Productivity Effects on Mexican Manufacturing Employment before and after NAFTA

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CID Working Paper No. 152
November 2007

Working Papers
Center for International Development
at Harvard University

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Keywords: employment, labour productivity, Mexico, total factor productivity, panel data methods

JEL codes: J23, J24, L60, O47

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Abstract: A vast literature employs vector autoregressions (VAR) methods in order to capture whether innovations in productivity lead to increases or decreases in employment for U.S. manufacturing. Studying 25 Mexican manufacturing industries with annual data from 1984 to 2000, we examine labour productivity (value added per employee) and total factor productivity (TFP) effects on Mexican manufacturing employment. We find that productivity measures vary considerably in Mexico. Making use of panel data methods that control for sector specific effects, the business cycle and real wages, interesting results emerge. First, there are strong positive impacts of TFP (without and with human capital) on manufacturing employment, as well as ambiguous effects of labour productivity on employment. Second, the capital stock effect on employment varies across periods, yielding a positive impact for post-NAFTA and for the overall period. We interpret the latter as evidence that the increase in FDI inflows in the post-NAFTA period has made capital a stronger complement to labour more recently.

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1. Introduction

There is now a vast and rapidly growing literature on how globalization (e.g., the combination of trade liberalization, outsourcing of labour positions, and growing FDI inflows) affects income inequality in developing countries. Attanasio et al. (2004) contains representative evidence for Colombia and Goldberg and Pavcnick (2007) provide a comprehensive and recent survey for developing economies, while Anderson (2005) reviews the impact on individual income. With more capital inflows and with capital utilization requiring skilled labour, this is expected to create a higher demand for skilled workers as testified by the literature on skill-biased technical change (SBTC) covered by Acemoglu (2002).[1]

As contentious as the literature on income inequality (wage differentials) may be, there is an equally interesting (yet less explored) story if one confines the analysis to observe the effects of globalization on sectoral employment. Indeed, there is an established literature employing vector autoregressions (VAR) methods to capture whether innovations in productivity lead to increases or decreases in employment with mixed results for U.S. manufacturing. Galí (1999), for instance, documents negative effects and Chang and Hong (2006) argue otherwise based on the aggregation of 458 4-digit U.S. manufacturing industries for the period 1958-1996. They show that technological improvements raise employment in most U.S. industries.

Having in mind the potential effect of globalization in an increasingly open economy like Mexico, it seems natural to question how factors such as trade integration, capital mobility and outsourcing might affect Mexico's productivity and how productivity can impinge on overall employment. Several studies have examined the

[1] On SBTC, see, among others, Autor et al. (1998), Berman et al. (1998), and Beaudry and Green (2005). For Mexico, in particular, see Esquivel and Rodríguez-López (2003), Robertson (2004), Verhoogen (2007), and Mollick (2007). For the effect of trade openness on relative wages in Mexico see, for example,

evolution of Mexico's productivity. Iscan (1998), for instance, examines the trade liberalization policies adopted by Mexico after 1986 and their positive effects on productivity. Comparing the performance of Chile and Mexico during the 1980s, Bergoing et al. (2001) report a steady decline in Mexico's TFP during the 1980s and first part of the 1990s. Similar evidence for aggregate productivity is observed by Lederman et al. (2005) and Loayza et al. (2004). Likewise, studying Mexico's manufacturing industry, Montes-Rojas and Santamaria (2007) report a positive rate of labour productivity and a negative, null or slightly positive TFP evolution during the post-NAFTA era, depending on the methodology employed and whether or not they consider 1995 in their estimations.

To the best of our knowledge, there are no studies examining the impact of TFP changes on the Mexican labour market, although some studies examine labour productivity and conclude that "the disappointing wage performance has occurred despite the fact that Mexican worker's productivity has increased since NAFTA took effect." Polaski (2004, p. 9). Related literature sheds light on this issue from different angles. For a cross-section of countries, Hall and Jones (1999) show that more open policies increase income per capita for a wide range of countries. Using plant level data for Colombia, Eslava et al. (2004) find that market reforms are associated with rising overall productivity that is primarily driven by reallocation away from low- and towards high-productivity businesses. In addition, a large body of theoretically work takes the standard viewpoint that trade occurs due to comparative advantage. Ferreira and Trejos (2006), for example, predict that tariffs and other trade barriers will be negatively correlated to TFP and poor countries with protectionist policies will have lower level of capital and output.

We measure in this paper the effects of changes in productivity and in capital stock on Mexican manufacturing employment. As such, we capture standard textbook

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Feenstra and Hanson (1997), and Feliciano (2001). For greater trade openness helping cost reductions in Mexican manufacturing, see Tybout and Westbrook (1995).

approaches to the demand for labour, such as Abel et al. (2008), who study the negative and steady relationship between the marginal product of labour (MPL) and L shifted by changes in productivity and/or capital stock. An increase in productivity would lead to a shift in the demand for labour outward since a beneficial supply shock increases MPL. By giving each worker more machines and equipment to work with, a rise in capital stock would also increase MPL and shift MPL up and to the right. Since our focus is on the effects of productivity changes on employment, the analysis operates through shifts in the labour demand curve. The alternative viewpoint by Jayachandran (2006) looks at how wages respond to fluctuations in productivity using a labour supply framework.

This paper revisits this issue under a panel data framework as a complement to the VAR approach in which TFP innovations (shocks) affect employment or hours worked. Data considerations based on Nicita and Olarreaga (2006) guide our methodology for the Mexican case since, at best, we would have 28 industries with required data. Eliminating the sectors with missing or incomplete data, the remaining 25 sectors have full data on output (real sector GDP), capital stock (gross fixed capital formation), value added and employment. This enables us to fully estimate TFP (under a standard and an augmented specifications that allows for human capital considerations) and labour productivity (calculated as the ratio of valued added to labour), ranging from 1984 to 2000 across 25 Mexican manufacturing industries.

By paying particular attention to the effects of NAFTA on productivity and employment, our analysis proceeds by using a panel data methodology. Our major results are as follows. We confirm the findings by Montes-Rojas and Santamaria (2007) that productivity measures fluctuate considerably in Mexico’s post-NAFTA era. The evidence presented gives account of considerable variability among productivity measures; specifically between labour productivity (VA/L) and alternative measurements of TFP, with and without accounting for human capital. Next, following Chang and Hong (2006), a bivariate model specified to explain the effects of productivity on employment is shown to have a very poor empirical fit but a trivariate model controlling for sector real capital (K) provides much sharper results, also in line with the theory.

Considering these findings, we finally make use of a multivariate model that, besides controlling sector specific and business cycle effects, also incorporates the effects of real wages and employs several alternative instrumental variables (IV) specifications to handle endogeneity concerns and potential measurement errors problems. Two sets of results are provided. First, there are strong positive impacts of TFP (without and with human capital) on manufacturing employment, as well as ambiguous effects of labour productivity on employment. Second, we find that the capital stock effect on employment varies across periods, yielding a positive impact for post-NAFTA and for the overall period. We interpret this as evidence that the increase in FDI inflows in the post-NAFTA period has made capital a stronger complement to labour in the more recent years.

2. The Data

We have originally 28 manufacturing industries in the database provided by Nicita and Olarreaga (2006). For Mexico, data relevant for the production functions are available until 2000 only. One (3 digit ISIC code 354: miscellaneous products of petroleum and coal) had negative gross fixed capital formation numbers for 1999 and was eliminated. Two of them (code 323: leather goods and code 353: petroleum refineries) had data only from 1994 onwards and were also eliminated from our study. This leaves 25 industries aggregated at the 3-digit code, whose levels of employment, capital stock, and production vary substantially over the period. While data are available for 17 industries from 1976 to 2000, we decide to take only the period from 1984 to 2000, given the upward movement in the figures in the 1984 year. We then break the full sample (1984-2000) into two subsamples of 1984-1993 (pre-NAFTA) and 1994-2000 (post-NAFTA).[2]

TFP is calculated in two alternative ways: with and without accounting for human capital. We denote those two productivity measurements as TFPH and TFP, respectively. Both of them are derived from a typical Cobb-Douglas production function with constant returns to scale. Human capital is computed as the product of the average years of schooling for the population over the age of 25 years and the total number of employees in each industry. Average years of schooling are extrapolated from Barro and Lee (2000) database on educational attainment. In addition to TFP and TFPH, we calculate the ratio of value added to total labour in each industry (VA/L) as an alternative measure of labour productivity.

Table 1 lists the 25 manufacturing industries in the sample and reports the average growth rates of labour (L), TFP, TFPH, VA/L, real output (Y), real wages (W) and real capital (K) before and after NAFTA. In Table 1, stars mark lower average growth rates in the post-NAFTA era. A first glance at the overall average growth rates suggests that in most cases manufacturing labour and both measurements of TFP (without or with capital) grew faster in the post-NAFTA era but not labour productivity.[3] Nonetheless, this is not consistently observed in every individual manufacturing industry. Out of 50 post and pre-NAFTA occurrences, labour keeps an indirect relation with TFP in 25 occasions, with TFPH in 24 and with VA/L in 27. The panel correlation coefficients between labour, TFP, TFPH and VA/L are in fact considerably low for the first two productivity measures

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[2] We also created another sample with the 17 industries which had complete data from 1976 to 2000, which included the upward shift in 1984. Since we do not have a good explanation for the abnormal break in 1984, we prefer to focus on the sample covering 25 industries running from 1984 to 2000.

[3] Assuming the standard growth-accounting approach with $Y = AF(K,L)$, by differentiation with respect to time and rearranging one gets $\Delta Y/Y = \Delta A/A + a_K \Delta K/K + a_L \Delta L/L$, where: a_K and a_L are capital shares and labour shares, respectively. Under constant returns to scale, $a_K + a_L = 1$. Substitution into the growth-accounting equation and subtraction of $\Delta L/L$ from both sides yields: $\Delta Y/Y - \Delta L/L = \Delta A/A + a_K (\Delta K/K - \Delta L/L)$. Since the capital/labour ratio usually grows, the equation implies that the growth rate of average labour productivity is generally higher than the growth rate of TFP.

(0.05 and 0.03) and unexpectedly negative for the later (-0.08). This confirms that the relation between labour and productivity is not straightforward and suggests that other factors might be also playing a role.

Labour also shows a strong response to the business cycle. In Table 1 we observe a highly consistent pattern of labour and output expansions (contractions) for the pre and post NAFTA periods. A labour contraction (expansion) is directly related to an output fall (raise) in 42 of the 50 pre and post-NAFTA periods. The association between both variables is quite high with a correlation coefficient of 0.86, much larger than the correlation coefficients for TFP, TFPH or VA/L. A similar pattern is observed for the capital stock, despite keeping an indirect relation with labour in 23 of 50 occurrences, this variable also presents a strong correlation with labour (correlation coefficient of 0.67). Finally, with respect to real wages, we observe they performed worst in the post-NAFTA period in all but one industry (ISIC 385 on Professional, Scientific and Controlling Equipment). This in fact reflects the circumstances faced by real manufacturing wages following the depreciation of the Mexican peso at the end of 1994. This latter finding puts the relation between wages and labour at odds with what a one-sided theory of labour demand would predict by showing a slightly positive correlation coefficient of 0.05.

[Table 1 here]

In order to visually observe the dissimilar behaviour of labour productivity and TFP (with or without accounting for human capital), in Figure 1 we plot the performance of our three alternative productivity measures for ISIC industry 381, fabricated metal products. The plot makes clear that TFP and TFPH follow a smoother behaviour than VA/L. It also shows that VA/L grows significantly after 1994. This improvement in VA/L is partially explained by the decline in the labour force that followed the considerable depreciation of the Mexican peso at the end of 1994 and the subsequent recession. Meanwhile, TFP and TFP maintain a steady development despite the aforementioned recession experienced by the Mexican economy.

As noted by Chang and Hong (2006), TFP is the "natural measure for technology because labour productivity reflects the input mix as well as technology". Intuitively, a higher VA/L may reflect higher worker productivity because more machines are available. On the other hand, TFP simply measures the contribution of all other inputs than capital (physical and human) and labour to economic growth. In the light of those significant variations in employment and productivity measures just observed, the following section employs a panel data approach that allows us to effectively control for potential cross-sectional and business cycle effects.

3. The Empirical Methodology

We consider panel unit root tests and incorporate lagged first-differences to account for serial correlation in the employment series. The equation below is estimated for each of the panels discussed earlier:

$$\Delta L_{it} = \alpha_0 + \alpha_1 L_{it-1} + \sum_{j=1}^{k} \alpha_{ij} \Delta L_{i\,t-j} + \nu_{it} \qquad (1),$$

where: L_{it} is the employment figures (number of persons employed) in manufacturing sector i at time t, Δ is the first-difference operator, and k is the number of lags. We report below the panel unit root tests proposed by Levin, Lin and Chu (2002), denoted LLC, and Im, Pesaran and Shin (2003), denoted IPS, with the Schwarz criterion employed for lag-length selection. The null hypothesis of unit root is $\alpha_1 = 0$; failure to reject the null is evidence in support of a unit root in the series. We also employ (1) on all other relevant series in this study: VA/L, TFP, TFPH, K, Y, and W.

The empirical methodology estimates the following panel data model for the impact of productivity on manufacturing employment (L_{it}):

$$L_{it} = \beta_0 + \beta_{1i} + \beta_2 A_{it} + \varepsilon_{it} \qquad (2),$$

where: the parameter β_{0i} represents unobserved sector specific fixed effects and A_{it} captures productivity levels calculated as explained in Section 2: labour productivity (VA/L), TFP abstracting from Human Capital and TFPH considering Human Capital. The coefficient β_2 is expected to be positive in (2) if increases in productivity lead to labour expansions as in Chang and Hong (2006) for U.S. manufacturing: the **procyclical productivity case**. On the other hand, β_2 is expected to be negative in (2) if increases in productivity lead to labour saving decisions as in Galí (1999): the **countercyclical productivity case**.

The fixed effects control for factors that vary across industries but are time invariant. The individual fixed effects may be either assumed to be correlated with the right hand side variables (fixed effects model: FEM) or be incorporated into the error term (random effects model: REM) and assumed uncorrelated with the explanatory variables.[4] Lamb (2003) argues that the choice between these two models is complicated when any of the right hand side variables are subject to measurement error. Hence, in addition to implementing conventional Hausman specification tests to decide upon the econometric model to adopt in each case, latter on we employ a pooled IV technique.

[4] We perform Hausman tests on the product of the difference between the parameter vector estimated by FEM and the vector estimated by REM and the covariance of the difference. See Johnston and DiNardo (1997) and Greene (2003). We conduct both set of estimations and report below the results from either the FEM or REM, which varied across specifications.

This allows us to handle endogeneity concerns as well as measurement error problems, particularly those affecting our estimated productivity figures.

In order to ease interpretation of the coefficients, we take logarithms on the series in both sides of the equation. It is unlikely, however, that the bivariate model in (2) captures the data generating process (DGP) since, as we observed earlier, employment decisions are also a function of the business cycles. In fact, in a boom firms may wish to expand employment faster than in recessions. It is thus important to control for business cycle components. Allowing for capital effects leads us to the augmented model below:

$$L_{it} = \beta_0 + \beta_{1i} + \beta_2 A_{it} + \beta_3 K_{it} + \varepsilon_{it} \qquad (3),$$

where: K_{it} is the real stock of capital of industry i at time t (nominal gross fixed capital formation deflated by the price level)[5]. Allowing for productivity and capital stock would also capture standard textbook approaches to the demand for labour. Abel et al. (2008), for example, define the marginal product of labour (and the wage rate) on the vertical axis against the amount of labour (L) on the horizontal axis. The negative relationship between MPL and L characterizes the demand for labour, which may be shifted by productivity and capital stock. An increase in productivity would lead to a shift in the demand for labour outward since a beneficial supply shock increases MPL. By giving each worker more machines and equipment to work with, a rise in capital stock would also increase MPL and shift MPL up and to the right.

A more elaborated way of deriving a labour demand equation is to proceed as in Barrell and Pain (1997, 1999). Assuming a Cobb-Douglas function given by $Y_{it}=A_{it}K_{it}^{\gamma}L_{it}^{\sigma}$,

[5] Another possibility, although prone to endogeneity, would be to let the shift factor be business cycle conditions more generally. We could allow for Y_{it} as the real output of industry i at time t.

obtaining the marginal productivity of labour $\left(\frac{\partial Y_{it}}{\partial L_{it}}\right)$ and equalizing it to the real wage (W), we obtain that $W_{it} = \frac{\beta A_{it} K_{it}^{\gamma}}{L_{it}^{1-\sigma}}$. Solving this identity for L_{it} and log-linearising the resulting expression leads us to

$$L_{it} = \beta_0 + \beta_{1i} + \beta_2 A_{it} + \beta_3 K_{it} + \beta_4 W_{it} + \varepsilon_{it} \qquad (4),$$

where W_{it} is the average real per capita wage in industry *i* at time *t.* This is obtained by deflating the wage bill in each industry *i* by the price level and dividing by the number of employees[6].

We explore the panel structure in the dataset, by estimating (2) to (4) using the feasible generalized least squares (FGLS) random-effects or fixed-effects models with cross-section weights and allowing for seemingly unrelated regression (SUR) weights for the variance-covariance matrix. These are appropriate when the residuals are both cross-section heteroscedastic and contemporaneously correlated. Application of the FGLS on a lagged dependent variable may result in biased estimates if the contemporaneous error term is correlated with any time average of the lagged dependent variable. In the present setting, there is no lagged dependent variable and we make use of the result in Pirotte (1999), who shows that the probability limit of the between estimator of a static relation converges to the long run effects. The weights and coefficients are updated continuously until convergence.

We conduct two serial correlation tests derived from the Lagrange Multiplier (LM) Breusch-Godfrey test. For each panel equation, a two-step procedure is

[6] In equation (4) we have that β_0=lnσ/(1-σ), , β_2=1/(1-σ), β_3=γ/(1-σ) and β_4=1/(σ–1). Barrell and Pain (1997, 1999) assume a CES production function for K and L. A derivation of the impact of an exogenous

implemented. The computed residuals of each model are regressed on the model's independent variables and on the (lagged one period) residuals. The results suggest serial correlation across all specifications, with higher statistic values for the bivariate models. For this reason, the standard errors reported are subject to both heteroscedasticity and autocorrelation.

Since (4) has the real wage on the right hand side, an instrumental variables procedure is implemented within the pooled IV context. After experimentation, instruments used were current exports and imports (X_t and M_t) and lagged output (Y_{t-1}) series, which are all statistically significantly on wage regressions as function of all of them at the right hand side. The empirical fit turned out to be good and formal tests suggest the IV equation is properly specified. We also experimented Barrell and Pain (1997)'s usage of current and lagged output as well as lagged real wages and several other sets of instruments.

4. Empirical Results

LLC and IPS panel unit root tests for the variables employed in our three different panel specifications ((2) to (4)) are reported in Table 2. For employment and TFP productivity levels, the unit root null is clearly rejected at the 1% significance levels for all panels. This suggests that the series of the bivariate DGP in (2) are clearly stationary under the panel structure. For labour productivity (VA/L), the unit root null is clearly rejected at the 1% significance levels by the IPS test but not by the LLC test. For output, the null is rejected by the LLC test at the 1% level but not for the IPS test. For capital stock, the null is rejected at the 5% level by LLC only. Since real wages (wage bill in constant prices deflated by producer prices) per sector's employee showed no discernible trend, we report

source such as FDI (which should affect technology) on labour demand can be found in Driffield et al. (2005). See also Hansen et al. (2006) for a recent survey.

both tests: with constant only and with constant and trend. In both cases, the unit root null can be rejected for wages as well. Based on the results from Table 2, it is fair to assess that, for any of the specifications in (2) - (4), the panel unit roots reject the null, suggesting stationarity of the series in most of the cases.

[Table 2 here]

Table 3 reports the estimates of the simple bivariate model (2) with only productivity (either labour productivity or TFP) as regressor. This conforms to the VAR literature initiated by Galí (1999) in that a bivariate model is assumed for productivity and employment. The method of estimation is the REM since the null suggesting that a REM is the right choice is never rejected. The values of the χ^2-distributed Hausman statistic are not reported but invariably suggest the REM can not be rejected in the bivariate specification (L, A).

The employment response for the full sample is mixed and at odds with what one expects partitioning the sample into two subsamples. While sector employment responds positively to TFP movements for the pre-NAFTA sample (between 0.155 and 0.158), the evidence on labour productivity effects varies: none for the whole and post-NAFTA period, and negative and statistically significant for the pre-NAFTA (-0.247). The model fit in (2) is quite low with not more than 7.3% (pre-NAFTA subsample) or virtually 0% (post-NAFTA subsample) of the employment variations explained by TFP fluctuations. The fit for the labour productivity models is similarly poor. Because of these findings and since (not reported) LM serial correlation tests indicate serious problems in Table 2, we move into the augmented model (3).

[Table 3 here]

The augmented models for employment at the sector level take into account capital effects in what can be seen as a business cycle version of the bivariate model (2). As already mentioned, this modification captures standard textbook approaches to the demand for labour, in which the negative and steady relationship between MPL and L is shifted by changes in productivity and/or capital stock. Contrary to Table 3, there is now evidence supportive of FEM throughout. The values of the χ^2-distributed Hausman statistic are very high and the REM can always be rejected. The FEM method is thus employed. Intuitively, allowing for anything else than productivity (e.g., capital stock or wages) makes the additional regressor be correlated with the country fixed effects.

Table 4 reports several interesting findings for equation (3) under the FEM feasible GLS approach. First, the effect of TFP on sector employment rate is statistically positive and significant, although less than proportional for both sub-samples, varying from $\beta_2 = 0.302$ to $\beta_2 = 0.368$ for the full sample and, similar values for the first sub-sample and smaller values ($\beta_2 = 0.167$ or 0.162) for the post-NAFTA subsample. In all these cases, increases in TFP lead to increases in employment. That is not the case for labour productivity, which has deleterious effects on employment for the full sample (-0.355), for the pre-sample (-0.116), and for the post-NAFTA sample (-0.108). The evidence consistently suggests that non-input effects associated to technological progress tend to have an unambiguously positive effect on employment, whereas labour productivity has its effect on employment as predominantly negative.

Second, taking into account education levels the human capital TFPH effect is also positive and very similar to those reported under TFP figures. Third, increases in capital fluctuations have a positive effect on employment. Other than the small negative (-0.035) in the pre-NAFTA subsample for the value added to labour productivity measurement (VA/L), our findings are consistent with a positive impact of capital fluctuation on employment as conjectured in (3). This would imply that labour and capital are complements in manufacturing, and the relationship is stronger for the post-NAFTA sample: coefficients varying from 0.110 to 0.126 versus closer to zero values in the pre-NAFTA. As the level of capital stock expands sector employment increases; with higher coefficients found for the post-NAFTA subsample. Fourth, the model specification is much better than in the bivariate model as can be verified from the adjusted R^2 and formal (not reported) serial correlation tests.

[Table 4 here]

A further modification allows the real wage to appear as regressor following the literature on empirical labour demand. As shown in equation (4), given our purposes of checking productivity changes on manufacturing employment, we let technical progress depend on the stock of capital, real wages and on productivity, with productivity measured by either VA/L or TFP (without or with human capital).

We implement error-orthogonality tests similar to those used by Revenga (1992, p. 274), in which the two-stage least squares residuals are regressed on the set of instrumental variables. The statistic formed by N times R^2 from this regression, where N equals the degrees of freedom from the original equation, asymptotically follows a chi-squared distribution. We report the latter statistic in Table 5 right below the coefficients. A weak relationship between the residuals and the instruments would indicate that the equation is properly specified. As clear from the row named "χ^2-stat. for IVs", the statistic of the null of no misspecification is not rejected at any relevant significant level.

After experimentation, current exports and imports and lagged output series were found to serve well as instruments. These series were employed as instruments to estimate an IV panel data model. We also experimented Barrell and Pain (1997)'s usage of current and lagged output as well as lagged real wages as instruments with limited success. The pre-NAFTA specification under VA/L, in particular, was severely misspecified with extremely large point coefficients and standard errors, along with negative adjusted R^2 statistics.

As Table 5 makes clear, the full sample and sub-samples suggest a fairly positive impact of productivity on Mexican manufacturing employment. For the full sample, the coefficient values vary from the very high coefficients under VA/L to 1.347 and 1.140 for TFP without and with human capital, respectively. These responses imply that technological advances lead to increases in manufacturing, consistent with the theory. Smaller values are found for the sub-samples: for the pre-NAFTA sample range, they vary between 0.530 and 0.652; and for the post-NAFTA sample they vary between 0.791 and 0.802. For the first column when labour productivity is used as the productivity measure, the estimated coefficient is too high (6.973) as is the wage elasticity (-3.724), leading to a much worse specification as captured by the adjusted R^2.

Allowing for endogenous wages through IVs, a rise in productivity leads to increases in employment at Mexican manufacturing. There is an important distinction on the capital stock effect, however. While the full sample appears to have a positive coefficient for capital stock when TFP measures are adopted - from 0.426 (without human capital) to 0.472 (with human capital) - this result is also present only for the post-NAFTA period (0.198 to 0.224). Capital and labour are complements only for the post-NAFTA period, presumably capturing large increases of FDI inflows into Mexico in the more recent period. Wages have the negative effect as expect overall and weaker and not statistically significant effects in the sub-samples. The positive sign and the statistic significance of β_2 confirm the results reported in Table 4 without wages. Overall, the Mexican economy has its manufacturing sector responding positively to productivity changes whenever productivity is captured by TFP.

5. Concluding Remarks

We study the role of productivity changes in the Mexican manufacturing labour market. The evidence presented gives account of considerable variability among productivity measures; especially between labour productivity (VA/L) and alternative measurements of TFP, with and without accounting for human capital. Following this finding, we employ a panel data approach to explore the relationship between productivity and labour. Making use of several alternative specifications that control for factors such as sector specific effects, the business cycle and real wages, we find consistent evidence suggesting that increases in TFP lead to increases in employment by Mexican manufacturing firms. The capital stock effect on employment varies across periods, yielding a positive impact for post-NAFTA and for the overall period. We interpret this as evidence that the increase in FDI inflows in the post-NAFTA period has made capital a stronger complement to labour in the more recent years.

We observe that non-input effects associated to TFP movements exert an unambiguously positive effect on employment. Our findings are consistent with Abel et al. (2008) theoretical remarks, higher productivity produce an outward shift of the labour demand, when productivity is measured by TFP but this result does not hold for labour productivity (VA/L). As in Chang and Hong (2006), our estimates suggest a positive impact of TFP on employment but a less clear impact of labour productivity on employment. Since productivity measures vary considerably, one implication of this study is that researchers should try to make use of more detailed datasets such as the one from Nicita and Olarreaga (2006) used in this paper. Not doing so would lead to misleading employment results based only on labour productivity.

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Figure 1. TFP, TFPH and VA/L Behaviour over Time for Industry 381: Fabricated Metal Products

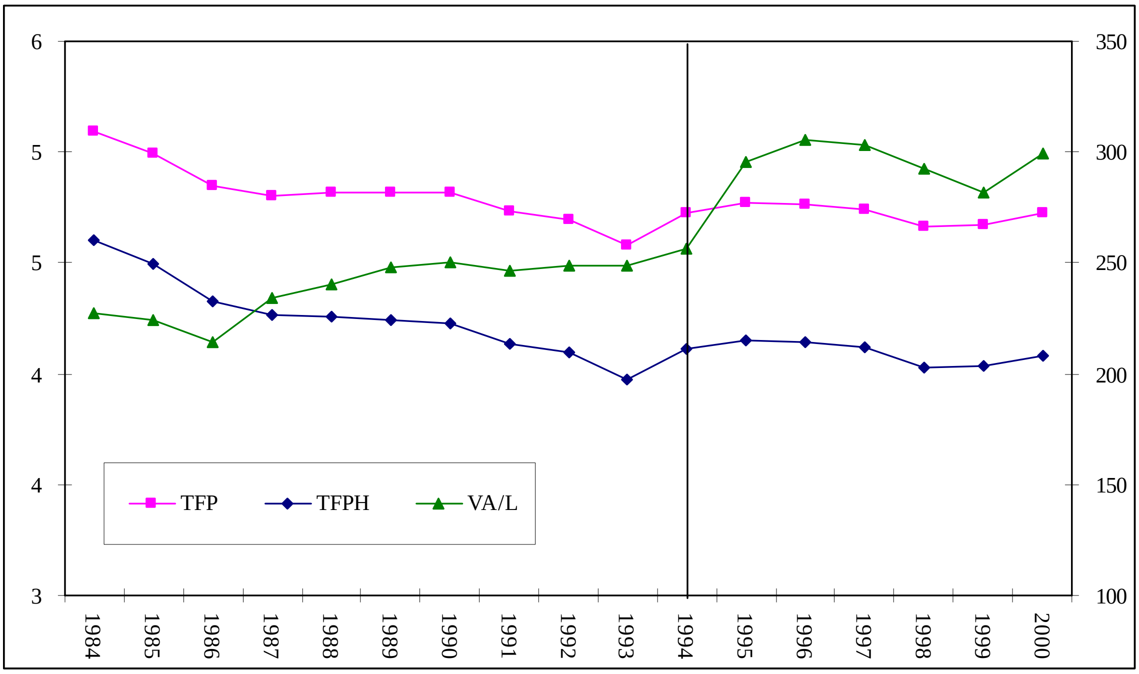

Table 1. Pre and Post-NAFTA Average Growth Rates

ISIC	Variable: Description	L pre	L post	TFP pre	TFP post	TFPH pre	TFPH post	VA/L pre	VA/L post	Y pre	Y post	K pre	K post	W pre	W post
311	Food products	0.03	0.69	-3.18	-2.80	-4.39	-3.26	2.44	1.54 *	1.31	1.94	14.51	14.19 *	4.27	-0.37 *
313	Beverages	1.57	0.48 *	-0.36	0.45	-1.61	-0.02	2.36	1.64 *	3.67	4.62	9.11	11.79	4.93	-0.44 *
314	Tobacco	0.50	-2.74 *	4.91	-4.53 *	3.61	-4.97 *	7.39	-2.35 *	7.61	-4.07 *	7.67	8.21	7.64	-1.08 *
321	Textiles	-4.53	1.74	-4.37	-3.79	-5.56	-4.23	-0.21	-0.25 *	-5.20	2.12	7.07	15.93	1.85	-2.34 *
322	Clothing	-2.80	1.45	-11.18	-6.63	-12.28	-7.07	0.16	-3.56 *	-4.98	0.60	39.70	23.14 *	2.54	-3.37 *
324	Footwear, except rubber or plastic	-8.03	-1.05	-8.34	-4.59	-9.46	-5.03	1.88	-3.15 *	-6.62	-1.53	33.78	11.60 *	4.29	-3.88 *
331	Wood products, except furniture	-5.98	-2.51	-0.13	-4.97 *	-1.36	-5.41 *	2.67	0.70 *	-4.51	-1.05	-0.12	19.03	0.63	-1.62 *
332	Furniture, except metal	-2.50	0.04	-5.46	-7.18 *	-6.62	-7.62 *	1.61	-0.95 *	-0.06	0.83	27.87	27.93	3.61	-2.81 *
341	Paper and paper products	-2.13	1.07	-1.98	1.73	-3.23	1.25	0.84	4.87	-1.05	5.82	8.29	10.52	2.62	-0.72 *
342	Printing publishing and allied industries	-2.70	-1.13	-9.52	-4.34	-10.64	-4.79	2.34	-1.78 *	-0.89	-0.59	43.09	14.74 *	4.74	-2.58 *
351	Industrial Chemicals	-3.88	-1.31	-5.31	1.71	-6.50	1.23	-0.44	1.64	-4.26	4.25	12.17	10.67 *	4.77	0.67 *
352	Other chemical products	1.03	0.92 *	-1.00	-0.58	-2.24	-1.05	6.08	5.17 *	3.07	6.05	10.45	19.50	6.36	1.22 *
355	Rubber products	-2.67	1.01	-5.43	-0.97	-6.62	-1.43	-3.69	-1.24	-5.82	3.65	4.91	12.31	2.64	1.23 *
356	Plastic products	1.33	1.30 *	-6.84	-2.90	-8.01	-3.35	1.34	0.16 *	1.21	3.91	31.25	20.36 *	3.82	-1.92 *
361	Pottery, china And earthware	1.92	4.77	-7.81	-1.91	-8.96	-2.36	2.09	-1.80 *	4.16	3.84 *	47.05	8.51 *	4.46	-0.87 *
362	Glass and glass products	-0.27	1.74	-1.51	-2.15 *	-2.73	-2.61	1.93	-2.42 *	0.91	0.44 *	8.77	4.51 *	5.68	-3.00 *
369	Other non metallic mineral products	-2.50	-4.15 *	4.24	4.33	2.96	3.84	7.38	8.40	4.06	3.65 *	4.89	5.42	5.36	-1.66 *
371	Iron and steel industries	-8.40	1.21	1.83	3.87	0.55	3.38	5.42	5.19 *	-3.66	8.98	0.94	13.20	4.32	0.17 *
372	Non ferrous metal basic industries	-2.73	1.56	-5.68	-1.18	-6.90	-1.65	2.00	2.09	-5.47	5.01	6.60	18.67	4.25	-2.69 *
381	Fabricated metal products	-2.81	-0.12	-5.39	0.14	-6.58	-0.33	1.08	2.83	-1.68	3.93	19.16	13.29 *	4.35	-2.13 *
382	Non electrical machinery	-3.70	4.29	-0.58	1.08	-1.80	0.61	3.82	0.94 *	1.81	13.10	17.05	29.82	4.45	-1.55 *
383	Electrical machinery appliances	-2.84	3.42	-5.23	-1.28	-6.42	-1.74	2.01	-1.21 *	-1.93	4.73	17.36	12.11 *	2.08	-0.90 *
384	Transport Equipment	-0.68	3.66	3.36	4.06	2.08	3.57	6.85	4.95 *	8.30	11.23	17.33	15.44 *	5.32	-0.67 *
385	Professional, Scientific and Controlling Equipment	1.90	5.22	-0.09	3.97	-1.29	3.48	4.29	11.29	8.66	19.18	33.35	38.30	-3.91	-2.29
390	Miscellaneous Manufactures	1.09	0.52 *	-9.15	-2.99	-10.30	-3.44	-1.31	0.09	-0.52	2.92	33.49	19.00 *	4.03	-2.56 *
	Overall average growth rates	-1.99	0.88	-3.37	-1.26	-4.57	-1.72	2.41	1.31	-0.08	4.14	18.23	15.93	3.80	-1.45

	TFP	TFPH	VA/L	Y	K	W
Overall Corr(L,Variable)	0.05	0.03	-0.08	0.86	0.67	0.05
positive correlation coefficients	13	10	10	21	20	6
negative correlation coefficients	12	15	15	4	5	19

Note: Stars mark a lower average growth rate in the post-NAFTA

Table 2: Panel Unit Root Tests for 1984-2000.

$$\Delta x_{it} = \alpha_0 + \alpha_1 x_{it-1} + \sum_{j=2}^{k} \alpha_j \Delta x_{i\,t-j+1} + \nu_{it} \qquad (1),$$

where x = L, TFP, TFPH, VA/L, Y, K, and W.

	Panel Unit Root Tests		**N * T**	**k**
Intercept only	LLC	IPS		
TFP	-11.553*** [0.000]	-7.393*** [0.000]	392	2 lags
TFPH	-14.607*** [0.000]	-9.496*** [0.000]	392	2 lags
W	-3.608*** [0.000]	-2.854*** [0.002]	377	2 lags
Intercept and Trend	LLC	IPS		
L	-5.197*** [0.000]	-1.695** [0.045]	395	3 lags
VA/L	-0.923 [0.178]	-3.519*** [0.0002]	370	3 lags
K	-6.804*** [0.000]	-1.204 [0.114]	366	3 lags
Y	-3.587*** [0.000]	-0.570 [0.285]	390	3 lags
W	-2.854*** [0.002]	-3.066*** [0.001]	371	3 lags

Notes: Reported statistics are for the series in levels. The number of cross-section units is always 25 while the number of time periods varies across series. For the panel unit root tests LLC and IPS under the unit root null, the p-values are given in brackets. The number of lags (k) was chosen by the Schwarz criterion. The symbols *, **, and *** refer to levels of significance of 10%, 5%, and 1%, respectively.

Table 3: REM Estimations of Employment in Levels.

$$L_{it} = \beta_0 + \beta_{1i} + \beta_2 A_{it} + \varepsilon_{it} \qquad (2),$$

where A = VA/L, TFP, and TFPH.

	Full 1984-2000			**Pre-NAFTA 1984-1993**			**Post-NAFTA 1994-2000**		
	VA/L	TFP	TFPH	VA/L	TFP	TFPH	VA/L	TFP	TFPH
β_0	10.888*** (0.729)	12.100*** (0.943)	12.010*** (0.862)	11.485*** (0.710)	9.344*** (0.570)	9.418*** (0.528)	10.738*** (0.727)	10.525*** (0.642)	10.628*** (0.628)
β_2	-0.110 (0.106)	-0.382*** (0.141)	-0.414** (0.140)	-0.247*** (0.081)	0.155*** (0.058)	0.158*** (0.056)	-0.040 (0.068)	-0.003 (0.058)	-0.029 (0.063)
DW	0.358	0.451	0.473	0.384	0.417	0.426	0.717	0.724	0.732
Adj. R^2	0.001	0.059	0.087	0.058	0.054	0.073	-0.003	-0.006	-0.004

Notes: Logarithms are taken on all series. The β_{1i}'s terms are included in the estimation but are omitted in the table. The Random Effects Model (REM) is used to estimate (2) after Hausman tests do not reject the null (Random Effect Model is correct) for any specification of the bivariate case (L, A). Productivity is measured by either labour productivity (VA/L) or total factor productivity (TFP) or total factor productivity adjusted for human capital (TFPH). The total number of observations is 425 for the full sample (25 cross sections times 17 time series), 250 for the pre-NAFTA sample (25 cross sections times 10 time series), and 175 for the post-NAFTA sample (25 cross sections times 7 time series). The entries below the coefficients are White-cross section SUR standard errors corrected for degrees of freedom. Cross section weights are used as the feasible GLS estimator for systems. The symbols *, **, and *** refer to levels of significance of 10%, 5%, and 1%, respectively. For the panel unit root tests LLC and IPS, the p-values are given in brackets.

Table 4: FEM Estimations of Employment in Levels.

$$L_{it} = \beta_0 + \beta_{1i} + \beta_2 A_{it} + \beta_3 K_{it} + \varepsilon_{it} \qquad (3)$$

where A = VA/L, TFP, and TFPH.

	Full 1984-2000			**Pre-NAFTA 1984-1993**			**Post-NAFTA 1994-2000**		
	VA/L	TFP	TFPH	VA/L	TFP	TFPH	VA/L	TFP	TFPH
β_0	8.069*** (0.373)	4.608*** (0.493)	4.037*** (0.527)	11.264*** (0.334)	8.577*** (0.329)	8.248*** (0.320)	9.356*** (0.633)	7.736*** (0.606)	7.800*** (0.598)
β_2	-0.355*** (0.055)	0.302*** (0.061)	0.368*** (0.065)	-0.116*** (0.039)	0.227*** (0.034)	0.252*** (0.036)	-0.108** (0.046)	0.167*** (0.039)	0.162*** (0.038)
β_3	0.273*** (0.027)	0.273*** (0.023)	0.304*** (0.023)	-0.035** (0.017)	0.028* (0.015)	0.051*** (0.015)	0.110*** (0.037)	0.123*** (0.036)	0.126*** (0.036)
DW	0.830	0.842	0.854	0.640	0.788	0.806	1.304	1.477	1.473
Adj. R^2	0.978	0.974	0.973	0.995	0.997	0.997	0.998	0.998	0.998

Notes: Logarithms are taken on all series. The β_{1i}'s terms are included in the estimation but are omitted in the table. The Random Effects Model (REM) is used to estimate (3) after Hausman tests do reject the null (Random Effect Model is correct) for any specification of the trivariate case (L, A, K). Productivity is measured by either labour productivity (VA/L) or total factor productivity (TFP) or total factor productivity adjusted for human capital (TFPH). Capital Stock (K) is real gross fixed capital formation by industry. The total number of observations is 425 for the full sample (25 cross sections times 17 time series), 250 for the pre-NAFTA sample (25 cross sections times 10 time series), and 175 for the post-NAFTA sample (25 cross sections times 7 time series). The entries below the coefficients are White-cross section SUR standard errors corrected for degrees of freedom. Cross section weights are used as the feasible GLS estimator for systems. The symbols *, **, and *** refer to levels of significance of 10%, 5%, and 1%, respectively. For the panel unit root tests LLC and IPS, the p-values are given in brackets.

Table 5: Pooled IV 2SEGLS Estimations of Employment in Levels.

$$L_{it} = \beta_0 + \beta_{1i} + \beta_2 A_{it} + \beta_3 K_{it} + \beta_4 W_{it} + \varepsilon_{it} \qquad (4)$$

where A = VA/L, TFP, and TFPH.

	Full 1984-2000			**Pre-NAFTA 1984-1993**			**Post-NAFTA 1994-2000**		
	VA/L	TFP	TFPH	VA/L	TFP	TFPH	VA/L	TFP	TFPH
β_0	-12.628 (10.208)	0.063 (1.332)	0.325 (1.224)	-12.293 (36.069)	6.115** (2.922)	6.496** (2.628)	-9.237 (16.792)	2.924 (1.814)	2.915 (1.858)
β_2	6.973* (3.574)	1.347*** (0.218)	1.140*** (0.175)	6.200 (9.070)	0.652** (0.310)	0.530** (0.258)	3.058 (3.230)	0.791** (0.346)	0.802** (0.352)
β_3	-0.075 (0.286)	0.426*** (0.032)	0.472*** (0.038)	-0.0004 (0.941)	-0.025 (0.190)	-0.029 (0.194)	0.039 (0.179)	0.198*** (0.044)	0.224*** (0.052)
β_4	-3.724** (1.582)	-0.678*** (0.122)	-0.512*** (0.115)	-3.020 (6.668)	0.290 (0.321)	0.424 (0.335)	0.387 (0.511)	0.155 (0.189)	0.166 (0.190)
χ^2-stat. for IVs	0.067	1.113	1.339	0.172	1.745	2.419	0.022	0.150	0.022
DW	0.814	0.815	0.839	1.158	0.906	0.837	1.073	1.212	1.240
Adj. R^2	0.392	0.968	0.974	0.827	0.991	0.991	0.942	0.995	0.995

Notes: Logarithms are taken on all series. The β_{1i}'s terms are included in the estimation but are omitted in the table. Instruments used were current imports and exports (M_t and X_t) and lagged output (Y_{t-1}) series, which are all correlated with wages as explained in the text. The Fixed Effects Model (FEM) is used to estimate (4) after Hausman tests do reject the null (Random Effect Model is correct) for any specification of the more general model (L, A, K, W). Productivity is measured by either labour productivity (VA/L) or total factor productivity (TFP) or total factor productivity adjusted for human capital (TFPH). Capital Stock (K) is real gross fixed capital formation by industry. The total number of observations is 425 for the full sample (25 cross sections times 17 time series), 250 for the pre-NAFTA sample (25 cross sections times 10 time series), and 175 for the post-NAFTA sample (25 cross sections times 7 time series). A weak relationship between the residuals and the instruments would indicate that the equation is properly specified. The row named "χ^2-stat. for IVs" shows the statistic of the null of no misspecification. The entries below the coefficients are White-cross section SUR standard errors corrected for degrees of freedom. Cross section weights are used as the feasible GLS estimator for systems. The symbols *, **, and *** refer to levels of significance of 10%, 5%, and 1%, respectively. For the panel unit root tests LLC and IPS, the p-values are given in brackets.