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Sources of productivity growth: Evidence from the Mexican manufacturing sector

Gabriel Montes-Rojas [a,*], Mauricio Santamaria [b]

[a] *Bureau of Economic and Business Research, University of Florida, 221 Matherly Hall, P.O. Box 117145, Gainesville, FL 32611-7145, United States*
[b] *The World Bank, United States*

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Abstract

We study labor and total factor productivity in the Mexican manufacturing sector for the 1994 to 2002 period. Labor productivity increased at an annual rate of 3 percent, while total factor productivity has null or negative growth depending on the methodology used. We conduct several robustness checks by providing alternatives measures of productivity growth. Moreover, we investigate the sources of productivity growth by studying the impact of international trade, investment, quality of the labor force and labor market institutions.

JEL classification: O47; O14

Keywords: Productivity growth; Mexico

1. Introduction

Latin America was characterized by long periods of zero or negative productivity growth. As documented in Fajnzylber and Lederman (1998) for the period 1950–1995, average annual growth of Latin-American total factor productivity (TFP) was 0.2 percent, consisting of timid growth for the period 1950–1979 (0.7 percent), negative growth in the 1980s of −1.7 percent, and recuperation in the 1990s of 1.1 percent. Mexico closely followed this pattern, with an overall average rate of only 0.3 percent.

* Corresponding author. Tel.: +1 352 392 0171x214.
E-mail addresses: rmontes@uiuc.edu, gabrielr@bebr.ufl.edu (G. Montes-Rojas).

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Table 1

Period	Total factor productivity	Labor productivity	Source	Author
1950–1974	2.0%	3.0%	National accounts	Chenery (1986)
1960–1980	1.1%	3.4%	National accounts	Hernández Laos and Velasco (1990)
1963–1981	3.6%	6.0%	Encuesta Anual Industrial	Samaniego (1984)
1983–1989	5.3%	2.1%	National accounts	Hernández Laos (1991)
1984–1990	4.8%	3.3%	Encuesta Anual Industrial	Brown and Domínguez (1999)
1981–1990	−1.84%/−3.33%		National accounts	Loayza, Fajnzylber, & Calderón (2004)
1991–2000	0.41%/0.06%		National accounts	Loayza et al. (2004)

Notes: All the references herein can be found in Brown and Domínguez (1999) except for the last two rows.

Table 1 presents a selection of estimates of productivity growth for Mexico. Although there is considerable variation, all the estimates agree on the sign: negative TFP growth in the 1980s, timid positive growth in the 1990s. However, the variability in the magnitudes suggests that the results are strongly dependent on the methodology used. The first goal of this paper is to contribute to this literature by estimating productivity growth in Mexican manufacturing for the 1994–2002 period. We use different methodologies to check the robustness of our findings. In summary, we find that labor productivity (LP) increased at a yearly rate of 3 percent, while TFP had a negative annual rate of more than 0.6 percent. Overall, these results show that the post-NAFTA (North American Free Trade Agreement) period is similar in several respects to previous decades, despite the occurrence of considerable economic changes.

Studies of Mexican productivity growth and competitiveness are in general motivated by one of the following reasons: measuring the impact of trade liberalization (Clerides, Lach, & Tybout, 1996; Fragoso Pastrana, 2003; Iscan, 1998; Robertson & Dutkowsky, 2002; Tybout & Westbrook, 1995) or testing convergence to the U.S. (Blomstrom & Wolff, 1989) or among states (López-Acevedo, 2002 and Koo, Deichmann, Fay, & Lall, 2002). Undoubtedly, the former is the dominant objective, but the latter attracted researchers' attention after NAFTA. Our paper contributes to this literature by estimating productivity growth for the post-NAFTA period.

Understanding the sources of productivity growth is a key concern of academics and policy makers. The second goal of this paper is to exploit the panel structure of our dataset to identify the elements associated with productivity growth. Bartelsman and Doms (2000) divide the sources of productivity growth into the following broad categories: international trade, quality of the labor force, technology and quality of institutions. We find that both LP and TFP growth rates are higher in sectors that are export-oriented, and those that had the highest investment rates. More interestingly, however, exports are associated with productivity growth only if they are accompanied by high investment ratios. Therefore, exporting *per se* does not guarantee productivity growth.

Moreover, we found that productivity growth was higher in sectors with abundant low-skilled labor (as measured by the average schooling) and with low ratios of blue collar to white collar workers. Finally we found that labor costs are negatively associated with TFP growth.

The paper is organized as follows. Section 2 sets out the theoretical and empirical approach and reviews previous studies of Mexico. Section 3 describes the data sources and assesses their limitations. Section 4 estimates labor and total factor productivity growth in the manufacturing sector and Section 5 analyze the sources of productivity growth. Conclusions are in the final section.

2. Sources of productivity growth

As mentioned above, Bartelsman and Doms (2000) identify four major sources of productivity growth: international trade, technology, quality of the labor force and quality of institutions.

International trade can be related to productivity in three ways. First, high-productivity firms have better prospects of holding comparative advantages and are more likely to overcome the obstacles to accessing international markets. Second, exposure to international competition may allow firms to learn about the latest technologies. Third, exporting allows operating at a more-efficient scale. In our empirical analysis, we cannot separate these three elements, but we can determine whether those sectors that are more export-oriented have higher productivity growth.

It should be emphasized that exporting may not necessarily translate into higher productivity but just more output. If the demand for exports exceeds the production capacities of firms, we may have a negative effect on productivity. Moreover, if comparative advantage rests on the use of cheap natural resources, exports may bring about an appreciation of the currency and thereby create disincentives to upgrade technologies in other sectors (a problem known as Dutch Disease). The same idea can be extended to the use of cheap labor: comparative advantage based on low wages may discourage the acquisition of better technologies.

Iscan (1998), studying the first Mexican episode of trade liberalization (mid 1980s), provides evidence that productivity growth is significantly correlated with the share of imported intermediate inputs in sectoral output and that the share of exports in total output increases average productivity by about 5 percent. However, the effects of trade liberalization on long-term productivity growth are found to be statistically insignificant.

The adoption of “state-of-the-art” technologies is another source of productivity growth. In developing countries, new technologies are embodied in imported capital goods, which means that they have an effect on LP but not on TFP. We evaluate the effect of the acquisition of new capital goods on productivity.

The quality of the labor force and of management may enhance a firm’s productivity. Moreover, a more educated workforce contributes to the adoption of better technologies, as well as appropriate use of it. In Mexico, several studies found a strong positive correlation between human capital and productivity growth.[1] However, if productivity growth occurs in sectors relatively abundant in low-skilled workers, we should encounter the opposite effect. The evidence in this matter is mixed. On the one hand, Esquivel and Rodriguez-Lopez (2003) find that technological progress has a negative impact on the wages of low-skilled workers. On the other hand, Montes Rojas (2006) suggests that after NAFTA and the consequent re-accommodation of resources, a non-neutral technological change occurred that favored low-skilled workers.

Finally, the quality of institutions and of the regulatory environment may affect firms’ decisions and incentives for innovating and investing. In particular, labor-market regulations and institutions play an important role in the determination of productivity growth, because by shifting the optimal level of employment, the adoption of technologies is also altered. Hiring and firing restrictions may raise the cost of labor adjustment which is often required after an innovation occurs. Cross-country evidence presented by Scarpetta and Tressel (2004) suggests a negative relationship between labor adjustment and TFP acceleration. Following Montes Rojas and Santamaría (2007), we construct a measure of the burden of labor costs using the ratio of non-wage costs to total labor costs.[2]

[1] See for instance López-Acevedo (2002), López-Acevedo and Tan (2003), and Canudas (2001).

[2] Two important variables that affect productivity, but cannot be included (because of data limitations) in our empirical analysis, are macroeconomic conditions and financial institutions. The volatility of the macroeconomic environment and

Table 2
EAI – summary statistics

Variable	Obs.	Mean	Std. Dev.	Median	Min	Max
Log Total Gross Production (TGP) (real values)	1845	14.85	1.39	14.86	9.53	19.47
Labor hours (in millions)	1845	16.14	20.79	9.66	0.101	203.3
Log labor hours	1845	2.28	1.09	2.26	−2.29	6.87
Number of workers	1845	6777	8638	4070	51.5	82221
Blue collars/white collars	1845	2.93	1.53	2.74	0.28	11.06
Capital stock*	1845	1.39	1.09	1.10	0.48	19.8
Investment/TGP	1845	0.044	0.058	0.033	0	1.67
#Firms by industry	1845	30.36	25.46	22	3	125
Workers/# firms	1845	251	243	179	12.2	2462

Notes: Encuesta Anual Industrial (EAI) 1994–2002.
* Computed using Method 1 Index (see the Appendix) with base value of 1 in 1994 for every sector.

3. Data sources

In order to estimate productivity trends, we use the *Encuesta Anual Industrial (EAI)*, a panel that covers medium and large manufacturing firms from 1994 to 2002. We also use information about the labor market taken from the *Encuesta Nacional de Empleo* Urbano (ENEU).

EAI. Main productivity patterns are taken from the EAI. It aggregates industries up to more than 205 sub-sectors following the Codificador Mexicano de Actividades Económicas, which allows us to consider as homogeneous goods produced by firms belonging to any sub-sector. For each sub-sector, the EAI covers enterprises that represent more than 80 percent of gross value of production and all firms that have more than 100 employees. In cases where production is mainly undertaken by small firms, the survey has more than 100 firms. The EAI excludes the informal sector (i.e., unregistered firms) and *maquiladora* plants. Therefore, the results obtained in this study are specific to the EAI coverage and may not be extrapolated to other sectors.

Theoretical considerations suggest that differences in efficiency endowments determine the dynamics of the firm, i.e., entry and exit. Measures of productivity may be affected if entering and exiting firms have different characteristics: more productive firms have a higher likelihood of survival and growth than less productive ones.[3] Moreover, technological change at the industry level is associated with the diffusion of technology among new establishments rather than with a simultaneous shift in the production frontier of an existing set of firms. We assume that each industry is a *pseudo-firm*, where changes in the number of firms by industry may be interpreted as internal efficiency changes. In the absence of firms' panel data information, the validity of the estimations crucially depends on the stability of the sample across periods. The composition of the sample determines that we may consider it as *stable*, in the sense that we can ignore possible bias from dynamic selection issues.

Table 2 reports some summary statistics for the EAI sample. The sectors used in this study show considerable variability in terms of output, labor and capital inputs. 50 percent of industries have

market distortions may impair productivity. However, the short length of our panel (1994–2002) is not appropriate for the study of the effect of business cycle variables on productivity. Financial institutions also play an important role for understanding productivity growth. Firms that do not have access to capital markets may be constrained to the use of inefficient technologies, which is naturally reflected in low productivity levels.

[3] See Tybout, 2000 for a discussion.

less than 22 firms and on average there are 30 firms per sub-sector. The average firm by industry employs 250 workers with a similar standard deviation. The ratio of blue collars to white collars has an average value of 2.9, but it ranges from 0.28 to 11, reflecting a variety of compositions of the manufacturing sectors.[4]

ENEU. Additional information about the labor force by industry is taken from the Encuesta Nacional de Empleo Urbano (ENEU), first quarter of each year. We consider only the sub-sample of salaried workers in private firms with more than 100 employees between the ages of 20 to 65. The ENEU industry classification differs from that of the EAI. For that reason, we match both industry classifications on a case by case basis.

4. Productivity in manufacturing

We construct several measures of LP and TFP to check the robustness of our findings. The reader is referred to the Appendix for a detailed definition of the variables used to construct the productivity measures and a description of the methodology. For both measures we obtain output indexes estimates using output (Y) and Value Added (VA). Moreover, we use two different measures of total production: *Total Gross Production* and *Value of Goods Produced*. We employ Index Number techniques for constructing measures of LP and TFP. For TFP, we construct an index of combined inputs using labor, capital and intermediate goods, and the composite index uses a Törnqvist formula, based on user cost shares.

For both LP and TFP we consider two different measures of the labor input: homogenous and heterogeneous. The first one corresponds to the total number of hours worked, while the second disaggregates the number of hours into blue collars and white collars. In addition, two different procedures are applied for measuring the capital stock. Method 1 estimates capital services using the Perpetual Inventory Method, while Method 2 obtains depreciation from the EAI. Although both methods are reported for robustness, Method 1 is our preferred specification.

Tables 3 and 4 summarize the aggregate estimates for the whole EAI set. LP and TFP for the manufacturing sector are weighted by the corresponding output measure in each sector, obtained by the average of the participation of each sector in the period 1994–2002. Following Nordhaus (2001), we call this the *pure productivity effect*, which implicitly assumes that no change in output composition occurred among industries. The tables report an index value with base 1994 for all LP and TFP cases considered here. The last two rows of the tables report average annual growth for the periods 1994–2002 and 1995–2002. In both tables, the first four columns use a homogenous measure of labor (total hours worked), while the last four disaggregate into blue collars and white collars, and it is referred as heterogeneous labor.

LP significantly increases over the period for all measures. Overall, this variable has a weighted average annual growth of 3 percent from 1994 to 2002. We observe that the crisis of 1994–1995 (known as the *tequila crisis*) was accompanied by a decline in LP of about 7 percent. However, there was a rapid recuperation in all the measures of LP. When we exclude the first year, average productivity growth for the period 1995–2002 increases by one percentage point. Using a heterogeneous labor input produces slightly lower estimates of productivity growth, but in every case it follows the same pattern as the homogeneous labor measures.

The evolution of TFP presented in Table 4 is very different from that of LP. All estimations yield negative or zero increments in the TFP: a maximum decline of 4.65 percent and minimum

[4] A detailed description of the employment structure and in the manufacturing sector can be found in Alarcón and Zepeda, 1998.

Table 3
Labor productivity (LP)

	Homogenous labor				Heterogeneous labor			
	Y/L (1)	VA/L (1)	Y/L (2)	VA/L (2)	Y/L (1)	VA/L (1)	Y/L (2)	VA/L (2)
1994	1	1	1	1	1	1	1	1
1995	0.96	0.93	0.96	0.93	0.94	0.92	0.93	0.91
1996	1.13	1.05	1.13	1.06	1.09	1.03	1.1	1.05
1997	1.12	1.04	1.12	1.06	1.1	1.03	1.1	1.05
1998	1.07	1.01	1.07	1.03	1.05	0.99	1.06	1.01
1999	1.11	1.07	1.11	1.09	1.09	1.03	1.09	1.08
2000	1.17	1.12	1.17	1.14	1.14	1.09	1.15	1.12
2001	1.2	1.16	1.20	1.18	1.18	1.13	1.19	1.17
2002	1.27	1.24	1.26	1.23	1.24	1.20	1.23	1.21
Average annual growth 1994–2002	3.24%	2.89%	3.13%	2.79%	2.91%	2.48%	2.85%	2.64%
Average annual growth 1995–2002	4.27%	4.31%	4.15%	4.19%	4.19%	3.97%	4.26%	4.30%

Notes: (1) Using Total Gross Production. (2) Value of Goods Produced.

of 0.6 percent. In general, Method 1 shows bigger TFP growth rates than Method 2. Excluding the critical year of 1995 (where TFP has a decline of up to 19 percent), produces positive increments for Method 1 and less negative values in Method 2.

The zero increment in TFP does not necessarily imply the absence of technological change. On the contrary, the increase in capital goods imports after NAFTA and the overall increase in investment ratios suggest that most improvements in technology were embodied in the acquisition of those goods. It is worth mentioning that in Section 5, a positive correlation between TFP growth and new equipment acquisition is found.

The stagnation or decline observed in TFP can be partially explained by the fact that the period is characterized by an important increase in investment. Therefore, the differences between LP and TFP can be attributed to the acquisition of capital goods, which significantly increased output per worker although it did not increase output enough. Fig. 1 shows that investment (as a proportion of Total Gross Production, INV/Y) in the entire manufacturing sector had a spike in 1996 where it reached a ratio of 5 percent, and a subsequent decline to about 3.5 percent. An inverse pattern was found by Brown and Domínguez (1999) for the years 1984–1990, which led the authors conclude that the increase in TFP during the period was partially explained by the decline in Capital Assets at an annual rate of 3 percent.[5]

Fig. 1 also plots the ratio of imported capital goods to total investment in capital goods (FINVK/INV): this series has a maximum value in 1996 (almost 40 percent of all new capital goods were imported) and then falls to about 30 percent in subsequent years. This reflects the fact that a considerable portion of the modernization of production technologies that occurred after NAFTA was due to the acquisition of technology embodied in imported capital goods. Finally, we also plot the ratio of investment in machinery and equipment to total investment. In

[5] The study attributes this fall to an over-capacity of the sector after the 1982 crisis. Nevertheless, after 1987 investment increased as a result of economic reforms. See also Gelos and Werner, 1998, for a discussion of investment flows during the period.

Table 4
Total factor productivity (TFP)

	Homogenous labor				Heterogeneous labor			
Method 1	Y/(L + K) (1)	VA/(L + K) (1)	Y/(L + K) (2)	VA/(L + K) (2)	Y/(L + K) (1)	VA/(L + K) (1)	Y/(L + K) (2)	VA/(L + K) (2)
1994	1	1	1	1	1	1	1	1
1995	0.93	0.83	0.93	0.83	0.91	0.82	0.92	0.81
1996	0.95	0.86	0.94	0.87	0.92	0.85	0.93	0.85
1997	0.94	0.84	0.94	0.85	0.91	0.83	0.93	0.84
1998	0.93	0.81	0.93	0.83	0.91	0.79	0.94	0.83
1999	0.94	0.84	0.94	0.86	0.92	0.82	0.94	0.86
2000	0.94	0.87	0.94	0.88	0.93	0.84	0.94	0.87
2001	0.94	0.85	0.93	0.86	0.93	0.83	0.92	0.87
2002	0.95	0.86	0.93	0.85	0.94	0.83	0.92	0.84
Average annual growth 1994–2002	−0.60%	−1.64%	−0.87%	−1.79%	−0.72%	−2.06%	−1.00%	−1.89%
Average annual growth 1995–2002	0.31%	0.55%	0.00%	0.38%	0.47%	0.22%	0.00%	0.56%
Method 2								
1994	1	1	1	1	1	1	1	1
1995	0.92	0.83	0.92	0.83	0.89	0.81	0.9	0.81
1996	0.92	0.79	0.92	0.8	0.88	0.78	0.91	0.78
1997	0.9	0.73	0.9	0.74	0.87	0.72	0.89	0.72
1998	0.88	0.68	0.87	0.69	0.85	0.67	0.85	0.67
1999	0.88	0.68	0.87	0.69	0.85	0.66	0.86	0.68
2000	0.88	0.7	0.87	0.71	0.85	0.69	0.86	0.7
2001	0.87	0.68	0.86	0.69	0.83	0.65	0.84	0.67
2002	0.89	0.76	0.85	0.68	0.88	0.73	0.83	0.67
Average annual growth 1994–2002	−1.40%	−3.05%	−1.98%	−4.53%	−1.49%	−3.47%	−2.24%	−4.65%
Average annual growth 1995–2002	−0.46%	−1.06%	−1.12%	−2.75%	−0.13%	−1.25%	−1.13%	−2.60%

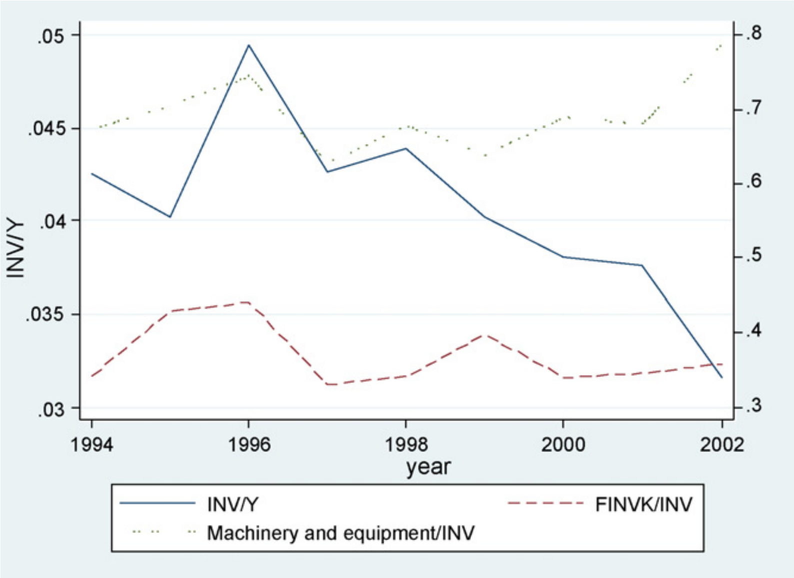

Fig. 1. Investment rates in manufacturing. *Source*: Authors' calculations using EAI.

this case, the figure shows that from 1994 to 2002 this ratio increased by 10 percent (from 70 to 80 percent).

Fig. 2 plots the average rate of productivity growth for both measures. We observe that the bulk of observations lies generally below the 45 degree line as a result of the differences mentioned above. Fig. 3 aggregates at the 8 sub-sectors level and shows non-weighted means and medians. The pattern of productivity growth is not homogeneous across sectors in terms of TFP, although it is relatively stable for LP. Sectors which did not participate in the NAFTA boom (food & beverages, textiles and non-metallic minerals) show positive TFP growth, while those that did (e.g., machinery & equipment) show negative TFP growth. Moreover, the fact that the (non-weighted) mean has a higher value than the median reflects the presence of high-growth sectors that drive our results.

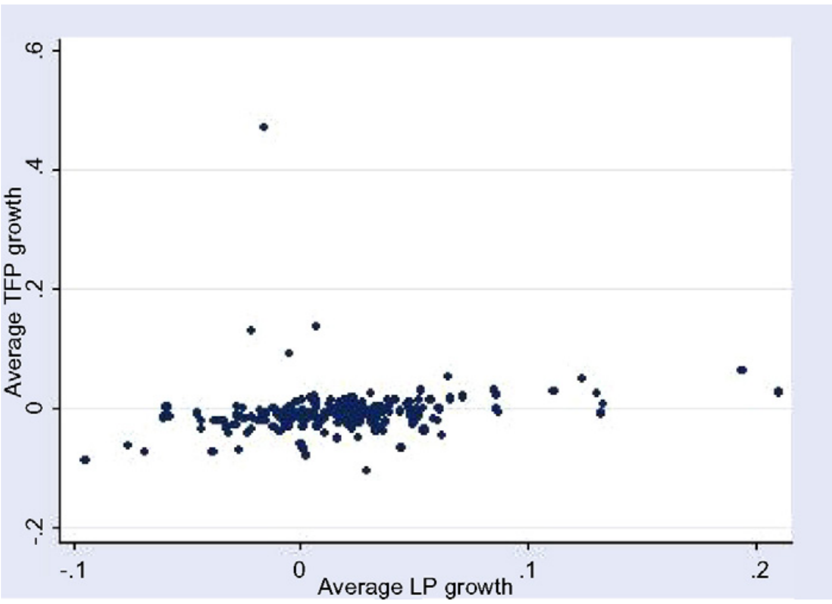

Fig. 2. LP and TFP growth rates. *Source*: Authors' calculations using EAI.

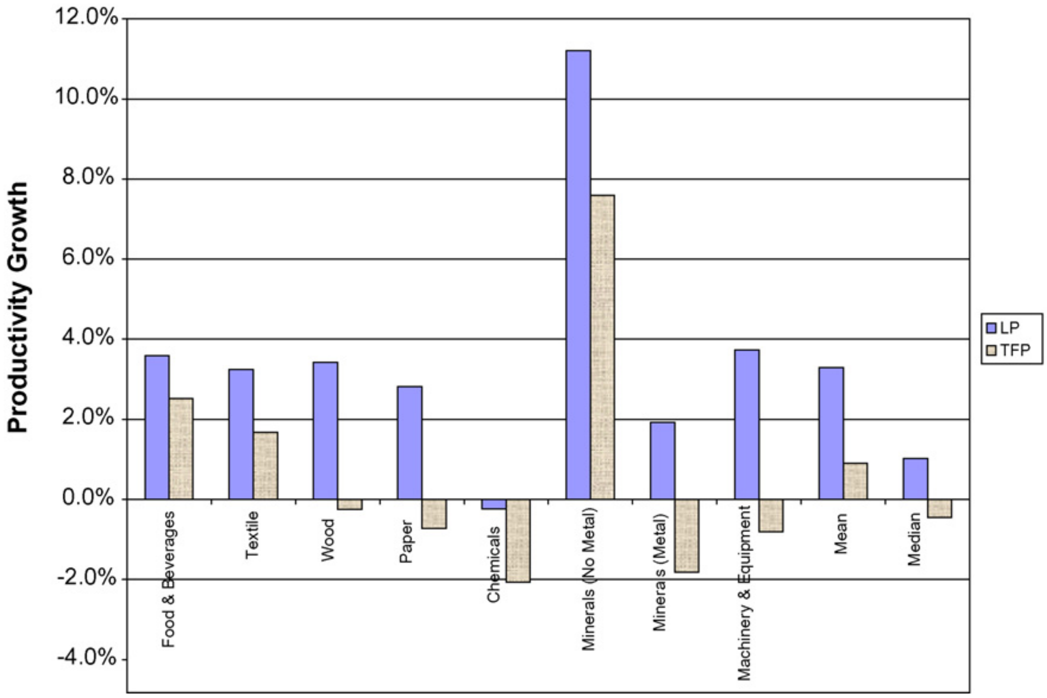

Fig. 3. LP and TFP growth rates by sector. *Source*: Authors' calculations using EAI.

5. Sources of productivity growth

Using the EAI dataset, several empirical issues concerning the sources of productivity can be examined. The baseline specification models the rate of productivity growth as a function of certain covariates. As in Bernard and Jones (1996), we include the maximum rate of growth by year as a separate covariate (Max LP/TFP growth), which allows us to control for technology transfers from the leading industry to the rest of the manufacturing sector. We also include the logarithm of the average size of establishments, that is, the number of workers divided by the number of firms in a given sub-sector (log Size). We use a random-effects specification of 1640 observations and 205 groups.[6] The baseline model is not reported here, but the coefficients of the included variables are of interest. The maximum rate of growth is positively related to LP/TFP, which tells us that productivity shocks are correlated among industries. The average firm size is negatively correlated with LP/TFP which implies that on average productivity growth was higher in medium-size firms than in large firms. This negative sign is not the result of the construction of the productivity series, provided that average firm size is relatively stable over the period of analysis.[7]

5.1. International trade

We include the portion of sales that corresponds to foreign sales (*X*/*Y*). Table 5 shows that sectors whose production is more export-oriented have on average higher LP and TFP growth: a 10 percent increase in the export ratio produces a 1.27 percent increase in annual LP growth

[6] In every case, the Hausman test (not reported) cannot reject the consistency of the random-effects model.

[7] A fixed-effects regression of log Size and its lag gives a coefficient of 0.74 (standard error 0.018), while random-effects specification yields a value of 0.99 (0.0036).

Table 5
Productivity growth sources: international trade

Variable	LP growth	TFP growth
X/Y	0.127**	0.101**
	(0.055)	(0.050)
Max LP/TFP growth	0.003	0.004
	(0.004)	(0.004)
Log Size	−0.027*	−0.030**
	(0.014)	(0.013)
R^2	0.0262	0.0130
Obs.	1640	1640
Groups	205	205

Notes: Random effects model. Productivity measures are obtained using Total Gross Production. In TFP we use Method 1 for calculating Capital Stock. Significance levels: (*) 10%; (**) 5%; (***) 1%. Robust standard errors in parenthesis.

and a 1 percent rise of TFP. These results confirm previous work on the subject, which links international trade to productivity growth.

5.2. Technology

Since technology may be embodied in capital goods (machinery and equipment, a new factory, etc.), productivity changes occur with changes in investment ratios. This raises the question of whether industries which invest more have higher productivity growth. The ratio of investment to total production is used to measure the average increase in capital stock. A simple regression would produce negative results because investment is endogenous with respect to productivity growth (capital is a component in the construction of TFP). In order to overcome this obstacle, we construct the average of the ratio by industry, and we use this variable as a regressor (*MINV*/*Y*).

Table 6 shows the impact of *MINV/Y* on productivity growth. Columns 1 and 2 estimate the baseline model with *MINV*/*Y* only. As expected, this variable has a larger effect on LP than on TFP, but is statistically significant in both cases. Columns 3 and 4 add a variable that reflects the composition of investment: the ratio of investment in machinery and equipment to total investment, MQ. The sign of this variable shows that the type of investment has an important role in productivity growth: for both LP and TFP, MQ is positive and statistically significant. Therefore, we confirm our conjecture that new technologies are embodied in new machinery and equipment.

Finally, models 5 to 8 also contain *X*/*Y* and the interaction of this variable with the *MINV*/*Y* and with MQ, respectively. These interactions are intended to explore a possible channel through which international trade may affect productivity, that is, by increasing in investment and changing the composition of investment.

In columns 5 and 6, we observe different patterns for LP and TFP. LP shows a positive main effect of *MINV*/*Y*, as well as a positive interaction effect, which means that export-oriented sectors are the ones in which new capital goods increase productivity the most. This is in line with the hypothesis that firms facing foreign competition are compelled to adopt “state-of-the-art” technologies. The negative effect of *X*/*Y* can be interpreted as productivity growth in industries that have comparative advantage (i.e., cheap labor), but do not modernize their production processes. In terms of the discussion in Section 2, this negative coefficient can be interpreted in line with the Dutch Disease idea. The TFP results, however, show that exporting does not translate into better

Table 6
Productivity growth sources: Capital goods

Variable	LP growth	TFP growth	LP growth	TFP growth	LP growth	TFP growth	LP growth	TFP growth
MINV/Y	2.981*** (0.395)	2.131*** (0.359)	2.895*** (0.395)	2.015*** (0.358)	1.456** (0.598)	1.628*** (0.545)	1.732*** (0.592)	1.943*** (0.532)
MQ			0.057*** (0.019)	0.076*** (0.017)			−0.114*** (0.031)	−0.128*** (0.028)
X/Y					−0.185* (0.104)	−0.006 (0.095)	−0.611*** (0.119)	−0.514*** (0.107)
MINV/Y * *X/Y*					7.675*** (2.316)	2.448 (2.110)	6.099*** (2.290)	0.580 (2.058)
MQ * *X/Y*							0.710*** (0.103)	0.846*** (0.092)
Max LP/TFP growth	0.003 (0.004)	0.003 (0.004)	0.003 (0.004)	0.003 (0.004)	0.003 (0.004)	0.003 (0.004)	0.003 (0.004)	0.004 (0.004)
Log size	−0.033** (0.014)	−0.034*** (0.013)	−0.037*** (0.014)	−0.040*** (0.013)	−0.047*** (0.014)	−0.041*** (0.013)	−0.049*** (0.014)	−0.045*** (0.013)
R^2	0.0554	0.0315	0.0607	0.0434	0.0641	0.0342	0.0957	0.0925
Obs.	1640	1640	1640	1640	1640	1640	1640	1640
Groups	205	205	205	205	205	205	205	205

Notes: Random effects model. Productivity measures are obtained using Total Gross Production. In TFP we use Method 1 for calculating Capital Stock. Significance levels: (*) 10%; (**) 5%; (***) 1%. Robust standard errors in parenthesis.

Table 7
Productivity growth sources

Variable	LP growth	TFP growth
SCH	−0.021** (0.010)	−0.022** (0.009)
B/W	−0.016* (0.009)	−0.011 (0.008)
X/Y	0.139** (0.056)	0.112** (0.051)
MINV/Y	2.954*** (0.396)	2.097*** (0.359)
Max LP/TFP growth	0.003 (0.004)	0.004 (0.004)
Log Size	−0.034** (0.014)	−0.033** (0.013)
R^2	0.0609	0.0372
Obs.	1382	1382
Groups	204	204

Quality of the labor force. *Notes*: Random effects model. Productivity measures are obtained using Total Gross Production. In TFP we use Method 1 for calculating Capital Stock. Significance levels: (*) 10%; (**) 5%; (***) 1%. Robust standard errors in parenthesis.

use of available technology through more investment. In fact, the exports effect disappears when this variable is interacted with investment ratios.

This line of reasoning is enhanced when we add MQ and its interaction with *X/Y* (see columns 7 and 8). In this case, the coefficient of *X/Y* is negative in both LP and TFP specifications, while its interaction is positive in both cases.

5.3. Quality of the labor force

We take from the ENEU the average years of schooling by industry (SCH)[8] and we create a variable containing the ratio of blue collar/white collar labor hours (*B/W*) from the EAI. Table 7 reports the effect of these variables on LP and TFP. Both variables are negative and statistically significant in the LP and TFP equations. As stated above, this means that the highest productivity growth occurs in sectors dominated by low-skill workers. The sign of *B/W* is in line with the sign encountered in the *log size* variable: industries with larger average firms are also those with the highest ratio of blue collars to white collars.

The negative sign corresponds to our level of aggregation (205 sectors) and, therefore, it does not imply an inconsistency with other studies at the firm level (see Section 2). In fact, this confirms the results of Montes Rojas (2006) showing that the post-NAFTA period was accompanied by non-neutral technological change that favored industries with abundant low-skilled workers. Note that this effect is not driven by the *maquilas*, because they are not included in our sample.

5.4. Labor costs

Traditionally, it has been established that high costs of workforce adjustment have a negative impact on the level of employment. For instance, Heckman and Pagés (2004) find that the effects on employment level are negative and substantial. Moreover, a lower levels of employment reduces

[8] This variable is constructed using salaried workers only in firms with at least 100 employees. We are grateful to an anonymous referee for this suggestion.

Table 8
Productivity growth sources: labor costs

Variable	LP growth	TFP growth	LP growth	TFP growth
NW	−0.219 (0.234)	−0.400* (0.212)	−0.186 (0.241)	−0.346 (0.218)
X/Y	0.107** (0.054)	0.083* (0.049)	0.137** (0.056)	0.108** (0.051)
INVK/Y	2.994*** (0.399)	2.189*** (0.362)	2.997*** (0.399)	2.177*** (0.363)
Max LP/TFP growth	0.003 (0.004)	0.004 (0.004)	0.003 (0.004)	0.004 (0.004)
Log Size	−0.034** (0.015)	−0.029** (0.014)	−0.029* (0.016)	−0.024* (0.014)
SCH			−0.020** (0.010)	−0.020** (0.009)
B/W			−0.016* (0.009)	−0.013 (0.008)
R^2	0.0583	0.0355	0.0613	0.0387
Obs.	1640	1640	1640	1640
Groups	205	205	205	205

Notes: Random effects model. Productivity measures are obtained using Total Gross Production. In TFP we use Method 1 for calculating Capital Stock. Significance levels: (*) 10%; (**) 5%; (***) 1%. Robust standard errors in parenthesis.

the marginal product of capital and incentives to save and invest, which in turn, affect economic growth.

We use the information provided by the EAI to construct a variable that will be a *proxy* for labor costs. Following Montes Rojas and Santamaría (2007), we construct the ratio of non-wage cost to total remuneration (*NW*) as a measure of the burden of social benefits on total labor costs. Table 8 presents the random-effects regression results for this model. On the one hand, the first column shows that NW has no significant effect on LP growth. On the other hand, NW has a significant effect on TFP growth: an increase of benefits of 10 percent results in a decline in TFP growth of 4 percent.

Finally we add *SCH* and *B/W* in order to control for the fact that employment adjustment is generally made for workers whose firing costs are the lowest, namely, young and less skilled employees (workers who receive on average fewer benefits in proportion to their gross wage). Columns 3 and 4 show that the effect of NW is reduced, and it is marginally insignificant for the TFP specification.

6. Conclusions

From an historical perspective, the post-NAFTA period is no different in many aspects from earlier decades. We calculated LP and TFP trends for the manufacturing sector using the EAI. The former increased over the period at an average annual rate of 3 percent, while the latter has zero or negative evolution for the same years: our preferred methodology showed a negative yearly rate of at least 0.6 percent.

We also studied the sources of productivity growth. In particular, we evaluated the effect generated by exports and acquisition of new capital goods (both with a positive effect), and labor costs (negatively correlated with TFP growth). Moreover, we found that productivity growth was higher in sectors with medium-size firms and relatively abundant low-skilled labor. This result is in line with the idea that NAFTA favored sectors relatively abundant in non-skilled labor. Finally, we contributed to the debate about the effect of labor costs on productivity growth. We found that sectors that have a relatively high burden of labor costs (as measured by the ratio of non-wage to total labor costs) have low TFP growth.

Appendix A. Methodological appendix

In this Appendix we present the methodology used for constructing measures of LP and TFP.

Three basic measures of output are used: Value Added (VA), Value of Goods Produced and Total Gross Production. The series are deflated using the Producer Price Index from the INEGI that correspond to the closest industrial aggregation. Fig. A1 presents the evolution of these variables for the whole EAI in nominal terms. While production variables are almost indistinguishable, VA has lower values. This determines that productivity growth using VA will be lower than using production values.

Labor input is estimated using Total Number of Hours Worked for all types of employees and for blue collars and white collars separately. The labor force includes not only time dedicated to production of merchandise, but normal waiting time between processes; time not dedicated to work because of technical failure, etc. Fig. A2 presents the evolution of this variable for the whole sample in comparison with the number of employees. It is observed that both measures have a similar pattern characterized by a decline in 1995–1997. Labor rigidities are present in the dissimilar variation of these series: in a context of recession, the number of employees falls less than the total number of hours, while the reverse is found in an expansion period.

For TFP measures, we construct an index of combined inputs using labor, capital and intermediate goods, and the composite index is done by a Törnqvist formula, using user-cost shares. As is common in the literature, we assume that capital services are proportional to the capital stock. Given that our goal is to construct an index of capital input (flow of productive services), an estimation of the net capital stock (K) in each period would be sufficient for our purposes. We use the Permanent Inventory Method (PIM) that consists of having an initial estimation of K, and updating this by using information on Investment and Depreciation.

We use the variable Capital Assets provided in the EAI 2001 as the reference estimation. Investment is disaggregated into the following categories: Machinery and Equipment, Office Equipment, Transport Vehicles and Construction. The first three series are deflated using the Producer Price Index that closely corresponds to them, while the latter is deflated by the Cost

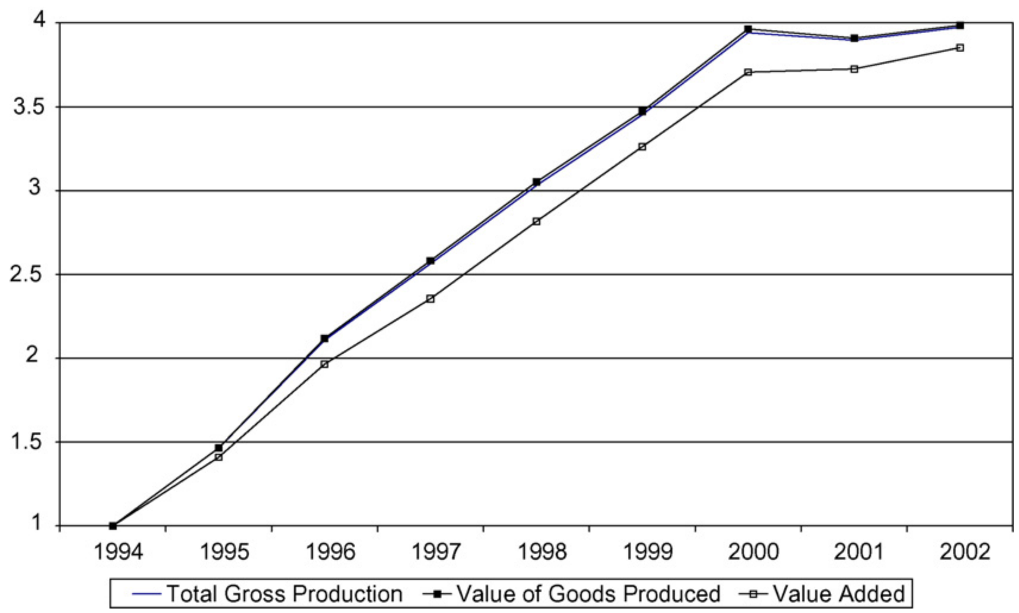

Fig. A1. Output measures.

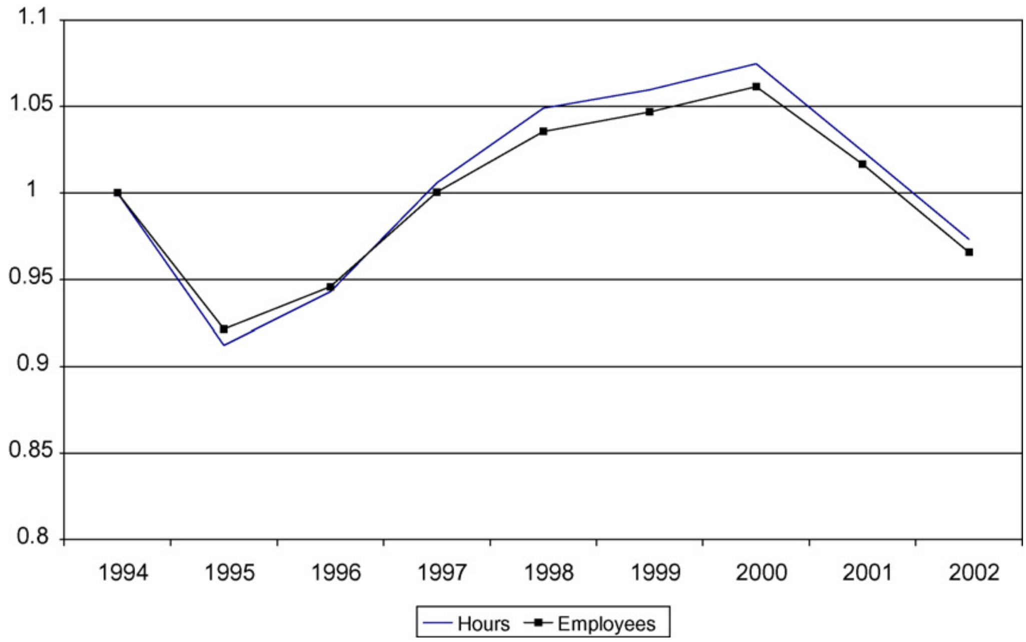

Fig. A2. Labor measures.

Index of Construction. Then, Depreciation is calculated using the lifetime of each type of asset given in the OECD (2001) manual. The depreciation rate is calculated as a weighted average of the implicit rate in a linear mortality pattern. Below is the lifetime and depreciation rate for each type of asset considered here:

Capital asset	Lifetime	Depreciation rate
Machinery	15	0.111
Office eq.	15	0.111
Vehicles	15	0.111
Construction	30	0.059

Alternatively we apply the PIM to the information provided in the EAI, that is, using the same reference capital stock and taking Depreciation and Gross Fixed Investment as given in the questionnaire for constructing the K series (Method 2). We use the 2001 Capital Assets estimated in terms of replacement value net of accumulation of depreciation. The EAI provides information on Depreciation based on firms' calculations. This estimation has two major drawbacks. First, companies may report depreciation for tax-purposes. In this case, firms then to over-estimate the real value of capital consumption. Second, consistency across sectors cannot be checked, and this may create biases when aggregation of productivity measures is needed. In consequence, this method provides a Depreciation estimate which is extremely high and it determines higher growth of K (see OECD, 2001, chapter 6 for a discussion about the Depreciation provided by Company Accounts).

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