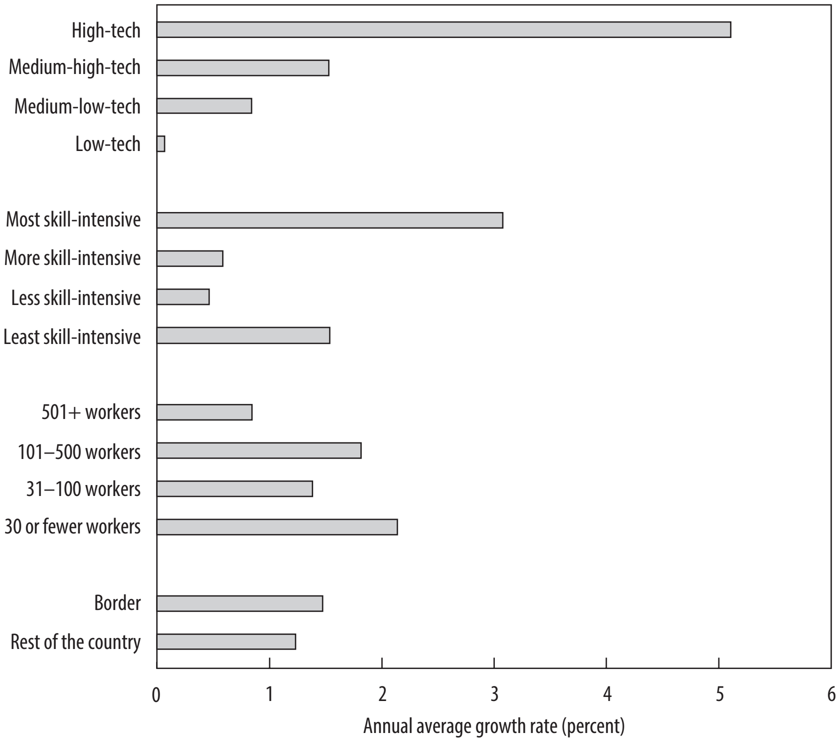


FIGURE 6. Average Plant TFP Growth, by Industry or Plant Characteristics, 1993 to 2000



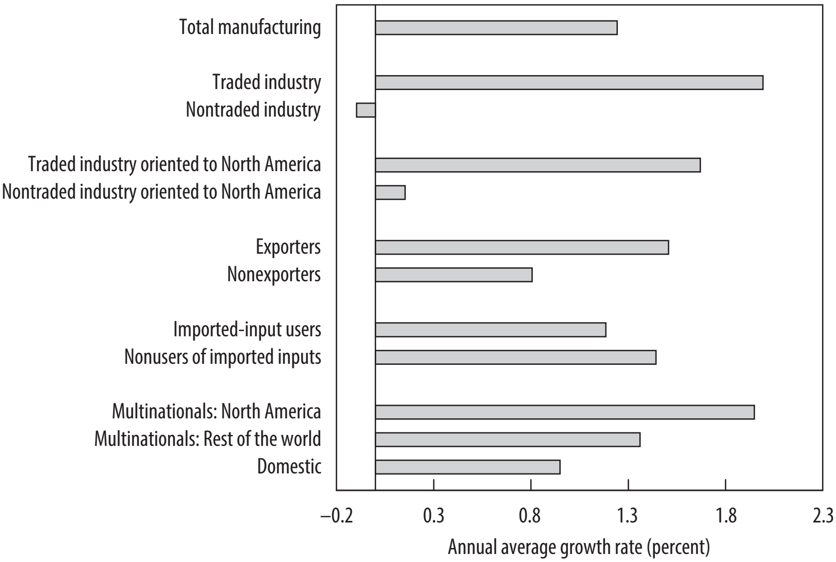
multinational corporations did better than domestic firms.[31] In this last regard, U.S.- or Canadian-owned foreign plants grew faster than other multinational corporations. Last, users of imported inputs did not grow faster than plants that relied exclusively on domestic materials. Later in the paper, I consider whether this initial evidence holds under a more careful econometric specification.

Intrafirm Gains versus Reallocation Gains

Before proceeding to the econometric analysis of the determinants of plant productivity, I need to distinguish between TFP changes that take place

31. I define foreign plants (that is, multinational corporations) as those in which foreign capital accounts for more than 50 percent of equity.

FIGURE 7. Average Plant TFP Growth, by Industry or Firm Characteristics, 1993–2000



within the manufacturing establishment and those that occur as resources are reallocated from less productive to more productive plants and industries. The following discussion extends the productivity decomposition methodology proposed by Griliches and Regev.[32] Specifically, letting

$$P_t^j = \sum\nolimits_{i \in j} s_{it}^j P_{it}^j$$

represent the aggregate TFP (in levels) in industry j and year t, manufacturing sector-wide productivity is

$$P_t = \sum\nolimits_j s_t^j P_t^j ,$$

where s_{it}^j represents firm i's share of industry j's output and s_t^j represents industry j's share of total manufacturing output. Productivity growth in the manufacturing sector is then given by the expression

$$(2) \qquad \Delta P_t = \underbrace{\sum\nolimits_j \bar{s}_t^j \left(\sum\nolimits_{i \in j} \bar{s}_{it}^j \Delta P_{it}^j \right)}_{\text{Within-firm TFP gains}} + \underbrace{\sum\nolimits_j \bar{s}_t^j \left(\sum\nolimits_{i \in j} \bar{P}_{it}^j \Delta s_{it}^j \right)}_{\text{Within-industry reallocation}} + \underbrace{\sum\nolimits_j \bar{P}_t^j \Delta s_t^j}_{\text{Reallocation across industries}} .$$

32. Griliches and Regev (1995).

The first right-hand-side term reflects the contribution to TFP growth of within-firm efficiency improvements, whereas the second and third terms reflect the contribution of resource reallocation from less productive to more productive firms within or across industries, respectively. A bar over a variable indicates the average over t and $t + 1$ for a given variable. The decomposition exercise follows Bernard and Jensen in classifying firms according to alternative industry typologies.[33]

An additional comment is in order before I present the decomposition results. As table 1 reflects, the paper estimates different production functions for nine two-digit manufacturing industries, which precludes aggregating TFP estimates across all manufacturing plants. To get around this constraint and implement the above decomposition, I normalize plant-level TFP estimates by subtracting the productivity of a representative plant within the two-digit industry.[34] The representative plant is defined as using inputs and producing output equivalent to the industry average in 1993, the initial year in the sample. While this normalization allows me to aggregate across industries in equation 2, one drawback is that the implicit TFP gains are not strictly comparable to the results reported previously.

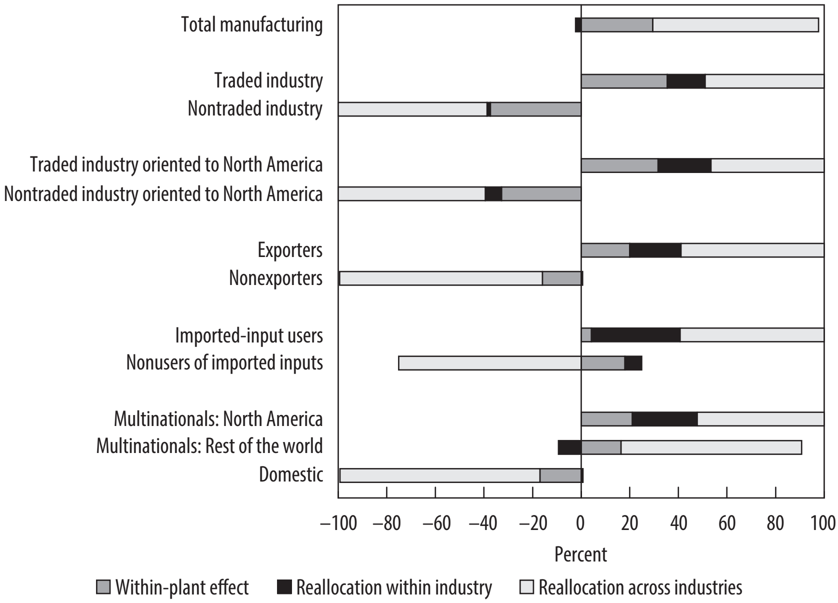
I now summarize the results, which are depicted graphically in figure 8. For the manufacturing sector in the aggregate, reallocation accounted for more than 70 percent of productivity growth during the 1993–2000 period. The bulk of the reallocation gains are explained by output share increases in the more productive industries; reallocation within industries has a negligible negative impact. Firm level productivity gains account for the remaining 30 percent of efficiency gains. Thus, my first result is that resource reallocation has been the main driver of productivity growth in the manufacturing sector.

To analyze the role played by economic integration, I apply the industry classification by trade orientation, as in figure 7. The picture that emerges is that greater exposure to world markets, either through exports or competition from imports, enhances efficiency. Industries with strong global trade links increased their share of manufacturing output and were responsible for all reallocation gains. Remarkably, all plant-level productivity gains occurred in traded industries, as productivity among firms in nontraded industries actually declined. This leads to my second result: industries with

33. Bernard and Jensen (2001).

34. Aw, Chen, and Roberts (2001) and Pavcnik (2002) use a similar normalization.

FIGURE 8. Productivity Decomposition, 1993 to 2000



strong trade links account for almost all productivity growth. Given the preponderance of North American trade for Mexico, the second result holds when industries are classified by whether they trade heavily in the region.

The exposure of individual plants to the international market varies, depending on whether they are exporters, are foreign owned, or use imported inputs. My third result therefore addresses productivity among different types of plants. Specifically, exporters and foreign-owned plants outperformed nonexporters and domestically owned plants. In the former, within-plant productivity gains were positive, whereas the latter actually saw productivity decline. The positive reallocation effect further suggests that exporters and foreign-owned plants saw their share of output rise. In contrast, my results do not unambiguously indicate that the use of imported inputs is an important channel through which trade reform affects productivity.

These first three results are in line with other studies that show that plant turnover is an important driver of aggregate productivity performance. Although one cannot attribute the reallocation gains directly to trade based solely on the previous exercise, the results strongly suggest that trade plays an important role in weeding less efficient producers out of the economy and in channeling resources to more efficient producers and industries. Indicators of the extent of linkages with North America do not contradict that conclusion.

NAFTA's Impact on Productivity

To provide more conclusive evidence on whether trade and investment liberalization and, in particular, NAFTA have had a positive impact on TFP performance, this section presents the results of an econometric exercise that isolates the different forces that influence manufacturing efficiency at the plant level. Some factors that affect productivity are specific to the plant, such as its age and size, whereas others reflect industry-wide characteristics and macroeconomic conditions that are external to the plant. The latter include industrial output concentration across either firms or regions, exchange rate fluctuations that affect external supply and demand, and changes in domestic consumption over the business cycle. The econometric exercise accounts for many of these factors. The present discussion focuses on changes in the economic environment stemming directly from NAFTA and from the integration of the Mexican economy with North America and the world at large. The pertinent variables are thus tariff elimination, the increased availability of imported inputs, and spillovers from foreign direct investment.

Empirical Strategy

Plant-level TFP estimates from the previous section are regressed on yearly measures of trade policy affecting Mexican manufacturers, controlling for plant, industry, and geographical characteristics to the extent possible. I consider both Mexican tariffs on world trade and the United States' preferential tariff margin on Mexican goods. Since Mexico's trade with Canada is relatively unimportant compared with its trade with the United States, I assume that U.S. tariff elimination captures NAFTA's potential benefits for Mexican manufacturers from improved market access. The exercise also incorporates information on a plant's exporting activities and imported input use, as well as data on foreign capital participation across manufacturing industries. Descriptive statistics on the variables used in this section appear in table 2.

The basic regression equation takes the following form:

$$\text{(3)} \qquad \text{PRODUCTIVITY}_{ijt} = \mathbf{TRADE}_{ijt}\boldsymbol{\beta}_1 + \mathbf{FDI}_{ijt}\boldsymbol{\beta}_2 + \mathbf{X}_{ijt}\boldsymbol{\Gamma} + \nu_{it}.$$

The analysis considers variants of equation 3 in which the dependent variable is either the level of or the change in log TFP, in order to measure how trade policy affects not only the level of productivity, but also its growth rate. The matrices $\mathbf{TRADE}_{ijt}$ and $\mathbf{FDI}_{ijt}$ include trade and investment variables affecting productivity at time t in any plant i belonging to industry j, and thus vectors $\boldsymbol{\beta}_1$ and $\boldsymbol{\beta}_2$ include the coefficients of interest. The trade variables are the average Mexican tariff on world imports, the preferential margin on Mexican goods exported to the United States vis-à-vis the rest of the world, the ratio of imports to output (in logs), and either the ratio of plant exports to output or dummies for exporters. The investment variables are the share of output produced by foreign-owned firms in industry j, to which plant i belongs and the share of output produced by foreign-owned firms in those industries ($k \neq j$) from (to) which industry j producers purchase (sell) inputs.

Matrix $\mathbf{X}_{ijt}$ captures other relevant plant- and industry-specific factors that affect plant productivity. At the plant level, the matrix includes dummies for plant size. Several plant-specific factors should affect the estimated TFP level, but the dataset at hand offers few plant controls. The OLS estimates may therefore be prone to omitted-variable bias. The immediate response to such a concern is to exploit the panel attributes of the data to control for plant fixed effects. Unfortunately, some plant attri-butes for which time series information is missing in the dataset (for example, foreign ownership) are lost when fixed effects are implemented. At the industry level, I include average capacity utilization, geographic and industrial concentration, an industry-level real exchange rate measure (defined as the product of the nominal peso-dollar exchange rate times the ratio of the industry-level producer price indexes in the United States and Mexico), U.S. consumption, and U.S. labor productivity.[35] I also include industry output excluding the plant's own output, as well as time fixed effects.

35. With regard to the exchange rate measure, producer prices in Mexico are a function of industry-level productivity, so the real exchange rate is probably correlated with the error term in equation 3, which would bias the econometric estimates. To avoid this, I use the product of the nominal exchange rate and U.S. producer prices (the numerator in the

TABLE 2. Descriptive Statistics[a]

Variable	Total 1993–2000	1993	1994	1995	1996	1997	1998	1999	2000
Change in log TFP from t to $t+1$	−0.019 (0.257)	−0.093 (0.355)	0.017 (0.295)	0.011 (0.249)	−0.016 (0.217)	−0.036 (0.177)	−0.014 (0.185)	0.013 (0.177)	— —
Log TFP	1.146 (0.451)	1.227 (0.354)	1.139 (0.427)	1.150 (0.474)	1.161 (0.471)	1.141 (0.460)	1.106 (0.450)	1.091 (0.484)	1.109 (0.497)
Mexican tariff on all imports	11.866 (13.001)	16.863 (14.587)	12.578 (12.107)	12.964 (14.207)	11.649 (13.727)	10.613 (13.252)	9.564 (11.878)	9.729 (10.950)	7.844 (7.677)
Log imports/output	−0.628 (1.242)	−1.157 (1.145)	−0.954 (1.122)	−0.892 (1.204)	−0.656 (1.137)	−0.468 (1.229)	−0.253 (1.229)	−0.124 (1.239)	0.009 (1.172)
Intraindustry FDI	0.151 (0.214)	0.142 (0.203)	0.146 (0.209)	0.153 (0.219)	0.153 (0.218)	0.152 (0.217)	0.156 (0.217)	0.157 (0.219)	0.153 (0.214)
FDI in backward-linked industries	0.192 (0.067)	0.175 (0.065)	0.186 (0.064)	0.195 (0.065)	0.195 (0.069)	0.194 (0.068)	0.199 (0.069)	0.204 (0.067)	0.202 (0.066)
FDI in forward-linked industries	0.351 (0.207)	0.326 (0.189)	0.334 (0.195)	0.367 (0.227)	0.353 (0.211)	0.354 (0.211)	0.357 (0.206)	0.362 (0.208)	0.368 (0.209)
U.S. preferential tariff	−2.932 (3.499)	−2.427 (2.839)	−3.011 (3.127)	−3.206 (3.587)	−3.182 (3.577)	−3.039 (3.563)	−3.015 (3.697)	−2.831 (3.908)	−2.697 (3.872)
Exports/sales	0.094 (0.212)	0.064 (0.183)	0.068 (0.188)	0.098 (0.220)	0.105 (0.222)	0.110 (0.222)	0.111 (0.223)	0.109 (0.223)	0.105 (0.220)
Exporter dummy	0.368 (0.482)	0.273 (0.446)	0.279 (0.448)	0.352 (0.478)	0.395 (0.489)	0.428 (0.495)	0.422 (0.494)	0.437 (0.496)	0.437 (0.496)
Imported inputs/total nonlabor costs	0.130 (0.208)	0.123 (0.201)	0.127 (0.204)	0.126 (0.207)	0.128 (0.209)	0.136 (0.212)	0.133 (0.209)	0.135 (0.211)	0.136 (0.211)

a. Standard deviations are in parentheses.

Econometric exercises such as this one can be affected by endogeneity problems in the trade variables. One possibility is that the less productive industries receive greater protection against external competitors. Another is that the U.S. preferential margin on goods imported from Mexico vis-à-vis the rest of the world is affected by the perceived productivity of Mexican producers. In addition, protection is likely to be granted to industries in which import penetration is high.[36] All of these possibilities would bias the coefficient estimates in equation 3.

The obvious solution to the potential endogeneity in the trade variables is to find appropriate instrumental variables and perform two-stage least squares regressions. Fortunately, the text of NAFTA itself provides instruments for both Mexican tariffs and for the U.S. preferential tariff margin for Mexican goods. In accordance with NAFTA Annex 302.2, Mexico and the United States are eliminating tariffs on regional trade from a base rate that reflects import duties in place on 1 July 1991. Tariff phaseout negotiations were concluded in July 1992, so the agreement—which defines a tariff level affecting each and every product from 1994 onward—does not reflect the productivity level of Mexican industries during the period of analysis. As shown earlier in figure 2, the tariff level on North American goods is highly correlated with actual tariffs applied by Mexico on imports from the rest of the world. NAFTA tariffs therefore serve as a good instrument for actual Mexican tariffs on total imports.[37]

With regard to import penetration in the Mexican market, I adapt the approach proposed by Frankel and Romer to find an instrument for trade openness based on the gravity equation.[38] Frankel and Romer use their methodology to assess the impact of trade openness on growth. Since openness is endogenous, they use the gravity equation to get a measure of

exchange rate variable) as an instrumental variable. With regard to U.S. labor productivity, it would be ideal to include total factor productivity performance at the industry level in the United States during the period of analysis in order to account for potential cross-border spillovers. Unfortunately, detailed industry-level TFP estimates for the United States covering the entire period of analysis are not readily available. I thus use figures on output per work hour from the Bureau of Labor Statistics as a proxy for TFP. Incidentally, U.S. TFP performance during this period may already be captured, to some extent, by the real exchange rate measure, since productivity changes would be reflected in industry producer prices.

36. Trefler (1993).

37. Canada, Mexico, and the United States have accelerated the tariff reduction for some goods since the initial implementation of NAFTA.

38. Frankel and Romer (1999).

TABLE 3. Instrumenting for Imports: Gravity Equation Estimation Results[a]

Explanatory variable	*(1)*
GDP	1.4156 (0.0187)***
GDP per capita	0.3247 (0.0535)***
Free trade agreement	0.7771 (0.1312)***
Distance	–0.9247 (0.0890)***
Landlocked	–0.0428 (0.0662)
Island	–1.0770 (0.0802)***
Land area	–0.1167 (0.0176)***
Border	0.1883 (0.0866)**
Common language	1.9305 (0.0667)***
Summary statistic	
No. observations	16,888
R^2	0.6430

* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level; *** statistically significant at the 1 percent level.

a. The dependent variable is the log of Mexican bilateral imports by industry. The estimation method is pooled OLS. The coefficient of the constant, as well as year and industry dummies, are not reported.

natural openness—that is, openness explained by geographic variables such as distance to other countries—which serves as an instrument for actual trade openness. Similarly, I fit a gravity equation using bilateral Mexican imports at the industry level and use the fitted values of the regressions to get a measure of the value of imports in each industry that is uncorrelated with the error term in equation 3 (see table 3).[39] The instrument is highly correlated with the observed imports-to-output ratio across industries.

Results

Table 4 presents the econometric results for estimated variants of equation 3. The first result from this exercise is that increased import competition in the 1990s played a major role in improving plant efficiency. Mexican

39. See López-Córdova (2003) for details.

tariffs have a negative and significant impact on both the level and the growth rate of productivity, confirming some of the findings for other countries discussed earlier. In Mexico, average tariffs fell by 10 percentage points from 1993 to 2000, mainly as a result of NAFTA. The point estimates in table 4 indicate that the reduction in tariffs led to an increase in the level of TFP of around 3 percent and in the growth rate of TFP of around 4 percentage points. In addition, an increase in the ratio of imports to output in a given industry is also negatively and significantly correlated with the level and growth rate of productivity, with a one percent increase resulting in a 0.5 percent rise in productivity and a 0.2 percentage point rise in its growth rate.

NAFTA not only opened the Mexican market to North American products, but also reduced tariff barriers on Mexican goods entering the United States and Canada. As we have seen, Mexican exports have grown remarkably since the agreement came into effect. The proportion of manufacturing producers that participates in world markets has also risen steadily since 1993. For example, among those plants in the sample that enter the regressions in table 4, the proportion of exporters rose from 30.4 to 45.7 percent. In addition, the probability that a Mexican manufacturing plant will become an exporter appears to have increased in response to the preferential margin on Mexican products entering the U.S. market, which resulted from NAFTA's tariff phaseout.[40]

Has the reduction in duties on Mexican products induced higher productivity among manufacturers? To arrive at a tentative answer to that question, consider the gap between duties paid by Mexican goods and those paid by imports from the rest of the world in the U.S. market. An increase in the gap (in absolute terms) means that Mexican goods enjoy a larger preferential margin over other imports and, consequently, that NAFTA might have created export opportunities for Mexican producers. I find, in my second result, that preferential access to the U.S. market for Mexican goods has a positive impact on plant productivity. The estimates in table 4 show that an increase in the preference granted to Mexican goods increases the level of productivity, with a one point increase raising TFP levels by 3.0 percent and growth rates by 1.1 percent.

40. Unfortunately, the dataset does not allow me to distinguish the destination of a plant's exports.

TABLE 4. Total Factor Productivity and Integration in Mexico: Regression Results[a]

	Log TFP		*Change in log TFP*						
Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Competition from imports									
Log imports/industry output	0.5053	0.5057	0.2088	0.2082	0.2088	0.2159	0.2078	0.2060	0.2151
	(0.0433)***	(0.0430)***	(0.0513)***	(0.0508)***	(0.0514)***	(0.0521)***	(0.0512)***	(0.0514)***	(0.0518)***
Mexican tariff on total imports[b]	−0.0026	−0.0026	−0.0031	−0.0030	−0.0031	−0.0040	−0.0030	−0.0030	−0.0040
	(0.0009)***	(0.0009)***	(0.0013)**	(0.0013)**	(0.0013)**	(0.0012)***	(0.0013)**	(0.0013)**	(0.0012)***
FDI spillovers[c]									
Intraindustry FDI	−0.2626	−0.0119	0.0533	0.1146	0.0532	0.0139	0.0532	0.0550	0.0128
	(0.0477)***	(0.1063)	(0.0477)	(0.1013)	(0.0477)	(0.0454)	(0.0477)	(0.0476)	(0.0453)
FDI-forward linkages	0.9116	1.2049	0.4160	0.4443	0.4160	0.4184	0.4134	0.4094	0.4171
	(0.1035)***	(0.1899)***	(0.1146)***	(0.1773)**	(0.1146)***	(0.1132)***	(0.1145)***	(0.1142)***	(0.1126)***
FDI-backward linkages	0.9489	0.5387	1.1690	0.9479	1.1691	1.1363	1.1678	1.1728	1.1368
	(0.1185)***	(0.2907)*	(0.1157)***	(0.2832)***	(0.1157)***	(0.1104)***	(0.1156)***	(0.1156)***	(0.1103)***
Intraindustry FDI*local firm		−0.3098		−0.0742					
		(0.1171)***		(0.1123)					
FDI-forward linkages*local firm		−0.3199		−0.0341					
		(0.1824)*		(0.1699)					
FDI-backward linkages*local firm		0.4509		0.2466					
		(0.3011)		(0.2908)					
Exporting activity									
U.S. tariff (Mx – RofW)[d]	−0.0336	−0.0335	−0.0113	−0.0111	−0.0113	−0.0105	−0.0111	−0.0109	−0.0104
	(0.0037)***	(0.0036)***	(0.0044)**	(0.0044)**	(0.0044)**	(0.0044)**	(0.0044)**	(0.0044)**	(0.0043)**
Exporter					−0.0002			−0.0068	
					(0.0047)			(0.0146)	
Exports/sales						0.0119			0.0553
						(0.0137)			(0.0367)
Exporter*local firm								0.0074	
								(0.0154)	

(*continued*)

TABLE 4. Total Factor Productivity and Integration in Mexico: Regression Results[a] (*continued*)

	Log TFP		*Change in log TFP*						
Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Exports/sales*local firm									−0.0483 (0.0397)
Imported intermediate goods									
Imported-input/material costs							−0.0320 (0.0137)**	−0.1070 (0.0362)***	−0.0965 (0.0343)***
Imported input*local firm dummy								0.0873 (0.0392)**	0.0785 (0.0374)**
Summary statistic									
No. observations	38,024	38,024	31,940	31,940	31,940	30,922	31,940	31,940	30,922
No. groups (class folio)	5,935	5,935	5,779	5,779	5,779	5,647	5,779	5,779	5,647
H_0: Sum FDI variables = 0 (χ^2 or *F* statistic)	93.27	80.51	106.25	97.18	106.41	107.69	105.98	106.85	107.76
Probability > *F* statistic or χ^2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H_0: Exports*domestic = 0 (χ^2)								0.01	0.23
Probability > χ^2								0.91	0.63
H_0: Imported inputs*domestic = 0 (χ^2)								1.76	1.56
Probability > χ^2								0.18	0.21

* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level; *** statistically significant at the 1 percent level.

a. The dependent variable in regressions 1 and 2 is log TFP; in regressions 3 through 9 it is the change in log TFP. All regressions were estimated using two-stage least squares on a panel with fixed effects. The endogenous variables are Mexican and U.S. tariffs, imports/output, and the industry real exchange rate. The instrumental variables are NAFTA-negotiated tariffs, predicted imports/output from the gravity equation, and the nominal exchange rate multiplied by the U.S. industry producer price index. All regressions include the following controls: size, industry output (excluding the plant' s own output), capacity utilization, industrial and geographic concentration indexes, U.S. consumption, U.S. industry labor productivity, and year dummies. Regressions 3 through 9 also include log TFP in year *t*. Standard errors are in parentheses.

b. "Mexican tariff" is the ISIC (revision 3) four-digit industry tariff on world imports, weighted by trade.

c. FDI variables refer to the fraction of output produced by foreign plants; linkages were calculated using Mexican input-output data as weights.

d. "U.S. tariff" is the difference between effective tariffs on Mexican imports and effective tariffs on imports from the rest of the world in the industry.

To further explore the question of whether export activities have promoted efficiency enhancement among Mexican producers, I estimated the impact on productivity growth rates of being an exporter and of the ratio of exports to sales, as in the U.S. case analyzed by Bernard and Jensen.[41] Since the more productive plants are probably the ones engaging in export activities, the analysis follows Bernard and Jensen in not estimating a regression of the TFP level on export variables. My third result confirms Bernard and Jensen's finding: Exporting does not have a positive effect on plant productivity growth. Exporting has an important role, however, in allocating resources to more productive firms and industries, thereby raising aggregate productivity as discussed earlier.

A fourth result concerns the use of imported intermediate goods in the production process. From 1993 to 2000, the use of imported inputs increased steadily from 28.5 percent to 34.7 percent of all nonwage costs of production, while the fraction of all plants using imported inputs rose slightly from 50.9 to 55.4 percent. It is remarkable that the steep devaluation of December 1994 did not dent this growth. Although one cannot conclude from the existing information that NAFTA was solely responsible for the upward trend in the use of foreign inputs, the agreement was, at the least, a major contributor to that trend. The econometric evidence in table 4 shows that imported inputs seem to have an adverse impact on productivity growth (column 7). Interacting imported input use (as a fraction of total costs) with a domestic-firm dummy reveals that this last result is due solely to foreign firms (columns 8 and 9). The use of imported inputs does not affect the efficiency of domestic firms, whereas productivity growth among foreign firms decreases with the use of more imported inputs, other things equal. This result can be formalized as follows: Productivity growth among users of imported inputs was lower than among nonusers, owing entirely to a negative impact among foreign plants.

This finding may seem paradoxical at first sight. It could reflect differences between foreign producers that use Mexico as a base for simple assembly operations of imported materials, with little productivity dynamism, and foreign firms that are not attracted to Mexico solely for its relatively low wages. Unfortunately, the dataset does not support further analysis of this topic, since *maquiladora* plants are not included in the original survey.

41. Bernard and Jensen (2001).

Finally, table 4 also contains information on whether the presence of foreign producers in Mexican manufacturing affects the performance of other producers in the sector. This possibility is of interest since regional integration arrangements generally seem to have a positive impact on FDI flows.[42] NAFTA is no exception, in that it has had a positive impact on capital flows into Mexico. In analyzing whether foreign capital inflows have had a positive or negative impact on the manufacturing sector, I distinguish between intraindustry spillovers, or the effect on plants within the same industry, and interindustry spillovers that occur as FDI flows to industries downstream or upstream in the production chain. This distinction follows Kugler, who argues that although foreign producers may prevent spillovers from benefiting their competitors in the same industry, spillovers may indeed occur among plants that supply or purchase goods from foreign manufacturers.[43] I implement this distinction, first, by calculating the share of output produced by foreign plants in each industry and, second, by using Mexico's input-output matrix to find a weighted average of foreign capital participation in industries that supply intermediate goods to and in industries that purchase intermediate goods from a plant's own industry. In Hirschman's terminology, the supplier industries represent backward linkages, while purchasing industries are forward linkages.[44]

My findings can be summarized in a final result: foreign presence adversely affects productivity among producers in the same industry, but the interindustry impact is positive, through both backward and forward linkages; the net effect of all three effects is positive.

As in Aitken and Harrison's work on Venezuela, intraindustry spillovers have a negative and statistically significant impact on the level of TFP, but not on the growth rate.[45] For example, use of the point estimates in regression 1 and the summary statistics in table 2, shows that a rise of one standard deviation (0.214) in foreign capital participation in the industry reduces productivity by approximately 5.5 percent.[46] One potential problem with the estimate is that foreign producers may choose to invest in industries in

42. See Levy Yeyati, Daude, and Stein (2002).

43. Kugler (2000).

44. Hirschman (1958).

45. Aitken and Harrison (1999). I am careful not to include the output of foreign-owned plants when measuring the share of FDI in the industry to which the plant belongs.

46. That is, by $e^{-0.2706*0.214} - 1$.

which Mexican producers are inefficient. Omitting the productivity level of domestic producers in the econometric exercise would result in the measure of intraindustry FDI being correlated with the error term in equation 3, thus biasing my estimates.[47] To address this possibility, I measure average TFP among domestic producers and include it in the regressions.[48] The coefficient on intraindustry FDI is no longer significant; other relevant estimates remain qualitatively unaltered, although their significance and magnitude sometimes change (see table 5).

In contrast with intraindustry FDI, foreign presence in industries with which a plant has backward or forward linkages has a positive and statistically significant effect on both the level and the growth rate of productivity.[49] If FDI in backward-linked industries rises by one standard deviation, TFP rises by almost 6.5 percent and its growth rate by around 8.1 percent (using the point estimates in regression 3); the corresponding figures for forward-linked industries are 20.7 percent and 9.0 percent, respectively. The point estimates in regressions 1 and 3 further suggest that if the share of output produced by foreign plants were to increase by one percentage point across all manufacturing industries, both the level and growth rate of plant productivity would increase by 1.6 percent.[50]

Concluding Remarks

The paper's findings indicate that the substantial liberalization of trade and investment flows in the Mexican economy in the 1990s, which was largely driven by the implementation of NAFTA, has enhanced manufacturing productivity considerably. This is particularly important in light of the poor performance that the economy as a whole experienced from the early 1980s through the mid-1990s.

47. I thank one of the discussants for pointing out this potential problem.

48. When measuring average TFP among domestic producers, I exclude plant *i* from that calculation to reduce the possibility that average TFP is correlated with the error term.

49. Including average TFP among domestic producers, as in table 5, does not affect this finding.

50. That is, $e^{0.01*(-0.2626+0.9116+0.9489)} - 1 = 1.6$ percent and $e^{0.01*(0.4160+1.1690)} - 1 = 1.6$ percent, respectively. As table 4 indicates, a test that the sum of all FDI coefficients is equal to zero is rejected in all regressions.

TABLE 5. TFP and Integration in Mexico: Regression Results after Accounting for Average TFP among Domestic Producers[a]

	Log TFP		Change in log TFP						
Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*
Competition from imports									
Log imports/industry output	0.1885 (0.0281)***	0.1952 (0.0281)***	0.1747 (0.0376)***	0.1752 (0.0374)***	0.1746 (0.0377)***	0.1759 (0.0379)***	0.1738 (0.0376)***	0.1725 (0.0377)***	0.1753 (0.0378)***
Mexican tariff on total imports[b]	−0.0015 (0.0008)*	−0.0016 (0.0008)**	−0.0027 (0.0012)**	−0.0027 (0.0012)**	−0.0027 (0.0012)**	−0.0036 (0.0011)***	−0.0027 (0.0012)**	−0.0027 (0.0012)**	−0.0035 (0.0011)***
FDI spillovers[c]									
Intraindustry FDI	−0.0126 (0.0424)	0.0548 (0.0929)	0.0738 (0.0467)	0.1220 (0.1005)	0.0737 (0.0467)	0.0344 (0.0445)	0.0736 (0.0467)	0.0750 (0.0467)	0.0328 (0.0445)
FDI-forward linkages	0.3990 (0.0765)***	0.4510 (0.1587)***	0.3608 (0.0936)***	0.3768 (0.1675)**	0.3609 (0.0935)***	0.3531 (0.0911)***	0.3585 (0.0935)***	0.3557 (0.0934)***	0.3525 (0.0908)***
FDI-backward linkages	0.2156 (0.1026)**	1.3788 (0.2536)***	1.1143 (0.1160)***	1.0637 (0.2791)***	1.1145 (0.1160)***	1.0829 (0.1112)***	1.1134 (0.1160)***	1.1191 (0.1160)***	1.0828 (0.1112)***
Intraindustry FDI*local firm		−0.0997 (0.1031)		−0.0606 (0.1124)					
FDI-forward linkages*local firm		−0.0294 (0.1608)		−0.0166 (0.1703)					
FDI-backward linkages*local firm		−1.3142 (0.2611)***		0.0554 (0.2867)					
Export activity									
U.S. tariff (Mx – RofW)[d]	−0.0139 (0.0027)***	−0.0148 (0.0027)***	−0.0087 (0.0035)**	−0.0087 (0.0035)**	−0.0087 (0.0035)**	−0.0076 (0.0034)**	−0.0086 (0.0035)**	−0.0085 (0.0035)**	−0.0075 (0.0034)**
Exporter					−0.0005 (0.0046)			−0.0033 (0.0145)	
Exports/sales						0.0127 (0.0136)			0.0673 (0.0361)*
Exporter*local firm								0.0031 (0.0152)	

Exports/sales*local firm									–0.0613 (0.0387)
Imported intermediate goods									
Imported-input/material costs							–0.0312 (0.0135)**	–0.1085 (0.0359)***	–0.0984 (0.0340)***
Imported input*local firm dummy								0.0900 (0.0388)**	0.0829 (0.0369)**
Summary statistic									
No. observations	37,999	37,999	31,924	31,924	31,924	30,906	31,924	31,924	30,906
No. groups (class folio)	5,934	5,934	5,778	5,778	5,778	5,646	5,778	5,778	5,646
H_0: Sum FDI variables = 0 (χ^2 or *F* statistic)									
Probability > *F* statistic or χ^2	22.68	11.35	122.57	113.22	122.77	122.55	122.19	123.21	122.36
H_0: Exports*domestic = 0 (χ^2)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Probability > χ^2								0.97	0.68
H_0: Imported inputs*domestic = 0 (χ^2)								1.59	1.21
Probability > χ^2								0.21	0.27

* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level; *** statistically significant at the 1 percent level.

a. The dependent variable in regressions 1 and 2 is log TFP; in regressions 3 through 9 it is the change in log TFP. All regressions were estimated using two-stage least squares on a panel with fixed effects. The endogenous variables are Mexican and U.S. tariffs, imports/output, and the industry real exchange rate. The instrumental variables are NAFTA-negotiated tariffs, predicted imports/output from the gravity equation, and the nominal exchange rate multiplied by the U.S. industry producer price index. All regressions include the following controls: size, average industry TFP in domestic plants (excluding plant's own TFP), industry output (excluding the plant's own output), capacity utilization, industrial and geographic concentration indexes, U.S. consumption, U.S. industry labor productivity, and year dummies. Regressions 3 through 9 also include log TFP in year *t*. Standard errors are in parentheses.

b. "Mexican tariff" is the ISIC (revision 3) four-digit industry tariff on world imports, weighted by trade.

c. FDI variables refer to the fraction of output produced by foreign plants; linkages were calculated using Mexican input-output data as weights.

d. "U.S. tariff" is the difference between effective tariffs on Mexican imports and effective tariffs on imports from the rest of the world in the industry.

A look at how productivity would have fared if the economy had not become more integrated with North America and the world at large can help put the findings in perspective. What would have happened if Mexican tariffs, the preferential tariff margin in the United States, the ratio of imports to output, and the participation of foreign producers in Mexican manufacturers had remained at 1993 levels? Of course, such an extreme scenario ignores the fact that international capital flows to emerging markets increased dramatically in the 1990s, and it assumes that Mexico's trade liberalization process would have stalled in 1993.[51] Despite these caveats, the counterfactual exercise is informative since, as the paper has suggested, NAFTA might have been the main driver behind the deepening of Mexico's economic liberalization in the 1990s. I thus take each variable separately and use the point estimates of regression 1 in table 4, as well as the descriptive statistics in table 2, to construct the scenario.[52] If tariffs had remained at their 1993 level of 11.866, productivity in 2000 would have been 2.5 percent lower. If no preferential access to the U.S. market had been granted to Mexican producers, TFP would have been 0.95 percent lower. If foreign presence across industries had remained unchanged through 2000, productivity would have been 6.1 percent lower. Finally, if import penetration had remained unchanged, productivity would have been 45 percent lower! These results, and especially the last, must be taken with a strong dose of caution. Still, this exercise serves to illustrate that NAFTA-led liberalization most likely offset other forces that held Mexican productivity back during the decade.

Even though NAFTA was the main mechanism behind the liberalization of the Mexican economy in recent years, nothing in the analysis, other than the preferential access to the U.S. market, restricts the results herein to the case of preferential liberalization. The main conclusion of this paper would hold if Mexico were to continue liberalizing trade and investment flows on a multilateral basis. Policymakers should keep this in mind in the coming years.

51. I thank the discussants for emphasizing the importance of these remarks.

52. For a given variable of interest, X, the percent difference in productivity between the counterfactual value of X, X_C, and its actual value, X_A, is given by the expression $e^{\hat{\beta}(X_C - X_A)} - 1$, where $\hat{\beta}$ is the estimated coefficient of X in table 4.