NAFTA and Mexico’s Manufacturing Productivity: An Empirical Investigation using Micro-level Data

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(Work in progress)

Abstract

Using a panel of Mexican manufacturing plants over the period 1993-1999, I estimate total factor productivity (TFP) at the plant level and study its evolution in the face of trade and investment liberalization under the North American Free Trade Agreement. I implement the Olley-Pakes (1996) algorithm on the data to correct for simultaneity and sample selection problems affecting OLS estimates. I then relate the evolution of TFP over the period to tariff levels in Mexico and the United States, import penetration, exporting activities, imported inputs use and foreign capital participation. I find that increased import competition and access to the U.S. market have had a positive impact on TFP. Foreign capital also has had a positive impact on TFP, but intra-industry spillovers are negative. Last, there is no clear evidence regarding the impact from the use of imported inputs or from exporting operations.

Keywords: NAFTA; trade liberalization; manufacturing; productivity; foreign direct investment

JEL Classification: D24, F13, F14, F15

1 Introduction

Mexico’s negotiation and ongoing 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

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United States, buttressing the liberalization reforms implemented since the mid-1980s. The implications for the country’s welfare are hard to understate, and yet there is little hard evidence so far as to how the agreement has impacted the Mexican economy.

In this paper I try to contribute 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. Productivity is perhaps the main engine for economic growth. Unfortunately, Mexico’s overall total factor productivity performance since the early 1980s and through the mid-1990s was rather disappointing, with average annual growth between -1 and -2 percent [World Bank (2000)]. Therefore, 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 experience is particularly relevant for countries participating in the ongoing negotiation of a Free Trade Agreement of the Americas or other regional trading arrangements. What should countries in the Americas expect from greater economic integration with the U.S. economy? Should they pursue preferential trading arrangements or is unilateral liberalization more desirable? While the paper does not attempt to answer such questions, some of its findings may offer important insights to the rest of the hemisphere. Second, while there have been several contemporaneous events that may confound studies on NAFTA (e.g., the devaluation of 1994), the agreement serves as an “experiment” that allows researchers to disentangle the different forces that have shaped the Mexican economy in recent years. For example, in this paper I exploit 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 apply the methodology proposed by Olley and Pakes (1996) to a panel of plants spanning the 1993-1999 period in order to address simultaneity and selectivity problems
that typically affect measures of total factor productivity based on micro-level data. The use of micro-level data to carefully assess the impact of NAFTA on the Mexican manufacturing sector is an innovation of this paper.\footnote{To my knowledge, this is the first study on the Mexican manufacturing sector that uses micro-level data and that explicitly accounts for the specific provisions of NAFTA.} 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.

The paper is organized as follows. In the next section I provide background on the liberalization strategy followed by Mexico since the mid-1980s. In section 3 I review the theoretical an empirical literature on the relationship between openness and productivity. Section 4 describes the methodology used in measuring total factor productivity in Mexican manufacturing and presents the estimates used in the econometric analysis of Section 5. I conclude the paper with final remarks in section 6.

## 2 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 licensing requirements fell from 100 percent to 36 percent. After joining the 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 the tariffs on industrial imports to five levels: 0, 5, 10, 15, and 20 percent ad valorem. By 1993 only 192 tariff-lines were subject to licensing requirements and the average ad valorem tariff was 11.4 percent [López Córdova (2001), Ten Kate (1992)].

NAFTA consolidated the liberalization of the Mexican economy and opened up the Canadian and U.S. markets to Mexican producers. The three countries have agreed to liberalize trade on most products by 2008, at the latest. Regarding manufacturing trade, Mexican import duties
on North American products experienced a rapid decline since 1994, the year in which the agreement came into 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 increased those figures 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.

Since the North American market represents over 75 percent of all Mexican imports, the elimination of tariffs on Canadian and U.S. goods explains most of the downward trend in average manufacturing tariffs depicted in Figure 2. Since 1993 Mexican tariffs on the rest of the world have also fallen, albeit more moderately, thanks in part to the subscription of other preferential trading arrangements such as the recent free trade agreement with the European Union. Despite these reductions, average most-favored nation tariffs have actually increased, although they affect a smaller number of trading partners.
The reorientation of the Mexican economy toward world markets during the 1990s, and specially toward the Canadian and U.S. markets, is apparent in Figure 3. Both imports and exports more than quadrupled from 1990 to 2000. Whereas imports from North America and from the rest of the world grew in tandem, Mexican exports to North America increased their share in total exports from 80 percent to 91 percent over the decade.

At the same time, foreign direct investment flows as a percent of GDP went from one to 2.4 percent. In particular, FDI inflows from the United States amounted to 18.4 billion dollars (in 1995 prices) from 1994 to 2000, of which 10.3 billion went to the manufacturing sector. As a fraction of total U.S. investment abroad, 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 has risen 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.\(^2\)

Given the substantial liberalization to trade and investment flows during the 1990s, driven

\(^2\)Figures based on information from the U.S. Bureau of Economic Analysis’ webpage.
Figure 3: Trade and FDI in Mexico, 1990-2000

(a) Trade

(b) Foreign Direct Investment

Source: Based on data from Mexico’s Secretaria de Economia

Source: World Bank, Global Development Network Database
to a good degree by the implementation of NAFTA, the question arises as to how the manufacturing sector has performed under the new policy environment. In the next section I survey the theoretical and empirical literature on the subject.

3 Trade, foreign investment and TFP: Existing literature (in progress)

Trade policy may have an impact on manufacturing productivity through different channels. First, there may be an import discipline effect as trade liberalization exposes domestic producers to greater competitive pressures. The import discipline effect, “the oldest insight in this [trade policy] area” (Helpman and Krugman 1989), would affect 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 therefore improve their ‘scale efficiency’ and, finally, by increasing the firms’ incentive to innovate.

The gains accruing from better firm management are quite intuitive, but economists have problems in putting a solid theory behind 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 preventing firms from trying to restrict output and raise prices. Lower prices are followed by higher output, which, in turn, lower average costs. This result, though, depends heavily on the assumption made about how easy firms enter and exit markets (see Tybout 2001). Finally, the argument about the incentives to innovate, which is key to link trade to long-term productivity growth, is also quite intuitive, but its theoretical foundations are somewhat shaky. Rodrik (1992) and Goh (2000), for instance, when trying to model the impact of protection on innovation reach totally different results. The former argues that trade might reduce the firms’ incentive to innovate if their market shares are reduced by imports, whereas the latter says that protection reduces innovation because it raises the

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3 The following discussion relies on Tybout (2000), Tybout (2001), and López-Córdova and Moreira (2002).
opportunity cost of technological effort.

Trade may also affect productivity at the aggregate level by inducing higher plant turnover. The argument is that “trade can promote industry productivity growth without necessarily affecting intra-firm efficiency” (Melitz (2002)). This would happen because the simultaneous expansion of imports and exports would force the least efficient firm to contract or exit and the most efficient to expand. Such “share effect” is basically an “once and for all” gain.

In addition, trade liberalization may expand the menu of intermediate inputs and capital available to firms and facilitates access to world-class technologies. That is, technology transfers may increase with the removal of trade barriers.

With regard to FDI, foreign capital participation may affect productivity through increased presence of “world class” competitors that would raise average productivity in the industry. In addition, as in the case of trade, FDI is expected to improve firm management, raise scale efficiency and provide more incentives to innovation. 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 channels more likely to have long-term implications for productivity growth, since they might 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 to developing countries, it has also its limitations. First, there is the issue of the “absorptive capacity”. Without a qualified workforce or investments in R&D, it is very unlikely that spillovers from FDI will occur. And second, given the foreign firms’ strong interest in protecting their competitive edge and, therefore, minimize technology transfer, spillovers are more likely to be “vertical” (among their clients and suppliers) than “horizontal” (among their competitors) (Kugler 2000).
Finally, 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 local supply (quality and variety) of intermediate goods (see e.g. Markusen and Venables (1999)). This would happen both directly, through investment in these industries, or indirectly, through investment in final (consumer) goods, which could create enough demand and technology spillovers for the establishment of intermediate industries.

### 3.1 Empirical studies

Most empirical studies concentrate on the trade channel and more specifically on the import discipline, scale, and turnover hypotheses. Pavcnik (2001), Fernandes (2001), Tybout and Westbrook (1995) and Muendler (2002) find evidence of a strong import discipline effect in, respectively, Chile (1979-86), Colombia (1977-1991), Mexico (1986-90) and Brazil (1986-98). There is little evidence of important turnover or scale-related gains. Nonetheless, Pavcnik’s (2000) estimates suggest that import discipline would have been dwarfed by the turnover effect and Muendler (2002) finds that the elimination of trade barriers increases the likelihood the low-efficiency firms will shut down which in the long run would have a positive impact on aggregate productivity.

Evidence on the other trade effects, particularly on those that are believed to impact 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 unimportant impact on productivity. Yet, Alvarez and Robertson (2000), working with plant-level data from Chile and Mexico, detect a significant and positive relationship between importing intermediate inputs and innovation in the latter country.

Evidence based on country and sectoral level-data also point to a positive input effect. For instance, Blyde (2002) finds that technological spillovers diffused through imported machinery has a positive impact on productivity and Schiff, Wan, and Olarreaga (2002) estimates point
to North-South and South-South technological spillovers, diffused through imports. North-
South spillovers would be higher and would affect mainly R&D intensive industries, whereas
South-South spillovers would be relevant mostly to other types of industries.

The acquisition of knowledge through exports is also the subject of a few studies but the ev-
idence is mixed. Clerides, Lach, and Tybout (1998) found no evidence of learning-by-exporting
son (Undated) results, in turn, point to a strong link between exporting and investment in
innovation in both Mexico (1993-95) and Chile (1993-95), and World Bank (2000), based on

Finally, the (scarce) evidence on the FDI channel tends to support the prevalence of vertical
(inter-industry) over horizontal (intra-industry) spillovers and to highlight the importance of
the countries’ absorptive capacity. For instance, Aitken and Harrison (1999) find that foreign
equity participation raises plant productivity in Venezuela (1976-89), but also that horizontal
spillover are negative. Likewise, Kugler (2000) reports limited horizontal spillovers for Colom-
bian manufacturing plants over 1974-1998, but finds evidence of “widespread inter-industry
spillovers from FDI”.

4 Total factor productivity in Mexico

I estimate total factor productivity at the plant level using micro-level data covering the 1993-
1999 period. Traditional approaches that use OLS estimation on panel data suffer from si-
multaneity and selectivity problems. To avoid such shortcomings, I apply the methodology
proposed by Olley and Pakes (1996).
4.1 Empirical strategy

I model output produced in each plant $i$ in a given industry during year $t$ according to a Cobb-Douglas production function (in logs)

$$y_{it} = \beta_o + \beta_l l_{it} + \beta_m m_{it} + \beta_k k_{it} + \omega_{it} + \varepsilon_{it}$$ (1)

where $y_{it}$ is output, $l_{it}$ represents labor work hours, $m_{it}$ are total material inputs, $k_{it}$ represent capital inputs, $\omega_{it}$ is total factor productivity, and $\varepsilon_{it}$ is an error term. Both $\omega_{it}$ and $\varepsilon_{it}$ 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 $\omega_{it}$, i.e., productivity, is unobserved by researchers, plant managers may observe $\omega_{it}$ or might make inferences about the plant’s productivity level. In turn, plant managers 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 (1996) proposed an estimation procedure that addresses both issues. They present a model in which a plant chooses whether or not to exit the market. If a plant decides to continue in the market, it then chooses next year’s capital stock through investment, considering the plant’s productivity level. Productivity is a function of the plant’s age and its capital stock and, therefore, investment. Then, information on a plant’s investment decisions allows us to control for the impact that the unobserved productivity level has on the choice of capital inputs.

Based on Olley and Pakes’ behavioral model, I estimate the following three regression equations. First, the production function 1 is transformed into

$$y_{it} = \beta_l l_{it} + \beta_m m_{it} + \phi (I_{it}, K_{it}) + \varepsilon_{it}$$ (2)
where

\[ \phi(I_{it}, K_{it}) = \beta_0 + \beta_k k_{it} + h(I_{it}, K_{it}) \].

That is, the productivity term \( \omega_{it} \) is modeled as a function \( h() \) of observed investment \( I_{it} \) and the stock of capital. I estimate equation 2 using a fourth order polynomial series estimator for function \( h() \).

Second, the probability that a plant survives into the next period is a function of the investment level and the capital stock:

\[ \Pr(\chi_{it+1} = 1|.) \equiv P(I_{it}, K_{it}) \]

The latter expression is estimated via a probit model on a polynomial series estimation. Estimating equations 2 and 3 yields consistent estimates of \( \beta_l \) and \( \beta_m \), as well as a fitted probability \( \hat{P} \) that the plant survives. That information is then used in a third equation which yields consistent estimates of \( \beta_k \):

\[ y_{i,t+1} - \beta_l l_{i,t+1} - \beta_m m_{i,t+1} = \beta_k k_{i,t+1} + \sum_{m=0}^{4} \sum_{n=0}^{4-m} \beta_{mn} \left( \hat{P} \right)^m \left( \hat{h} \right)^n + \nu_{it} \]

where \( \hat{h}_{it} \equiv \hat{\phi}_{it} - \beta_k k_{it} \) and \( \hat{\phi}_{it} \) is the fitted value of \( \phi_{it} \) in equation 2.

### 4.2 Data

I implement the Olley-Pakes algorithm using a panel of Mexican manufacturing plants spanning the period 1993-1999. The panel started with 6,800 plants, although plant exit has reduced the sample to 5,700 plants during the period of analysis. Furthermore, data problems limited the sample used in this study to 5,300 plants.

The data come from an annual industrial survey—the Encuesta Industrial Anual, EIA—carried out by Mexico’s Instituto Nacional de Geografía e Informática (INEGI). The EIA contains information on employment, input use, shipments and production, and investment at the plant level, and its data were complemented with information from various others INEGI sources; Appendix A describes the data in more detail.
Table 1: Production function estimation results

<table>
<thead>
<tr>
<th>Manufacturing division</th>
<th>31</th>
<th>32</th>
<th>33</th>
<th>34</th>
<th>35</th>
<th>36</th>
<th>37</th>
<th>38</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unskilled labor</td>
<td>0.099</td>
<td>0.188</td>
<td>0.163</td>
<td>0.118</td>
<td>0.037</td>
<td>0.041</td>
<td>0.156</td>
<td>0.101</td>
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<tr>
<td></td>
<td>(0.011)***</td>
<td>(0.011)***</td>
<td>(0.022)***</td>
<td>(0.017)***</td>
<td>(0.011)***</td>
<td>(0.021)**</td>
<td>(0.033)***</td>
<td>(0.013)***</td>
</tr>
<tr>
<td>Skilled labor</td>
<td>0.071</td>
<td>0.107</td>
<td>0.101</td>
<td>0.103</td>
<td>0.142</td>
<td>0.131</td>
<td>0.062</td>
<td>0.114</td>
</tr>
<tr>
<td></td>
<td>(0.008)***</td>
<td>(0.010)***</td>
<td>(0.016)***</td>
<td>(0.012)***</td>
<td>(0.007)***</td>
<td>(0.018)**</td>
<td>(0.019)**</td>
<td>(0.009)***</td>
</tr>
<tr>
<td>Materials</td>
<td>0.800</td>
<td>0.697</td>
<td>0.724</td>
<td>0.753</td>
<td>0.773</td>
<td>0.785</td>
<td>0.784</td>
<td>0.789</td>
</tr>
<tr>
<td></td>
<td>(0.009)***</td>
<td>(0.015)***</td>
<td>(0.020)***</td>
<td>(0.013)***</td>
<td>(0.009)***</td>
<td>(0.020)**</td>
<td>(0.029)**</td>
<td>(0.008)***</td>
</tr>
<tr>
<td>Capital</td>
<td>0.065</td>
<td>0.086</td>
<td>0.061</td>
<td>0.076</td>
<td>0.080</td>
<td>0.113</td>
<td>0.090</td>
<td>0.046</td>
</tr>
<tr>
<td></td>
<td>(0.006)***</td>
<td>(0.009)***</td>
<td>(0.009)***</td>
<td>(0.004)***</td>
<td>(0.004)**</td>
<td>(0.005)**</td>
<td>(0.005)**</td>
<td>(0.004)***</td>
</tr>
<tr>
<td>Observations</td>
<td>2747</td>
<td>1619</td>
<td>228</td>
<td>940</td>
<td>2762</td>
<td>493</td>
<td>152</td>
<td>2992</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.23</td>
<td>0.12</td>
<td>0.39</td>
<td>0.20</td>
<td>0.16</td>
<td>0.33</td>
<td>0.30</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Bootstrapped standard errors in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

In addition, I created a database on 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 import duties, both preferential (i.e., NAFTA duties) and MFN, and FDI flows. The database covers, but is not limited to, the period of analysis. Importantly, the database has a high degree of industry disaggregation, which allows us to consider variation in the NAFTA trade liberalization compromises to study the agreements implications.

4.3 Total factor productivity estimates

Table 1 shows the Olley-Pakes estimates of the production function parameters in equation 1. The algorithm was applied to eight different manufacturing subsectors. With this estimates, I calculated (log) TFP as the residual

\[
TFP_{it} \equiv \omega_{it} = y_{it} - \hat{\beta}_l l_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_k k_{it},
\]

where “^” designates a coefficient’s estimate.

From 1993 to 1999 Mexican manufacturing productivity grew at an average annual rate of 1.1 percent. As Figure 4 shows, there were wide differences in the productivity performance of different manufacturing industries. Whereas log TFP in the basic metals industry fell by 2.8 percent per annum, log TFP in machinery and equipment, computing equipment and precision instruments rose at yearly rate of 4.7, 5.6 and 3.1 percent, respectively.
Although such changes coincided with NAFTA’s first 7 years, we cannot establish a causal relationship between the agreement and productivity performance from the above figures. Indeed, distinguishing between NAFTA’s contribution to productivity performance proves rather challenging, especially when we consider that a number of events very likely 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.

There is nevertheless strong evidence suggesting 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 5 provides some support to the latter claim. As the figure illustrates, import competing industries saw productivity jump by 4.2 percent annually from 1993 to 1999, or by 3.1 percent if one considers only those industries that compete with North American goods. As in other countries that have implemented trade reforms, importing industries are likely to be more susceptible to foreign competition and therefore are more likely to make the necessary adjustments to increase productivity in order to stay in business. Exporting industries experienced more modest productivity growth, 1.6 and 1.3 percent, respectively, whether we consider world or North American markets. The lower relative growth rate could be explained by the possibility that, in order to participate in foreign markets successfully, producers must show a good degree of efficiency, leaving little room for additional productivity improvements. But perhaps the more telling contrast in Figure 5 is the poor performance in industries with little trade links with world markets, which experienced a meager 0.3 percent annual growth. In addition, as Figure 5 illustrates, both exporting plants and multinational corporations (MNCs)\(^4\) out-performed their counterparts. In this last regard, US- or Canadian-owned foreign plants grew faster than other MNCs. Last, users of imported inputs did not grow faster than plants that relied exclusively on domestic materials. Section 5 considers whether this initial evidence holds once we implement a more careful econometric specification.

4.4 Intra-firm gains versus reallocation gains (Preliminary)

Before proceeding to the econometric analysis of the determinants of TFP, let us distinguish between TFP changes that take place within the manufacturing establishment from those that occur as resources are reallocated from less to more productive plants and/or industries. To that effect, the following discussion extends the productivity decomposition methodology proposed by Griliches and Regev (1995). Define aggregate TFP in industry \(j\) at time \(t\) as

\[
P_{jt} = \sum_{i \in j} s_{it} P_{it},
\]

\(^4\)As Appendix A explains, I define foreign plants (i.e., MNCs) as those in which foreign capital accounts for more than 50 percent of equity.
Figure 5: Annual TFP Growth in Mexico, 1993-99, by Industry or Plant Characteristics

Source: Author's calculation.
where \( s_{it}^j \) is plant \( i \)'s share of industry \( j \)'s output and \( P_{it}^j \) is its TFP at time \( t \), and sector-wide productivity as the output-share (\( s_{it}^j \)) weighted average across all industries, \( P_t = \sum_j s_{it}^j P_{it}^j \). As in Griliches and Regev (1995), the change in \( P_t \) is given by the expression

\[
\Delta P_t = \sum_j \Delta \left( s_{it}^j P_{it}^j \right) = \sum_j \bar{s}_{it}^j \Delta P_{it}^j + \sum_j \bar{P}_{it}^j \Delta s_{it}^j,
\]

where an over-bar over a variable represents the average over periods \( t \) and \( t-1 \) for that variable.

In the latter decomposition, the first term captures within-industry productivity gains while the second captures gains that stem from the reallocation of resources across industries. Extending this decomposition within each industry we have:

\[
\Delta P_t = \sum_j \bar{s}_{it}^j \left( \sum_{i\in j} \bar{P}_{it}^j \Delta P_{it} + \sum_{i\in j} \bar{s}_{it}^j \Delta s_{it} \right) + \sum_j \left( \bar{s}_{it}^j \bar{P}_{it}^j \right) \Delta s_{it}^j
\]

Equation 5 distinguishes between the contribution to TFP growth in the manufacturing sector stemming from plant-level efficiency gains (first right-hand side term), from reallocation of resources from less to more productive plants within an industry (second term), and from resource reallocation across industries (third term). Using a similar decomposition, Bernard and Jensen (1999) emphasize that one may opt for classifying plants according to alternative industry typologies. As in Figure 5, I classify industries and/or plants according to their trade orientation and integration to the North American and world economy.

An additional comment is in order before presenting the decomposition results. As Table 1 reflects, the paper estimates different production functions for eight 2-digit manufacturing industries. As such, one cannot aggregate TFP estimates across all manufacturing plants. In order to go around this constraint and to implement the above decomposition, I normalized the TFP estimates by subtracting from them the productivity of a “representative plant” within
the 2-digit industry. Such representative plant is defined as using the inputs and producing output equivalent to the industry average in 1993, the initial year in the sample. While allowing aggregation across plants in equation 5, one drawback from this normalization is that the implicit TFP gains are not strictly comparable to the results reported previously.

Figure 6 depicts the contribution to TFP growth stemming from the three channels in equation 5. Looking first at the manufacturing sector as a whole, the figure highlights the importance of resource reallocation for productivity growth. Moreover, it appears that within-plant productivity during the period of analysis contributed negatively to aggregate productivity growth, perhaps due to the macroeconomic instability of the decade. The distinction according to industry or plant characteristics suggests that greater trade orientation, as well as higher foreign capital participation, explain the bulk of the productivity gains in Mexican manufacturing during the 1990s, both because of their impact on within-plant productivity gains and through the reallocation of resources to more productive producers.

5 NAFTA’s impact on productivity

In order to provide more conclusive evidence on whether NAFTA has had a positive impact on TFP performance, this section presents results from an econometric exercise that isolates the different forces that influence manufacturing efficiency at the plant level. Some factors that may affect productivity are specific to the plant, such as its age and its size, whereas others reflect industry-wide characteristics and macroeconomic conditions that are external to the plant. The latter include, among others, industrial output concentration —either across 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. For purposes of the present discussion, we are interested in changes in the economic environment stemming directly from NAFTA and from the integration of the Mexican economy.
Figure 6: Productivity decomposition
to North America at large. Among these we consider tariff elimination, an increased availability of imported inputs, and spillovers from foreign direct investment.

5.1 Empirical strategy

I regress the TFP estimates from the previous sections on yearly measures of trade policy affecting Mexican manufacturers, controlling to the extent possible by plant, industry, and geographical characteristics. I consider both Mexican tariff on world trade and the United States’ preferential tariff margin on Mexican goods. Since Mexico’s trade with Canada is relatively unimportant compared to trade with the United States, I assume that U.S. tariff elimination captures NAFTA’s potential benefits for Mexican manufacturers due to improved market access. I also incorporate information on a plant’s exporting activities and imported input use, as well as data on foreign capital participation across manufacturing industries.6

The basic regression equation takes the following form:

\[ tfp_{it} = T_{jt}B + X_{ijt}\Gamma + \nu_{it}. \] (6)

The elements of vector \( B \) are the coefficients of interest. Matrix \( T_{ij} \) reflects trade and investment variables affecting any plant \( i \) belonging to industry \( j \), while matrix \( X_{ijt} \) capture other relevant plant- and industry-specific factors that affect plant productivity. I consider variants of equation 6 in which the dependent variable is either the level or the change in log TFP in order to measure not only how trade policy affects the level of productivity, but also its growth rate. When looking at TFP levels, however, I consider only those observations in which the plant survives into the next period, so that the same plants enter regressions in TFP levels and TFP changes. Further, this restriction prevents obtaining biased estimates of the coefficients of interest by preventing the inclusion of only the more productive plants in the levels regression, as exiting plants would likely be less productive.7

6 Descriptive statistics on the variables used in this sections appear in Appendix A, Table 3.
7 Muenler (2001) focuses exclusively on the change in log TFP for this reason.
Before presenting the econometric results, two points are in order. First, there are several plant-specific factors that we would expect to affect the estimated TFP level. Unfortunately, the dataset at hand offers few plant controls and, as a result, OLS estimates may be prone to omitted-variable biases. The immediate response to such concern is to exploit the panel attributes of the data to control for plant fixed effects. Unfortunately, some plant attributes for which time series information is missing in the dataset (e.g., foreign ownership) are lost when I implement fixed effects.

A second point to keep in mind is that econometric exercises such as the one I perform might be affected by endogeneity problems in the trade variables. One possibility is that the less productive industries receive greater protection from external competitors. Another is that the United States preferential margin on Mexican imports 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 (Trefler (1993)). All of the above possibilities would bias the coefficient estimates in equation 6.

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 tariff and for the U.S. preferential tariff margin for Mexican goods. According to NAFTA Annex 302.2, tariffs in Mexico and the United States on regional trade are being eliminated from a base rate that reflected import duties in place in 1st July 1991. In addition, tariff phase-out negotiations concluded in July 1992. Therefore, the agreement defined a tariff level affecting each and every product from 1994 onward that does not reflect the productivity level of Mexican industries during the period of analysis. As we saw 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, so NAFTA tariffs...
serve as a good instrument for actual Mexican tariffs on total imports.\textsuperscript{8}

With regards to import penetration in the Mexican market, I adapt the approach proposed by Frankel and Romer (1999) to find an instrument for trade openness based on the gravity equation.\textsuperscript{9} I fit a gravity equation using bilateral Mexican imports at the industry level and use the fitted values of such regressions to get measure of the value of imports in each industry that is uncorrelated with the error term in equation 6; Appendix B provides more detail on this approach. The instrument is highly correlated with the observed imports-to-output ratio across industries.

5.2 Results

Table 2 presents estimation results for some variants of equation 6. The econometric exercises first confirm that heightened import competition that follows the reduction in tariffs and a greater participation of foreign goods in the domestic market raise productivity. Mexican tariffs have a negative and significant impact both on the level and on the growth rate of productivity, confirming some of the findings for other countries discussed earlier. In Mexico, average tariffs fell by 7.5 percent points from 1993 to 1999, mainly as a result of NAFTA. Then, according the point estimates in Table 2, the reduction in tariffs led to an increase in log TFP of 3.75 to 6.5 percent and in the growth rate of TFP of 9.0 percent. In addition, an increase in the ratio of imports to output in an industry is also negatively and significantly correlated with the level and growth rate of productivity. The point estimates indicate that increasing that ratio by one standard deviation (1.062) would increase the level and the growth rate of productivity by roughly 2.1 and 1.9 percent.

\textsuperscript{8}Canada, Mexico and the United States have accelerated the reduction in tariffs for some goods since NAFTA came in effect. Thus, I am careful not to use actual preferential tariffs in North America, but the import duties that were negotiated back in 1992 and that are spelled out in NAFTA Annex 302.2, as the former could also be affected by endogeneity problems.

\textsuperscript{9}Frankel and Romer (1999) use their methodology to assess the impact that trade openness has on growth. Since openness is endogenous, they use the gravity equation to get a measure of “natural openness” —i.e., openness explained by geographic variables such as distance to other countries— which serves as instrument for actual trade openness.
<table>
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<th>Reg 4</th>
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<td>(0.1740)**</td>
<td>(0.1677)<strong>/(0.1677)</strong></td>
<td>(0.1677)<strong>/(0.1677)</strong></td>
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<td>From backward linkages</td>
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<td>(0.0788)**</td>
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<td>Ho: Sum FDI spillovers = 0 - Chi2 statistic</td>
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<td>24.33</td>
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Notes:
(1) All regressions were estimated using two-stage least squares on a panel with fixed effects. Instruments are: (i) NAFTA-negotiated tariffs to control for the potential endogeneity of tariffs in Mexico and the United States; and (ii) a gravity equation-based estimate of imports at the industry level for the imports-output ratio.
(2) All regressions include the following controls: Age, age squared, size, industry output (excluding the plant's own output), capacity utilization, industrial and geographic concentration indices, U.S. consumption, log of exchange rate times US PPI in the industry, and year dummies. Regressions 4 to 9 also include log TFP in year t.
(3) "Mexican tariff" is the ISIC (rev 3) 4-digit industry tariff on world imports, weighted by trade. "US tariff" is the difference between effective tariffs on Mexican imports and on imports from the rest of the world in the industry. FDI variables refer to the fraction of output produced by foreign plants; linkages were calculated using Mexican input-output data as weights.
(4) Standard errors in parentheses
* Significant at the 10% level.
** Significant at the 5% level.
*** Significant at the 1% level.
In addition to opening the Mexican market to North American products, NAFTA also reduced tariff barriers on Mexican goods entering the United States and Canada. Mexican exports since the agreement came into effect have shown a remarkable pace of growth. Importantly, since 1993 the proportion of manufacturing producers that participate in world markets has risen steadily. For example, among those plants in our sample that enter the regressions in Table 2, the proportion of exporters rose from 38 to 44.9 percent. There are also some indications that the preferential margin on Mexican products entering the U.S. market that resulted from NAFTA’s tariff phase-out has increased the probability that a Mexican manufacturing plant becomes an exporter.\textsuperscript{10}

Has the reduction on the duties paid by Mexican products induced higher productivity among manufacturers? As a tentative answer to that question, let us 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. The estimates in Table 2 show that an increase in the preference granted to Mexican goods increases the level of productivity, but not its rate of growth. A one standard deviation increase in the preferential margin (3.361) increases productivity among Mexican manufacturers by 1.7 percent.

To further explore the question of whether exporting activities have promoted efficiency enhancement among Mexican producers, in Table 2 I also report estimates on 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 (1999). Since it is likely that the more productive plants are the ones that engage in exporting activities, I follow Bernard and Jensen (1999) in not estimating a regression of the level of TFP on export variables. The Mexican case confirms

\textsuperscript{10}Unfortunately, the dataset does not allow me to distinguish the destination of a plant’s exports.
Bernard and Jensen’s finding that exporting does not have a positive effect on TFP growth and that, in fact, being an exporter appears to be negatively correlated with productivity growth.

Another result concerns the use of imported intermediate goods in the production process. From 1993 to 1999, the use of imported inputs increased steadily from 27.3 percent to 33.7 percent of all non-wage costs of production. Similarly, the fraction of all plants using imported inputs rose slightly from 48.9 to 51.7 percent during the 6-year span. It is remarkable that the steep devaluation of December 1994 did not dent such growth. Although from the existing information one cannot conclude that NAFTA was solely responsible for the upward trend in the use of foreign inputs, one can hypothesize that the agreement was, at the least, a major contributor to that trend. The econometric evidence in Table 2 shows that the use of imported inputs does have a positive effect on the level of productivity, with an increase by one standard deviation (0.208) in the use of imported inputs increasing productivity by 0.96 percent. In contrast, imported intermediate inputs actually have a negative impact on productivity growth. The latter seemingly puzzling result coincides with a similar finding by Muendler (2001) for the case of Brazil. Muendler argues that the result might be explained by the failure among manufacturers to adjust their production practices to the increased availability of imported inputs in a timely manner.

Last, Table 2 also contains information on whether the presence of foreign producers in Mexican manufacturing affects the performance of other producers in the sector.\footnote{The following discussion is based on ongoing research with Mauricio Mesquita-Moreira (IDB) that looks at the impact of FDI on Brazilian and Mexican manufacturing.} This possibility is of interest since regional integration arrangements seem to have a positive impact on FDI flows [see Stein and Daude (2001)]. In order to analyze whether foreign capital inflows have had a positive or negative impact on the manufacturing sector, I distinguish between intra-industry spillovers, or the effect on plants within the same industry, and inter-industry spillovers that occur as FDI flows to industries downstream or upstream in the production chain. This distinction
follows Kugler (2000), who argues that although foreign producers may prevent spillovers from benefiting their competitors in the same industry, spillovers may indeed occur that favor plants that supply or that purchase goods from foreign manufacturers. I implement this distinction by calculating, first, the share of output produced by foreign plants in each industry. Then, using Mexico’s input-output matrix, I 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. Using Hirschman’s (1958) terminology, the former are industries with whom there are “backward linkages”, while with the latter there are “forward linkages”.

Table 2 reports my findings. First, as in the work by Aitken and Harrison (1999) on Venezuela, intra-industry spillovers have a negative and statistically significant impact on the level of TFP, but not on the growth rate.\(^{12}\) A rise of one standard deviation (0.209) in foreign capital participation in the industry reduces productivity by approximately 2.6 percent. In contrast, FDI 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. If FDI in backward-linked industries rises by one standard deviation, TFP rises by almost 29 percent and its growth rate by around 15 percent, whereas corresponding figures from forward-linked industries are 15 percent and 10 percent, respectively. As an additional exercise, consider what would happen if the share of output produced by foreign plants increased by one percentage point across all manufacturing industries. The point estimates in Table 2 suggest that in that scenario plant productivity would increase by 1.4 percent and its growth rate by 1.0 percent.\(^{13}\)

\(^{12}\)When a plant is foreign-owned, I am careful not to include its output in measuring the share of FDI in the industry to which the plant belongs.

\(^{13}\)That is, \(e^{0.01\times(-.15+1.1+4)} = 1.01359\) and \(e^{0.01\times(7+28)} = 1.00984\), respectively. As the last row in Table 2 indicates, a test that the sum of all FDI coefficients is equal to zero is rejected in all regressions.
6 Concluding remarks

The previous findings indicate that the substantial liberalization of the Mexican economy to trade and investment flows during the 1990s, driven mainly 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 since the early eighties and through the mid-1990s.

To put the findings in perspective, let us consider how productivity would have fared if the economy had not become more integrated to North America and the world at large. Specifically, let us assume that 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 the same levels as in 1993. Using the point estimates of regression 3 in Table 2, as well as the descriptive statistics in Table 3, one can conclude that total factor productivity would have been almost 10 percent lower in 1998 than our data indicate. Thus, NAFTA-led liberalization has offset other forces that held Mexican productivity back during the decade.

As a final remark, one must acknowledge that even though NAFTA was the main mechanism behind the liberalization of the Mexican economy in recent year, 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. Policy makers ought to keep this in mind in the coming years.

Appendix A: Data description

Plant-level data: I use a panel of manufacturing plants from the annual industrial survey (EIA, Encuesta Industrial Anual) collected by Mexico’s INEGI (Instituto Nacional de Estadística Geografía e Informática). EIA includes approximately 6,800 plants, although missing data reduced the number of plants used in this study to around 5,300. The original sample was designed so as to account for at least 80 percent of the value of output in each of 205 industries in the Clasificación Mexicana de Actividades y Productos (CMAP), out of 306 industries in the
manufacturing sector. All plants with more than 100 employees were included in the initial sample. In addition, a random sample of smaller plants was added to the sample and in some cases of all plants in an industry were included. Still, the sample is biased toward medium and large plants.

Although good information exists to explain attrition, the sample was not updated, except rarely, to account for plant entry in an industry. Thus, my analysis includes only plants that existed in 1993 and that either were in operation throughout the period of analysis or that exit the sample because they went out of business; plants that stopped reporting information to INEGI or that shutdown for reasons other than a decision to exit the industry (e.g., a strike) were dropped from the sample.

EIA contains information on the book value of fixed assets, investment, domestic and imported material inputs, hours worked and number of employees, the value of domestic and foreign sales, and the total value of output, among other. Additional plant level information, such as working hours by skill level, was obtained from INEGI’s monthly industrial survey (Encuesta Industrial Mensual) or from unpublished INEGI information. Access to the data was granted by INEGI upon condition of confidentiality.

Industry-level producer and input price indices were obtained from Banco de México’s webpage. Such indices are classified according to the national accounts classifier and were transformed to the CMAP classification using a correspondence table provided by INEGI. An implicit price index for gross fixed asset formation was obtained from INEGI’s Banco de Información Económica database.

**Capital stock:** In order to obtain a series for the stock of capital at the plant level, I used the perpetual inventory method, \( K_{it+1} = (1 - \delta_{it})K_{it} + I_{it} \), where \( K_{it+1} \) is the stock of capital at the beginning of year \( t + 1 \) in plant \( i \), \( I_{it} \) is investment in fixed assets during year \( t \) and \( \delta_{it} \) is the depreciation rate of capital during the year. First, using the implicit price index for fixed asset formation, I transformed investment figures into 1993 prices. Then, for very year, I calculated the depreciation rate using the reported amount of depreciated assets during the year, reported at book value, and the book-value of assets at the beginning of the year. Last, I defined the initial value of the capital stock as the book-value of fixed assets at the beginning of 1993, the first year in my sample, and updated the capital stock series with the investment and depreciation rates found earlier.

**Trade and tariff data:** Detailed trade and import duties data for Mexico and the United States were obtained at the Harmonized System 8- or 10-digit tariff line level, respectively. Mexican data come from INEGI and Secretaría de Economía and, for the United States, from the U.S. Department of Commerce. Mexican tariff information include preferential tariffs applied on specific countries according to the several free trade agreements negotiated by Mexico.

Data were aggregated to the four-digit industry level, according to the International Standard Industrial Classification (ISIC), revision 3, using a correspondence table provided by the United Nation’s Economic Commission for Latin America and the Caribbean (CEPAL (1998)). U.S. tariffs on imports from Mexico and the rest of the world were calculated dividing collected duties by the customs value of imports. In order to obtain Mexican tariff figures at the industry level, 8-digit HS tariffs were aggregated to the 6-digit level using the value of Mexican imports as weights. I then aggregated to the ISIC industry level using U.S. exports to the world, excluding Mexico, as weights.

**Foreign capital participation:** INEGI provided information on the percent of equity owned by foreigners, with some detail on the country of ownership, for the year 1994. Information for other years was unavailable. I assumed the structure of ownership remained unchanged throughout the period of analysis. I defined a plant to be “foreign” if foreigners owned more than 50 percent of equity. With this information at hand, I calculated the fraction of industry output produced by foreign plants in each industry to account for the possibility of spillovers from foreign direct investment. In the econometric exercises, I excluded a foreign plant’s own output when measuring foreign capital participation in the industry to which the plant belongs.

In order to account for the possibility of spillovers from industries upstream or downstream in the production process, I calculate average foreign capital participation in industries with
backward or forward linkages. To this effect, I use intermediate good purchases from and sales to other industries as weights in calculating such averages, relying on an input-output matrix for Mexico provided by the Inforum Project at the University of Maryland.

APPENDIX B: INSTRUMENTING FOR THE ENDOGENEITY OF IMPORTS

As argued in the text, a rise in the participation of imports in the domestic market raises the degree of competition faced by manufacturers, inducing them to reduce inefficiencies and increase productivity. In order to test that hypothesis, however, one must deal with the fact that more productive industries will be better equipped to compete with foreign imports and, as a result, the share of imports in the domestic market will be reduced. To deal with the two way causality between productivity and import penetration, the paper adapts an approach proposed by Frankel and Romer (1999) that relies on the gravity equation to find an appropriate instrumental variable for imports that is uncorrelated with productivity.

Using industry-level bilateral import figures for Mexico with every other country in the world, I fit the following gravity equation:

\[
\ln(IMP_{ijt}) = \ln(GDP_{it}) + \ln\left(\frac{GDP_{it}}{POP_{it}}\right) + fta_{it} + \ln\left(distance_{it}\right) + \ln(land area_{i})
\]
Table 4: Instrumenting for Imports: Gravity Equation Estimation Results

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<tr>
<td>Land area</td>
<td>-0.0824 (0.0201)*****</td>
</tr>
<tr>
<td>Border</td>
<td>0.1628 (0.0529)*</td>
</tr>
<tr>
<td>Common language</td>
<td>1.9744 (0.0711)*****</td>
</tr>
<tr>
<td>Observations</td>
<td>14659</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.6429</td>
</tr>
</tbody>
</table>

Notes:
- Robust standard errors in parentheses.
- Significant at: * 10%; ** 5%; *** 1%.
- Constant coefficient, as well as year and industry dummies, are not reported.

According to the gravity equation literature and to trade theory, one expects Mexican imports to be positively correlated to its partners’ GDP, GDP per capita, having common border or speaking a common language, and sharing an FTA. In contrast, imports are expected to be negatively affected by distance and geographic isolation (being landlocked or an island), and the partner’s land area (which proxies for the size of the domestic market in the partner country). As Appendix Table 4 illustrates, all variables in the gravity equation are significant, except for landlocked, and have the expected sign.

The correlation between fitted and actual values of log imports is 0.8. After transforming to levels, I aggregate bilateral fitted import values across countries in order to get a measure of total Mexican imports at the industry level explained solely by the gravity equation variables.
and that, therefore, is uncorrelated with the error term in equation 6. The correlation between
the ratio of this measure of imports to industry output and the actual ratio is high, above 0.97.
References


