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NAFTA and Productivity Convergence between Mexico and the US*

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This paper revisits the question of whether NAFTA contributed to the productivity convergence between Mexico and the US. It introduces improved procedures for generating total factor productivity (TFP) data and applies new and more appropriate econometric methods. With these refinements, the paper provides some counter-evidence to the previous literature's findings of technology convergence toward a smaller gap level and NAFTA's positive effect on it. Our main result suggests an increasing TFP gap level, while some robustness checks, although not documenting increasing gaps, weaken the claim of the previous literature. The paper also applies a difference-in-difference approach and finds no evidence of sizeable effects of NAFTA.

JEL: F15, F43
Keywords: NAFTA, Productivity

1. Introduction

One of the most important trends in global trade relations in recent decades has been the increase in the number of 'North-South' free trade agreements (FTAs). Many developing nations have signed or are negotiating trade liberalisation agreements with developed counties. The Mediterranean countries are signing FTAs with the EU under the so-called Barcelona process. Many Asian countries, especially in South East Asia, are signing FTAs with Japan, and the US has continued to sign FTAs with Latin American countries.

One of the key motives of these North-South agreements, at least from the South perspective, is the technology transfer from advanced nations that they

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hope to promote via trade and foreign direct investment, (FDI). Specifically many observers expected FTAs to foster a convergence of technology levels between the developed and developing nation partners.

NAFTA, as the first major FTA between a developing country and a developed country, is a natural starting point for an empirical investigation into whether North-South FTAs provide the hoped-for technology spillovers, technology transfers and attendant productivity convergence. As Figure 1 shows, Mexico's imports and FDI inflows rose rapidly after the signing of NAFTA in 1994. Not surprisingly, a significantly large portion of Mexico's imports are from the US. From 1980 to 2004, the US's share was between 60 and 70% of total imports, while Japan, the second largest trading partner had only about 4.8% of the share. Furthermore, Canada's share was only around 2%. Looking at Mexico's exports, an even greater share of Mexican exports goes to the US[1]. We see the same pattern in FDI flows into Mexico.

Since the level of US technology was far in advance of the Mexican level, this intensification of trade and investment should have resulted in an important technology convergence between Mexico and the US. Because more than 10 years have passed since NAFTA became effective on 1 of January 1994, we now have sufficient data to study the issues in some depth.

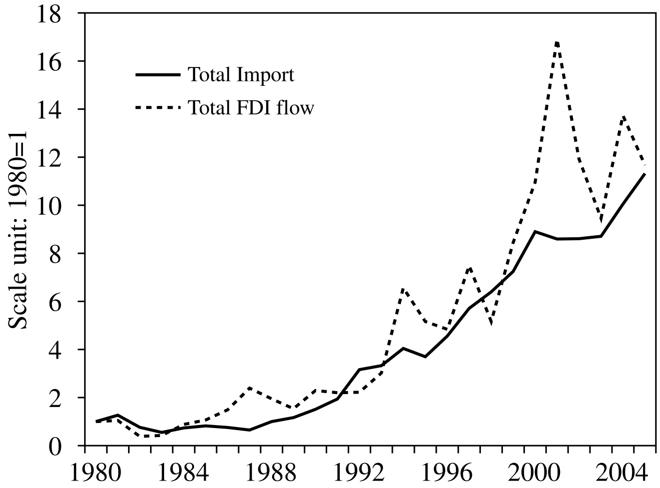
This paper analyses whether there is a technology convergence between Mexico and the US using a panel of 3-digit ISIC sectoral data from 1986-2000[2]. It is not the first paper to study US-Mexican technology convergence in the post-NAFTA setting. Easterly, Fiess, and Lederman (2003)—hereinafter, EFL (2003)—studies the issue using a similar data. The present paper introduces a number of refinements in the calculation of the productivity gaps, and also proposes to use alternative estimation methods. First, it employs the Industry-Specific Purchasing Power Parity (PPPs) instead of the GDP-based PPPs for currency conversion. Second, in the computation of capital stocks, it works with the hyperbolic depreciation rates, which are considered to be more appropriate in measuring TFP more accurately. Finally, it points out a potential problem with the estimation method used in previous studies and proposes a different estimation method.

The basic result of these refinements is a finding that on average across industries there is a convergence of productivity, but importantly, to a larger productivity gap. Moreover, NAFTA's effect on the evolution of productivity gaps is found to be ambiguous, which goes at odds with the previous literature's

[1] All these figures for import and export amounts are by the author's computation from United Nations Commodity Trade (UN Comtrade) database. Although the evidence is mixed, in economics, there is a strand of literature which discusses technology diffusion from exporting. The underlying logic is that intermediate goods buyers in developed countries help their suppliers in developing countries improve production system and especially product quality through dispatching engineers to the supplier's plant and receiving trainees from the suppliers. See for example, Bernard and Jensen (1999), Tybout and Westbrook (1995), Clerides, Lach and Tybout (1998), Alvarez and Robertson (2004). Turning our eyes to Mexico's export, the share of the US is even higher. The share of 72% in 1986 steadily rose, reaching 86% in 2005.

[2] In this paper, the terms "technology" and "productivity" are used interchangeably.

FIGURE 1
MEXICO: TOTAL IMPORTS AND TOTAL FDI INFLOW
1980-2005



Source: Author's calculation based on the data from INEGI (Instituto Nacional de Estadística, Geografía e Informática) for FDI inflow values and the data from UNCOMTRADE for import values.

finding. The paper also extends the analysis applying a difference-in-difference approach to better capture the effect of NAFTA and found statistically insignificant coefficient estimates.

After a brief review of the literature, Section 3 describes the methodology to be employed in this paper. Section 4 discusses the result of TFP gap analysis of the simple model argued in Section 3. Section 5 extends the analysis using the difference-in-difference approach. The final section concludes.

2. Literature Review

While a great deal of research has been done on the technology spillover effects of integration in general—for example see the recent volume edited by Hoekman and Javorcik (2006)—much less has been written on the productivity convergence effects of North-South FTAs per se. The evidence on the technology diffusion from FDI is still not abundant and the picture is mixed.

Javorcik (2004), working with data from Lithuania, presents evidence of vertical technology diffusion from FDI but finds little evidence for horizontal technology diffusion. Batra and Tan (2002) presents evidence that both vertical and horizontal technology diffusion from FDI is significant in the Malaysian data. By contrast, Haddad and Harrison (1993) using data from Morocco, and Aitken and Harrison (1999) using data from Venezuela cast doubt on the existence of any sort of technology spillovers from FDI.

A study that is close to the present paper is Lopez-Córdoba (2003). Using Mexican data, that paper finds vertical technology diffusion but no horizontal technology diffusion. This does not directly address the key issue in the present study, namely the *convergence* of US and Mexican productivity levels.

In addition to these detailed studies on technology diffusion, there have been many contributions on convergence in general. Seminal contributions corroborating the prediction of convergence in labour productivity are Baumol (1986), and Barro and Sala-i-Martin (1991, 1992). While these studies are cross-country analysis, time series analysis for labour productivity is conducted by Bernard and Durlauf (1995). This paper finds no convergence in the OECD countries.

However, there is a potential concern relating to the use of labour productivity as a measure of technology. Labour productivity confounds pure technology improvement—which corresponds to the Hick's neutral technology parameter—with the effect of factor accumulation. As a result, we cannot tell if an increase of labour productivity has come from a pure increase of the technology parameter or an increase of the capital stock, or a combination of the two.

The other measure of productivity, which is called Total Factor Productivity or Multifactor productivity, captures the technology parameter. Since it is intrinsically unobservable, TFP is measured as the residual of output minus the contribution of inputs. If the Hick's neutral technology diffuses more rapidly and deeply thanks to trade liberalisation, we should observe TFP convergence across partner countries. The key paper on this, Bernard and Jones (1996), studies technology convergence across the OECD countries[3], using TFP and finds evidence of technology convergence in the service sector but no evidence in the manufacturing sector.

Easterly, Fiess and Lederman (2003) is the paper in the literature that is closest to the present study looks at NAFTA's effect on productivity convergence. EFL (2003) studies the productivity convergence at industry level between Mexico and the US using panel data on Mexican manufacturing industries, which covers a maximum number of 28 industries over a maximum time period of 25 years. It shows that technology convergence was occurring between Mexico and the US prior to NAFTA and that NAFTA contributed to the acceleration of this phenomenon. As mentioned above, the present paper improves upon the EFL study by introducing some refinements to TFP calculations based on recent methodological advances and it applies more appropriate econometric techniques.

3. METHODOLOGY

For an international comparison of TFP, we should bear in mind two issues. The first is which production function we assume. The other is the currency conversion and the nominal-to-real conversion. The importance of these issues is elaborated below.

[3] It does not include Mexico.

3.1 Production function

As to the first issue of the production function, TFP computation for an international comparison of productivity calls for a careful treatment. Cobb-Douglas production function is often used for the computation of TFP as is done in the classic paper by Solow (1957). However, the same way of computation of TFP is problematic when our purpose is international comparison of productivity. As Bernard and Jones (1996) argues, the distance of productivity differs depending on which country's technology is employed as the basis of the comparison. Consider a productivity comparison between countries *a* and *b*. If we take *a* as the base, the question is: Using *a*'s inputs level and employing *b*'s technology, how much more proportional output can the country *a* produce? On the other hand, if we take *b* as the base, the question is: Using *b*'s inputs level and employing *a*'s technology, how much proportionally more output the country *b* can produce? The numbers computed for these two base are almost always different. This is analogue to the well-known index number problem of the consumer price index (CPI), namely the Paasche and the Laspeyres indices.

To avoid this problem, Caves, Christensen and Diewert (1982)—henceforce, CCD (1982)—proposes a TFP index which is invariant to the choice of the base country. CCD-TFP index is derived from the transcendental log production function with the constant returns to scale assumption. This index is widely used in technology comparison purposes. See Young (1992), Keller (2002), Nickell *et al.* (2001), Nicoletti and Scarpetta (2003), for example. As Keller (2002) shows, based on the CCD-TFP index, the TFP of industry *i* of country *c* at time *t* is computed as:

$$\ln TFP_{cit} = \left(\ln Y_{cit} - \overline{\ln Y_{it}}\right) - \overline{\sigma_{cit}}\left(\ln L_{cit} - \overline{\ln L_{it}}\right) - \left(1 - \overline{\sigma_{cit}}\right)\left(\ln K_{cit} - \overline{\ln K_{it}}\right) \quad (1)$$

where Y, L and K represent value added, labour input and capital stock, respectively[4]. Subscripts c, i and t represent country, industry and time, respectively. The bars on Y, L and K denote average of each variables across countries at a given time[5].

[4] The other important feature of CCD TFP index is that it is superlative in the sense that it is exact, not approximate for the flexible transcendental log functional form. Note that the growth accounting employed by Solow (1957) is $(\dot{A}/A) = (\dot{Y}/Y) - \alpha(t)(\dot{K}/K) - (1-\alpha(t))(\dot{L}/L)$. But this is a continuous time version. It has to be modified for empirical purpose to apply to discrete time. The following widely used approach is due to Thörnqvist (1936) $\log(A(t+1)/A(t)) = \log(Y(t+1)/Y(t)) - \overline{\alpha(t)}\cdot\log(k(t+1)/k(t)) - (1-\overline{\alpha(t)})\cdot\log(L(t+1)/L(t))$. However, this is an approximation. It is not exact.

[5] Namely, $\overline{\ln Z_{it}} = (1/C)\sum_c \ln Z_{cit}$ for Z=Y, L, K while $\overline{\sigma_{cit}} = 1/2\,(\sigma_{cit} + \overline{\sigma_{it}})$, where $\sigma_{cit}, \forall c,i,t$ is the cost share of labour, and $\overline{\sigma_{it}}$ is the average across countries, $\overline{\sigma_{it}} = (1/C)\sum_c \sigma_{cit}$.

3.2 Currency conversion and nominal-to-real conversion

As to the second issue of the currency conversion and the nominal-to-real conversion, we need to use PPPs for the former and deflation index for the latter. While, the nominal-to-real conversion is rather trivial, the currency conversion needs a careful attention. The importance of using sector/industry-specific Purchasing Power Parities (PPPs) instead of GDP-based aggregate PPPs has been emphasised for some time in the literature.

The Industry-Specific PPPs very often differ substantially from the GDP-based aggregate PPP. This is because GDP-based PPPs: (1) include import prices and exclude export prices; (2) include transport and distribution margins; (3) include indirect taxes and exclude subsidies; and (4) refer to final output and not intermediate goods. Sørensen (2001) demonstrates that the results of non-convergence of technology in manufacturing sector among the OECD countries shown by Bernard and Jones (1996) are not robust when theoretically superior sector/industry-specific PPPs are used in the analysis.

Jorgenson and his associates and Van Ark and Pilat (1993) propose differing ways of constructing the sector/industry-specific PPPs. Jorgenson and his associates' PPPs are based on consumer price surveys while those of Van Ark and Pilat make use of producer price surveys. Jorgenson and his associates' method is more widely used especially because the method of Van Ark and Pilat has a critical drawback of covering a very small proportion of products. The coverage reaches less than a quarter of manufacturing products even in the case of the US and Germany[6].

The computation of the Industry-Specific PPPs in this paper follows the methodology used by Van Biesebroeck (2004)[7], which itself is based on Jorgenson and Kuroda (1990). The procedure of the Industry-Specific PPPs computation consists of three steps.

First, the raw data used in this paper are PPPs for 207 basic heading categories computed by the OECD. The OECD computes these PPPs from the price and expenditure data they collect for approximately 3000 standardized products. Second, these PPPs for 207 basic categories are mapped into the industrial classification of sectors, using expenditure as weights[8]. Third, adjustments are made for trade[9]. More details on the process of computation and the computed Industry-Specific PPPs are described in the Appendix A. Table 1 shows the difference between GDP-based PPPs and the simple average of industry-Specific PPPs of the 18 manufacturing industries analysed in this paper[10]. As we can see

6 'Comment' by Dale Jorgenson on Van Ark and Pilat (1993) p.53.

7 Van Biesebroeck (2004) did not compute PPPs for Mexico.

8 I am grateful to Van Biesebroeck for providing me with the STATA command for mapping of these 207 basic heading products into ISIC Rev.3, which he constructed for Van Biesebroeck (2004).

9 Ideally, adjustments should also be made for indirect taxes and differences in retail or wholesale margins. However, due to the data limitation, these adjustments were not able to be performed.

10 Due to the availability of the price and expenditure data of standardised products, the number of industries is limited to eighteen.

in the table, there is a large gap between the two, especially in the first part of the time series. The higher number of the Industry-Specific PPPs *before* NAFTA means lower value added of Mexican manufacturing industries in terms of US dollars for these years than those computed using the GDP-based PPPs, which then reduces the estimated TFP for these years. On the other hand, there is less difference in the Industry-Specific PPPs *after* NAFTA. So, the switch from the GDP-based PPPs to the Industry-Specific PPPs does not change much the estimated TFP *after* NAFTA. Thus, we can predict that the use of the Industry-Specific PPPs will yield less convergence of TFP than the case of using the GDP-based PPPs as in EFL (2003).

TABLE 1
THE INDUSTRY-SPECIFIC PPPS AND THE GDP-BASED PPPS

Year	Industry-specific PPPs (simple average over 18 industries analysed)	GDP-based PPPs
1986	0.413	0.22
1987	1.007	0.52
1988	1.983	1.03
1989	2.019	1.26
1990	2.250	1.54
1991	2.613	1.84
1992	2.802	2.06
1993	3.010	2.21
1994	3.173	2.35
1995	4.549	3.18
1996	5.905	4.12
1997	6.706	4.80
1998	7.813	5.58
1999	8.609	6.26
2000	8.965	6.79

Source: Author's computation.

3.3 Data

Data source and data construction

Data of the value added (*Y*), Capital (*K*), Hours Worked (*L*) and the factor shares are computed using the data from UNIDO INDSTAT3 2005 ISIC Revision 2. The capital stocks are constructed from the gross fixed capital formation (GFKF) in INDSTAT, using the perpetual inventory method with 18 years of capital life and the hyperbolic depreciation rate used by US Bureau of Labor Statistics (BLS)[11]. Because of the limited availability of data, the panel data cover 18 manufacturing industries for 15 years (1986-2000). The constraint on the number of industries comes from the availability of PPP data while 15 years is the maximum length of time due to the availability of GFKF data for Mexico[12]. Since the data from INDSTAT are denominated in current local currencies, Y for Mexico is first converted into current US dollars (for cross country comparison) using the Industry-Specific PPPs described above, while K for Mexico is changed into current US dollars using PPP over investment from Penn World Table. Then, the resultant data in current US dollars undergoes the nominal-to-real conversion (for across time comparison) using the Producer Price Index for each three digit industries drawn from BLS. L is computed as the number of employment drawn from INDSTAT multiplied by the average hours worked taken from the OECD.

Capital stock computation

As mentioned above, one of the refinements in the data construction in this paper concerns the computation of capital stock data. When some constant numbers of depreciation rate δ and of capital service life T are chosen such as in EFL (2003), the capital stock at time t is computed as:

$$(2) \qquad K_t = \sum_{n=0}^{T-1} (1-\delta)^n \cdot I_{t-n}$$

where K_t is the capital stock at time t, δ is the depreciation rate, I is GFKF, and T is the capital service life.

This paper introduces refinements in the computation of K_t on two fronts. First, it computes the capital service life from BLS data rather than assuming an arbitrary number[13]. Second, it uses hyperbolic depreciation rates instead of constant depreciation rates. With hyperbolic depreciation rates, assets lose efficiency more slowly at first, then rapidly later in life.

The hyperbolic age-efficiency function is[14]:

$$(3) \qquad S_n = (L - n)/(L - B \cdot n)$$

11 EFL (2003) assumes a 5 percent depreciation rate per year and apparently uses 10 years as capital service life. In this paper, rather than taking an arbitrary number of 5 percent depreciation rate, the hyperbolic depreciation rate, which is considered to better represent the depreciation process and is used by BLS, is employed. Also, instead of assuming 10 years, in this paper, the capital service life is computed from the capital life data of BLS. The computed number of 18 years is used in the data construction.

12 Three digit is the most disaggregated level we can use for the current study. At four digit, GFKF data are available only from the middle of 1980s, which precludes us from constructing capital stock data for years prior to NAFTA.

13 The detailed explanation of the capital service life computation is in the Appendix B.

14 Detailed explanation is provided at the web-site of Bureau of Labor Statistics, U.S. Department of Labor, URL: http://www.bls.gov.

where S_n is the relative efficiency of a *n*-year old asset, *L* is the service life, *n* is the age of the asset and *B* is the parameter of efficiency decline.

BLS assumes the parameter of efficiency decline, *B*, to be 0.5 for equipment and 0.75 for structures. Since GFKF data are not available separately for equipment and structures, we computed the average capital service life of these two categories, using average proportions of investment amounts of each category from 1970 to 2000 as weights. Thus, *B* used in this paper is 0.56375 (*i.e.*, 0.5**0.745*+0.75**0.255*) where the numbers in *italics* are the weights. Thus, essentially this paper replaces $(1-\delta)^n$ in the above equation with S_n and uses the computed number of 18 years for *T*. Hence, the formula of capital stock computation in this paper is:

$$K_t = \sum_{n=0}^{T=1} S_n \cdot I_{t-n} \tag{4}$$

The above U.S. capital service life and the hyperbolic age-efficiency function are also applied for the computation of capital stocks in Mexico because there is no similar data available for Mexico.

The refinement introduced in this paper increases the estimated capital stocks both in Mexico and the US by the order of 1.4 on average for the whole years (1986-2000). However, the impact of the increase for Mexico differs before and after NAFTA. The average increase before NAFTA is 1.53 while that after NAFTA is 1.28. On the other hand, there is almost no change in the magnitude of increase for the US before and after NAFTA. It is 1.44 for pre-NAFTA and 1.40 for post-NAFTA. An increase of capital stock means a decrease of TFP. Thus, the above difference between 1.53 and 1.28 means that pre-NAFTA Mexico's TFP gets much lower than post-NAFTA TFP. Therefore, we can predict that this refinement will lead to a convergence of TFP to a smaller gap than EFL (2003)'s finding.

3.4 Estimation model

The econometric model to be employed in this paper for the convergence/divergence analysis is the following AR(1) model, which is similar to the one used by EFL (2003).

$$G_{i,t} = \alpha_0 + \alpha_1 G_{i,t-1} + \alpha_2 (G_{i,t-1} \cdot NAFTA) + \alpha_3 \cdot NAFTA + \eta_i + \lambda_t + \varepsilon_{i,t} \tag{5}$$

where, $G_{i,t}$ is the gap in TFP of industry *i* at time *t* between Mexico and the US, *NAFTA* is a year dummy for 1994-2000, $G_{i,t}$ NAFTA, the interaction term between the lagged dependent variable and NAFTA dummy is the slope *NAFTA dummy*, η_i mesures the industry-specific effects, λ_t is the time (year) specific effects and $\varepsilon_{i,t}$ are *i.i.d.* errors.

The usual treatment of panel data by the fixed effects (within group estimation) can solve the problem of the omitted variable bias by eliminating η_i. However, due to the presence of the lagged dependent variable as one of the regressors, the within groups transformation introduces another correlation between the independent variable and the error term. The lagged dependent variable under the within group transformation is $G^*_{i,t-1} = G_{i,t-1} - (1/T-1)(G_{i,2} + ... + G_{i,T})$, while, defining the composite error as $\zeta_{i,t} \equiv \eta_i + \lambda_t + \varepsilon_{i,t}$, it becomes:

$$\zeta^*_{i,t} = \left(\lambda_t - \frac{1}{T-1}\sum_{t=2}^{T}\lambda_t\right) + \left(\varepsilon_{i,t} - \frac{1}{T-1}(\varepsilon_{i,2} + \varepsilon_{i,3} ... + \varepsilon_{i,T})\right).$$

Here, the $G_{i,t\text{-}1}$ term in the explanatory variable $G^*_{i,t-1}$ is correlated with $\varepsilon_{i,t\text{-}1}$ in the error term. Consequently, the coefficient estimates by the within group estimation are biased and inconsistent. The usual solution for endogenous variables is Instrumental Variable estimation (IV). One may think about instrumenting the endogenous variable with lagged variables. But it does not work here since all the lagged terms are both within the transformed variable and the transformed errors. To address this problem, Anderson and Hsiao (1981) proposes to take difference instead of taking mean deviation as is done in the within groups transformation so that lagged variables can be used as an instrumental variable. Namely, the difference of lagged dependent variables, $G_{i,t-1} - G_{i,t-2}$, is correlated with the error term, $\varepsilon_{i,t} - \varepsilon_{i,t-1}$, but we can use $G_{i,t-2}$ as instrumental variables for $G_{i,t-1} - G_{i,t-2}$, because it satisfies the two conditions for IV: it is correlated with the variable instrumented and uncorrelated with the error term. Arellano and Bond (1991) proposes to use further lagged variables as IV to extract more information from the data: *e.g.*, to use $G_{i,t-2}$, $G_{i,t-3}, \ldots$, $G_{i,1}$ as IV for $G_{i,t-1} - G_{i,t-2}$. This is so called Arellano-Bond Generalized Method of Moments (GMM) estimator. In using Arellano-Bond GMM, there are several points we should bear in mind. As Roodman (2006) reminds us, this method is designed for 'small T, large N' panel data, where T is the time period and N is individuals, industries, or others. (N is industries in the analysis of this paper.) Therefore, the coefficient estimates obtained from small N sample can be far away from the true values.

Bond (2002) proposes a useful check on whether the results we obtain from the Arellano-Bond Difference GMM estimation are plausible or not. He proposes to run both of the OLS and the fixed effect panel regression. It can be shown that the OLS estimate of the lagged dependent variable is upward biased while the fixed effect regression estimate is downward biased (Hsiao, 2003). Thus, the true parameters are likely to be somewhere in-between of these numbers. Roodman (2006) calls this range between the OLS estimate and the fixed effect panel regression estimate as 'hoped-for-range'.

4. Estimation Results

We first discuss the estimation results under the above refinement of the data construction. Then, we compare this result with EFL (2003) to see where the difference between this paper and EFL (2003) comes from.

4.1 A problem of using Arellano-Bond Difference GMM

Table 2 shows the regression result of the OLS, the fixed effects panel regression and the Arellano-Bond Difference GMM under the refinement of the data construction. Arellano-Bond tests for autocorrelation show that the instrumental variables sets are adequate. However, the coefficient estimate of lagged dependent variable, 0.391 from the Arellano-Bond Difference GMM is far-off the 'hoped-for-range' of 0.842 - 0.985. The upper bound of 0.985 is the OLS estimate, while the lower bound of 0.842 is the estimate from the fixed effect panel regression. The coefficient estimates much lower than the plausible range in the Arellano-Bond Difference GMM is the robust phenomena for minor changes in the estimation, such as the use of two-step GMM and a change of instrument sets[15].

TABLE 2
ESTIMATION RESULTS OF VARIOUS ESTIMATION METHODS
DEPENDENT VARIABLE: GAP IN TFP (US TFP – MEX TFP)

	(1) OLS	(2) Fixed effects	(3) A-B difference GMM
Lagged TFP gap	0.985***	0.842***	0.391**
	(0.000)	(0.000)	(0.007)
Slope NAFTA dummy	-0.218***	-0.282***	-0.418***
	(0.000)	(0.000)	(0.001)
NAFTA dummy	0.273***	0.287***	0.0529
	(0.000)	(0.000)	(0.294)
Constant	-0.129***	0.0669*	
	(0.000)	(0.048)	
R^2	0.931	0.811	
Hansen test *p*-value			0.993
A-B second order serial correlation *p*-value			0.235
Number of observations	213	213	178

Source: Own estimation.
Notes: A-B: Arellano-Bond, *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[15] Due to a large number of combinations of the minor changes, the estimation results from the minor changes are not reported here.

4.2 Discussion on the appropriate estimation methods

A possible improvement can be expected by the use of the System GMM instead of the Arellano-Bond Difference GMM, again under the assumption of large N and small T. As mentioned above, the Arellano-Bond difference GMM takes difference of variables and instruments these *differenced variables* with past levels of the original *level variables*. Then, if the levels (here TFP gaps between the US and Mexico) are close to random walk, the past levels, which are used as instrumental variables, do not predict well the current difference. In other words, the correlation between the instruments (past levels, for example, $G_{i,t\text{-}2}$ and $G_{i,t\text{-}3}$) and the variables instrumented (the differenced variable, $G_{i,t\text{-}1}$-$G_{i,t\text{-}2}$) is weak. To address this so-called 'weak instruments problem', Blundell and Bond (1998) proposes the 'so-called' system GMM. Essentially, the system proposes to stack two sets of observations, one in differences and the other in (original) levels as:

$$\begin{pmatrix}\Delta y\\ y\end{pmatrix}=\delta\begin{pmatrix}\Delta y_{-1}\\ y_{-1}\end{pmatrix}+\begin{pmatrix}\Delta X\\ X\end{pmatrix}\beta+\begin{pmatrix}\Delta\varepsilon\\ \alpha+\varepsilon\end{pmatrix} \tag{6}$$

and to use past differences as instruments for current levels. This is because the past differences are better predictors of current levels than the past levels are for current differences, when the time series are close to random walk. Indeed, almost all time series of the data used in this paper are found to be close to random walk. Only in 2 industries out of the 18 industries were the null hypotheses of unit root rejected. Table 3 shows the result of the System GMM. The first column shows the result of usual system GMM. The second column is that with collapsing the instrument matrix. Hansen test p-value of the first column shows 0.997, which is very close to 'too good' value of one, which indicates a potential problem of 'too many instruments'. Thus, the second regression is done, collapsing the instrument matrix, thereby reducing the number of instruments. A notable point is that the coefficient estimates of both regressions lie within the 'hoped-for-range'. The specification test indicates that the instrument set is valid.

Therefore, our preferred estimation method is not Arellano-Bond Difference GMM, but the System GMM.

Another potential solution for the current problem of small T and non-large N dynamic panel is to use the fixed effect estimation and perform a rough bias correction. As argued above, the coefficient estimate of the fixed effect estimation is downward biased. However, a rough estimation of the true parameter is possible, using the bias formula shown by Nickell (1981).

$$\hat{\gamma}_{FE}=\gamma-\frac{(1+\gamma)}{T} \tag{7}$$

TABLE 3
ESTIMATION RESULT OF THE SYSTEM GMM
DEPENDENT VARIABLE: GAP IN TFP (US TFP – MEX TFP)

	(1) System GMM	(2) System GMM with collapse option
Lagged TFP gap	0.935***	0.877***
	(0.000)	(0.000)
Slope NAFTA dummy	-0.185*	-0.251***
	(0.024)	(0.000)
NAFTA dummy	-0.0200	0.0412
	(0.785)	(0.485)
Constant	0.203***	0.204***
	(0.000)	(0.000)
Hansen test p-value	0.997	0.638
A-B second order serial correlation p-value	0.606	0.498
Number of observations	213	213

Source: Own estimation.
Notes: A-B: Arellano-Bond , p-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

where $\hat{\gamma}_{FE}$ is the estimate by the fixed effect estimation, γ is the true parameter value, T is the number of time periods (here, the number of years). The approximated value of the true parameter γ is 0.97.[16]

Having argued our preferred estimation methods, we interpret these coefficient estimates. Taking the case of the fixed effects, we have:

(8) $$G_t = \left(0.97 - \underbrace{0.282}_{\text{Slope dummy}}\right) G_{t-1} + \left(\underbrace{0.287}_{\text{Dummy}} - \underbrace{0.0669}_{\text{Constant}}\right)$$

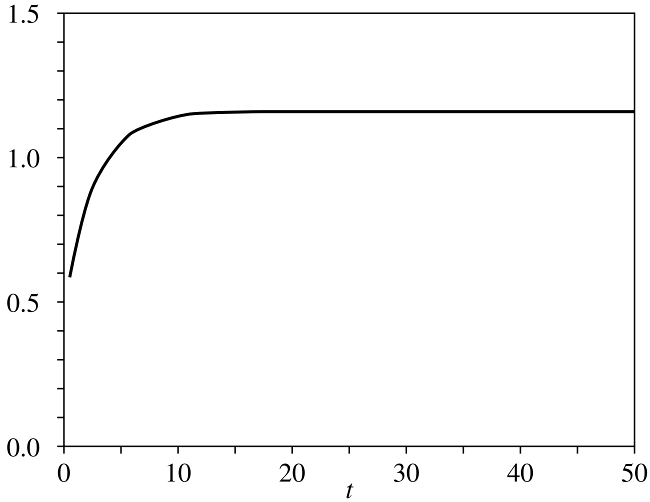
Repeatedly substituting the lagged TFP gaps yields the dynamic equation:

$$\begin{aligned} G_t &= 0.688^x G_{t-x} + (0.287 - 0.0669)\sum_{k=1}^{x} 0.688^{k-1} \\ &= 0.688^x G_{t-x} + 0.3539\sum_{k=1}^{x} 0.688^{k-1} \end{aligned}$$

[16] The coefficient estimate of the fixed effect panel regression, $\hat{\gamma}_{FE}$ is 0.842. Plugging this number and T=15 into the bias formula and solving for γ , we get 0.97.

Figure 2 plots the time profile for the average initial (*i.e.* before NAFTA) TFP gap[17]. It indicates an increasing TFP gap. For slightly longer than 10 years, the TFP gap increases, then it converges to a level higher than that at the beginning. The initial increase of the gap essentially comes from the sufficiently positive coefficient estimates of NAFTA dummy and of the constant. EFL (2003) only runs Arellano-Bond difference GMM, which is found to be downward biased as discussed above, and only looks at the coefficient estimate of lagged TFP gap and concludes that TFP converges between the US and Mexico. Apart from the problem of Arellano-Bond difference GMM in the current case, a precise interpretation of the results needs to include all the coefficient estimates. In the current case, NAFTA reduces the slope by 0.282 as the slope dummy coefficient shows, but at the same time, it increases the *level* of the gap, which is indicated by the positive coefficient estimates of NAFTA dummy. Moreover, to precisely measure the dynamics, we need to take into consideration the constant, 0.3539. The whole effect of these coefficient estimates leads to the initial increase of the gap, but the TFP gap does not explode. Instead, it converges as time goes by because the sum of the coefficient estimates on the lagged TFP gap, here, 0.688 is less than one. But it converges to a higher gap level than the original level. NAFTA's effects on the TFP gap is ambiguous. It decreases the slope but increases the level.

FIGURE 2
TIME PROFILE OF TFP GAP
BETWEEN THE US AND MEXICO: FIXED EFFECTS

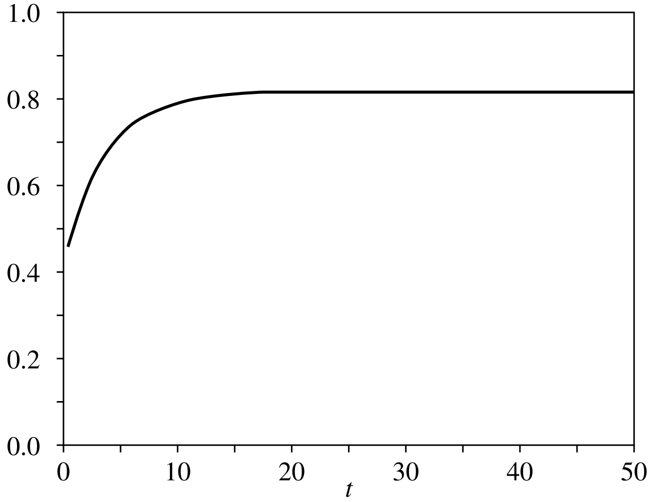


Source: Own estimation.

[17] I thank Professor Yasuyuki Todo of University of Tokyo for the suggestion of checking the dynamic equations and plotting the time profile.

In the case of the system GMM, the equivalent equation to the above (7) is: $G_t = (0.935 - 0.185)\ G_{t-1} + 0.203$, and the time profile for the average TFP gap is in Figure 3.

FIGURE 3
TIME PROFILE OF TFP GAP BETWEEN THE US AND MEXICO
(GMM system)



Source: Own estimation.

We notice that the gap increases for some time and then converges to a higher level. As to NAFTA's effects, NAFTA reinforced the convergence as represented by the statistically significant negative coefficient estimate of NAFTA slope dummy and insignificant coefficient estimate of NAFTA dummy.

In summary, we conclude that there is no clear evidence for NAFTA's contribution to the TFP convergence. This is in contrast with the finding of the previous literature. Although incomplete but as a simple check for the appropriateness of the model chosen here, we plot TFP gap evolution for each industry (See the Appendix A4 for the TFP evolution of each industry). The plots indicate increasing gaps rather than narrowing gaps after NAFTA, which goes at odds with EFL(2003), but is closer to our econometric findings above.

As a robustness check, we performed the same analysis excluding tobacco industry, which is usually different from the other manufacturing industry in that it is much more highly capital intensive and the market structure is monopolistic. The TFP plot in the Appendix B also shows a difference of this industry. The results shown in Table 4 exhibit no qualitative difference from the above original ones.

As a further robustness check, we have changed the years of capital life and depreciation rates and obtained no qualitatively different estimation results. Some of the results are in Appendix C.

TABLE 4
ESTIMATION RESULTS, EXCLUDING TOBACCO INDUSTRY

	(1) OLS	(2) Fixed effects	(3) A-B difference GMM	(4) System GMM with collapse option
Lagged TFP gap	0.947^{***}	0.833^{***}	0.463^{**}	0.825^{***}
	(0.000)	(0.000)	(0.004)	(0.000)
Slope NAFTA	-0.158^{**}	-0.240^{***}	-0.495^{**}	-0.222^{*}
	(0.007)	(0.000)	(0.005)	(0.028)
NAFTA dummy	0.0328	0.0344	0.0662	0.0298
	(0.497)	(0.583)	(0.344)	(0.764)
Constant	0.111^{***}	0.246^{***}		0.247^{***}
	(0.001)	(0.000)		(0.000)
R^2	0.897	0.772		
Hansen test *p*-value			0.982	0.702
A-B second order serial correlation *p*-value			0.307	0.671
Number of observations	201	201	168	201

Source: Own estimation.

Notes: A-B: Arellano-Bond , *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. No System GMM without collapse option passes the specification test.

4.3 Comparison with EFL (2003)

This section aims to sort out the sources of the difference between this paper's result shown above and that of EFL (2003). Table 5 shows the estimation results using the perpetual inventory method for the construction of capital stock and GDP based PPPs for currency conversion as EFL (2003) did[18]. The coefficient estimate of Arellano-Bond Difference GMM is much below the coefficient estimate of the Fixed effect – a sign of bias. Two System GMM results are much closer to the credible range, 0.893-0.903 and the two pass the specification test.

If we take the estimation result of Arellano-Bond Difference GMM as EFL (2003) does, it indicates a convergence of the TFP toward a smaller gap level. However, the problem of using Arellano-Bond GMM for the current dataset is as discussed above. The two System GMM results show a slight change toward an evidence against the TFP convergence to a smaller gap level. Thus, the largest difference of the results between EFL (2003) and this paper comes from the use of alternative estimation methods. The fixed effects model shows a negative coefficient for the slope NAFTA dummy but a positive and sizable coefficient for the NAFTA dummy, which leads to the same conclusion as the case of our refinement. Overall, when we follow the data construction of EFL (2003) but use appropriate estimation methods, the results are mixed. Some of the results go against the findings of EFL (2003), *i.e.*, TFP convergence toward a small gap level. Other results weakens the claim of the EFL (2003).

As mentioned above, besides the application of more appropriate estimation methods, this paper introduces two refinements on data construction. In order to see what difference these refinement bring in, we listed up the results of the two System GMM in Table 6[19]. We discuss one by one. The first columns (1) show the results using the perpetual inventory method with 5 percent depreciation rate and 10 years of capital life for capital stock computation and GDP based PPPs for currency conversion as in EFL (2003). Similarly, the second columns (2) show the results using the perpetual inventory method with 5 percent depreciation rate and 10 years of capital life for capital stock computation and Industry Specific PPPs for currency conversion. (3) is the case with Hyperbolic Depreciation Function and GDP based PPPs. Finally, (4) is the case of this paper's refinement, which we have seen above, *i.e.* with Hyperbolic Depreciation Function and Industry Specific PPPs. Moving from (1) to (2), in both of System GMM 1 and System GMM 2, we notice larger coefficient estimates for the lagged TFP gap and smaller coefficient estimates for the Slope NAFTA dummy. This is in line with our prediction in Section 3.2, where we predicted an increasing gap or a less narrowing gap coming

[18] The estimation coefficients do not match with those of EFL (2003) since the number of years and industries are different, which is required in order to make it compatible with the case of this paper's refinement. In their study, EFL (2003) reports 0.65 and -0.28 as the coefficient estimates of the lagged dependent variable and NAFTA slope dummy.

[19] The full results of the regressions for the case (2) and (3) are in the Appendix C. The cases (1) and (4) are already included in the main text.

TABLE 5
ESTIMATION RESULTS
PERPETUAL INVENTORY METHOD 5 PERCENT, 10 YEARS, GDP BASED PPPS

	(1) OLS	(2) Fixed effects	(3) A-B difference GMM	(4) System GMM	(5) System GMM with collapse option
Lagged TFP gap	0.903***	0.893***	0.715***	0.908***	0.792***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Slope NAFTA dummy	-0.274***	-0.363***	-0.696***	-0.243*	-0.402***
	(0.000)	(0.000)	(0.000)	(0.014)	(0.001)
NAFTA dummy	0.0867	0.304***	-0.0564	-0.0120	0.131
	(0.064)	(0.000)	(0.329)	(0.851)	(0.059)
Constant	0.0123	-0.0228		0.190***	0.184***
	(0.713)	(0.493)		(0.000)	(0.000)
R^2	0.888	0.861			
Hansen test *p*-value			0.936	0.982	0.222
A-B second order serial correlation *p*-value			0.238	0.132	0.598
Number of observations	213	213	178	213	213

Source: Own estimation.

Notes: A-B: Arellano-Bond , *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

from the use of Industry specific PPPs instead of GDP based PPPs. From (1) to (3), we again see almost the same tendency. But the magnitude of the change is smaller than the case from (1) to (2). This is not in line with our prediction in Section 3.3, where we have predicted a less increasing gap or a more narrowing gap. However, considering the rather small change from (1) to (3), we do not of think it as an important matter worth investigating. Finally, with the two refinements on the data construction, we reach (4). We find larger coefficient estimates for the lagged TFP gap and smaller coefficient estimates for the Slope NAFTA dummy, compared with (1).

In sum, apart from the application of more appropriate estimation methods, which is the main factor of the difference between this paper's findings and those of EFL (2003), we find that the refinement on data construction further strengthens the need for caution when we look at the previous literature's findings.

TABLE 6
ESTIMATION RESULTS, VARIOUS CASES

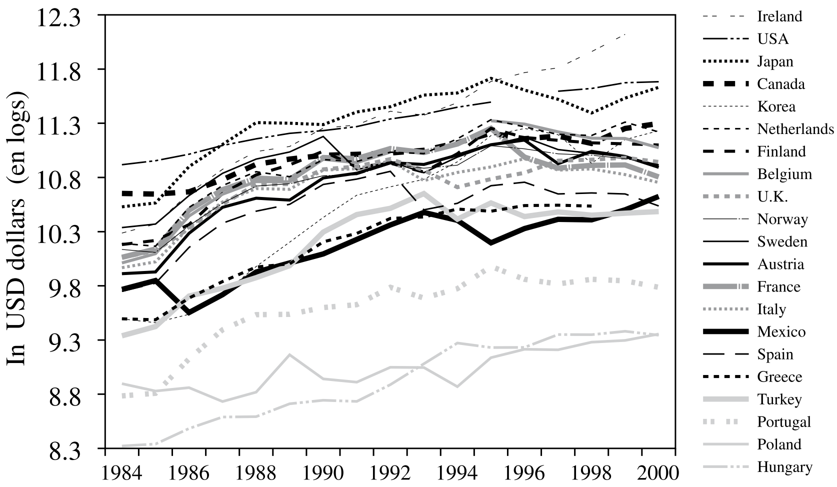
	System GMM 1			
	(1)	(2)	(3)	(4)
Lagged TFP gap	0.908***	0.990***	0.923***	0.935***
	(0.000)	(0.000)	(0.000)	(0.000)
Slope NAFTA	-0.243*	-0.236**	-0.254**	-0.185*
	(0.014)	(0.008)	(0.008)	(0.024)
NAFTA	-0.0120	-0.0134	-0.0524	-0.0200
	(0.851)	(0.873)	(0.344)	(0.785)
Constant	0.190***	0.205***	0.192***	0.203***
	(0.000)	(0.000)	(0.000)	(0.000)
	System GMM 2 (with collapse option)			
	(1)	(2)	(3)	(4)
Lagged TFP gap	0.792***	0.852***	0.840***	0.877***
	(0.000)	(0.000)	(0.000)	(0.000)
Slope NAFTA	-0.402***	-0.282***	-0.339***	-0.251***
	(0.001)	(0.001)	(0.000)	(0.000)
NAFTA	0.131	0.110	0.0294	0.0412
	(0.059)	(0.151)	(0.547)	(0.485)
Constant	0.184***	0.224***	0.175***	0.204***
	(0.000)	(0.000)	(0.000)	(0.000)

Source: Own estimation.
Notes: A-B: Arellano-Bond , $p-$values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, (1) Perpetual Inventory Method 5 percent 10 years, GDP based PPPs (2) Perpetual Inventory Method 5 percent 10 years, Industry Specific PPPs (3) Hyperbolic Depreciation Function, GDP based PPPs (4) Hyperbolic Depreciation Function, Industry Specific PPPs.

5. DIFFERENCE-IN-DIFFERENCE APPROACH

The above analyses only use the TFP gap between the US and Mexico. The timing of the signing of NAFTA is correlated with other economically relevant developments in Mexico, such as a downturn. Difference-in-difference approach by including other countries in the analysis could help us single out the effect of NAFTA more precisely. We analyse the issue using Value added per employee instead of TFP because using TFP substantially narrows down the number of countries and excludes Canada, another NAFTA member, due to the lack of the data for capital after 1991. Before a formal analysis by regressions, we plot the evolution of Value added per employee in Figure 4. There seems to be no specific tendency for Mexico to catch up with the US in comparison with the other countries.

FIGURE 4
EVOLUTION OF VALUE ADDED PER EMPLOYEE[20]



Source: Author's computation.

A formal analysis corroborates this impression. Regression results are in Table 7. The data covers 21 countries, 18 industries for 31 years (1970-2000). The list of the countries included and the selection criterion of the countries are in the Appendix A6. As additional control variables, we have added a Mexico dummy, which applies to the whole sample for Mexico, and a Mexico slope dummy, which is the product of Mexico dummy multiplied by the lagged dependent variable. The

[20] The period of study is 1984-2000 since the data for Total Manufacturing are available only from 1984 while the data for each 3 digit industry is available from 1970, which are used in the regression analysis.

coefficient estimates on the two variables of our interest, i.e., the slope NAFTA dummy and the NAFTA dummy, in the System GMM are statistically insignificant, suggesting that there is no evidence of NAFTA's contribution to productivity convergence toward a narrower gap level[21].

TABLE 7
ESTIMATION RESULTS OF DIF-IN-DIF USING VALUE ADDED PER EMPLOYEE

	OLS	Fixed effects	System GMM
Lagged VA per employee gap	0.985***	0.866***	0.845***
	(0.000)	(0.000)	(0.000)
Slope Mexico dummy	-0.0947***	-0.0735**	-0.271
	(0.000)	(0.004)	(0.591)
Slope NAFTA dummy	-0.00159	-0.0483	0.207
	(0.970)	(0.268)	(0.572)
Mexico dummy	0.123***	–	2.507
	(0.000)	–	(0.084)
NAFTA dummy	0.00442	0.0967	-1.406
	(0.936)	(0.086)	(0.107)
Constant	0.0357***	0.156***	0.122
	(0.000)	(0.000)	(0.079)
R^2	0.945	0.784	
Hansen test *p*-value			0.172
A-B second order serial correlation *p*-value			0.0760
Number of observations	9750	9750	9750

Source: Own estimation.
Notes: A-B: Arellano-Bond , *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

6. Concluding Remarks and Possible Future Work

This paper revisits the question of whether NAFTA contributed to the productivity convergence between Mexico and the US. It introduces improved procedures for generating TFP data and applies more appropriate econometric methods. With these refinements, the paper provides some counter-evidence to the previous literature's findings of technology convergence toward a smaller gap level and NAFTA's positive effect on it. One main result even suggests an

[21] Arellano-Bond Difference GMM result is not shown because it never passes the specification test and the coefficient estimates are largely below the fixed effect's estimates, which is a sign of bias.

increasing TFP gap level, while some robustness checks, although not documenting increasing gaps, weaken the claim of the previous literature. The paper also applies Difference-in-difference approach to better single out the effects of NAFTA and finds no evidence on it.

The productivity evolution might be substantially different across industries. The above analysis is done for the average TFP gap levels across industries. One interesting question to be further explored is how the performances are different across industries. FTAs, such as NAFTA, not only reduce the trade cost but also enable Mexican firms to have better access for external finance. Thus, we expect that the industries which heavily depend on external finance have better chance to fare well vis-à-vis the US counterparts than the industries which rely less on external finance. Using Rajan and Zingales (1998) industry classification by external dependency index, we have divided the 18 industries into three groups and have done the same regression analysis. Estimation results and the time profiles for each group are in Appendix E. Contrary to our conjecture, the industries of low external dependency tend to narrow the TFP gap while those of medium and high external dependency tend to widen the gap. Further studies on industry level analysis and on the underlying mechanism for the technology gap evolution are potential future works which may yield interesting findings and policy implication.

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APPENDIX

A. COMPUTATION OF THE INDUSTRY SPECIFIC PPPs[22]

The starting data is the PPPs calculated for 209 basic categories for the year 1999 by the OECD. Namely,

$$\text{(A1)} \quad PPP_{c,t} = \frac{P_{c,t}^{peso}}{P_{c,t}^{dollars}} \,,$$

where c represents categories, t is year, $P_{c,t}^{peso}$ is price of the category c at time t. Similarly for $P_{c,t}^{dollars}$.

Mapping these PPPs into International Standard Industry Codes (ISIC) Revision 3, using the expenditure data also compiled by the OECD as weights yields the Industry-Specific PPPs as:

$$\text{(A2)} \quad PPP_{i,t} = \frac{P_{i,t}^{peso}}{P_{i,t}^{dollars}} \,.$$

The PPPs computed are for t=1999.

The industry-Specific PPPs so far computed are based on the consumption expenditure. In order to compute the Industry-Specific PPPs at production level, it is necessary to adjust export and import portions. The following identity holds,

$$\text{(A3)} \quad \begin{aligned} PPP_{epend} \times Consumption = \; & PPP_{prod} \times Production \\ & + ex.rate \times Imports - ex.rate \times Exports \end{aligned}$$

since total consumption is domestic production plus imports minus exports.

In Mexican pesos the following identity holds as well,

$$\text{(A4)} \quad Consumption = Production + Imports - Exports$$

From these two identities, (A3) and (A4), we can compute the production PPP as:

$$\text{(A5)} \quad PPP_{prod} = PPP_{\exp end} + (ex.rate - PPP_{expend}) \times \frac{Exports - Imports}{Production}$$

The exports and imports data are taken from UNIDO Industrial Supply-Demand Balance Database (ISDB) ISIC Revision 3. The exchange rate data comes from Penn World Table.

[22] The description here draws on Van Biesebroeck (2004).

The Industry-specific PPPs for years other than the year 1999 are calculated, using industry-specific deflation ratio in Mexico and the US as:

$$\text{(A6)} \quad PPP_{i,h} = PPP_{i,t} \times \frac{(P_{i,h}/P_{i,t})^{peso}}{(P_{i,h}/P_{i,t})^{dollars}}$$

The data of deflation rates come from US Bureau of Labour Statistics (BLS) for the US and Mexico's Instituto Nacional de Estadística, Geografia e Informática (INEGI) for Mexico. As the Producer Price Index (PPI) of the US is based on SIC code, the correspondence from SIC to ISIC Rev.3 was performed. Due to the unavailability of correspondence table, I made a correspondence table. This correspondence table does not enable a perfect match, but mostly captures the correspondence. The original data of PPI for Mexico is based on ISIC Rev.2. It was converted into ISIC Rev.3, using an approximate correspondence table shown below, which itself is based on the correspondence table at UN Statistics office.

TABLE A1
CORRESPONDENCE US SIC – ISIC REV.3

US SIC	ISIC Rev.3
20	15
21	16
22	17
23	18
24	20
25	36
26	21
27	22
28	24
29	23+26
30	25
31	19
32	26
33	27
34	28
35	29
36	31+32
37	34+35
38	33
39	36

Source: Author's elaboration from the original classifications.

TABLE A2
CORRESPONDENCE ISIC REV.3 – ISIC REV.2

ISIC Rev.3	ISIC Rev. 2
15 Manufacture of food products and beverages	311 Food products 313 Beverages
16 Manufacture of tobacco products	314 Tobacco
17 Manufacture of textiles	321 Textiles 332 Manufacture of furniture and fixtures, except primarily of metal
18 Manufacture of wearing apparel; dressing and dyeing of fur	322 Wearing apparel, except footwear
19 Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	323 Leather products 324 Footwear, except rubber or plastic
20 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	331 Wood products, except furniture 332 Manufacture of furniture and fixtures, except primarily of metal
21 Manufacture of paper and paper products	341 Paper and products
22 Publishing, printing and reproduction of recorded media	342 Printing and publishing
23 Manufacture of coke, refined petroleum products and nuclear fuel	353 Petroleum refineries 354 Misc. petroleum and coal products
24 Manufacture of chemicals and chemical products	351 Industrial chemicals 352 Other chemicals
25 Manufacture of rubber and plastics products	355 Rubber products 356 Plastic products
26 Manufacture of other non-metallic mineral products	361 Pottery, china, earthenware 362 Glass and products 369 Other non-metallic mineral products
27 Manufacture of basic metals	371 Iron and steel 372 Non-ferrous metals
28 Manufacture of fabricated metal products, except machinery and equipment	381 Fabricated metal products
29 Manufacture of machinery and equipment n.e.c.	382 Machinery, except electrical
30 Manufacture of office, accounting and computing machinery	382 Machinery, except electrical 385 Professional and scientific equipment
31 Manufacture of electrical machinery and apparatus n.e.c.	383 Machinery, electric
32 Manufacture of radio, television and communication equipment and apparatus	383 Machinery, electric
33 Manufacture of medical, precision and optical instruments, watches and clocks	381 Fabricated metal products 382 Machinery, except electrical 385 Professional and scientific equipment
34 Manufacture of motor vehicles, trailers and semi-trailers	384 Transport equipment
35 Manufacture of other transport equipment	383 Machinery, electric 384 Transport equipment
36 Manufacture of furniture; manufacturing n.e.c.	390 Other manufactured products 332 Manufacture of furniture and fixtures, except primarily of metal
37 Recycling	610

Source: Author's elaboration from UN correspondence table.

TABLE A3
INDUSTRY SPECIFIC PPPS

Since the sufficient number of the necessary data for the computation of TFP, i.e., Capital, Labours, and Value added are available only in ISIC Revision 2, the above computed Industry-Specific PPPs for ISIC Revision 3 are converted into ISIC Revision 2. The finally computed PPPs are:

Industry code	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311 Food products	0.30	0.67	1.32	1.40	1.68	2.10	2.32	2.46	2.61	3.58	4.86	5.70	6.72	7.71	8.13
313 Beverages	0.30	0.67	1.32	1.40	1.68	2.10	2.32	2.46	2.61	3.58	4.86	5.70	6.72	7.71	8.13
314 Tobacco	0.30	0.64	1.16	1.14	1.24	1.37	1.37	1.56	1.94	2.63	3.61	4.03	4.06	3.48	3.52
321 Textiles	0.49	1.26	2.48	2.58	2.82	3.27	3.43	3.66	3.80	5.22	6.89	8.09	9.30	10.50	11.19
331 Wood products, except furniture	0.34	0.78	1.63	1.77	1.93	2.40	2.35	2.14	2.12	2.89	3.68	4.24	4.81	5.17	5.71
341 Paper and products	0.47	1.16	2.22	2.27	2.79	3.41	3.93	4.62	5.03	6.78	8.67	8.95	10.09	11.49	12.11
351 Industrial chemicals	0.40	0.95	1.79	1.76	2.01	2.41	2.81	3.04	3.26	4.48	6.14	7.28	8.30	9.69	10.57
352 Other chemicals	0.40	0.95	1.79	1.76	2.01	2.41	2.81	3.04	3.26	4.48	6.14	7.28	8.30	9.69	10.57
354 Misc. petroleum and coal products	0.20	0.46	1.00	0.92	0.88	1.20	1.47	1.66	1.89	2.77	3.41	4.17	6.20	6.29	4.89
355 Rubber products	0.27	0.67	1.32	1.32	1.51	1.83	2.15	2.32	2.51	3.61	5.04	6.05	7.01	8.23	9.22
362 Glass and products	0.48	1.21	2.55	2.67	2.91	3.19	3.58	3.79	3.80	4.69	6.10	7.13	8.47	9.44	9.99
369 Other non-metallic mineral products	0.48	1.21	2.55	2.67	2.91	3.19	3.58	3.79	3.80	4.69	6.10	7.13	8.47	9.44	9.99
371 Iron and steel	0.47	1.09	2.18	2.29	2.64	2.95	2.91	3.10	3.25	5.36	7.27	8.03	9.79	10.86	11.26
372 Non-ferrous metals	0.47	1.09	2.18	2.29	2.64	2.95	2.91	3.10	3.25	5.36	7.27	8.03	9.79	10.86	11.26
381 Fabricated metal products	0.53	1.33	2.56	2.53	2.77	3.14	3.26	3.46	3.56	5.34	6.87	7.94	9.16	9.92	10.10
382 Machinery, except electrical	0.42	1.05	2.07	2.06	2.24	2.52	2.62	2.80	2.92	4.49	5.82	6.85	8.02	8.74	8.97
383 Machinery, electric	0.56	1.39	2.70	2.69	2.92	3.28	3.39	3.56	3.61	5.46	6.94	8.00	9.20	9.89	10.02
384 Transport equipment	0.53	1.33	2.61	2.60	2.82	3.15	3.23	3.38	3.43	5.22	6.66	7.72	8.95	9.64	9.76

Source: Author's elaboration.

B. Computation of Capital Service Life

The detailed data of capital service life used by BLS is available from Fraumeni (1997). Gross fixed capital investment (equivalent to GFKF above) consists of private non-residential *equipment* and private non-residential *structures*. Capital service lives for both of equipment and structures are calculated as the simple arithmetic average. That of equipment is 13.85 years while that of structure is 35.50 years. Since GFKF data is not available separately for private non-residential *equipment* and for private non-residential *structures,* a weighted average is taken using average proportions of investment amounts of each category: equipment and structures, from 1970 to 2000 as weights. 13.85 x *0.745* + 31.40 x *0.255* = 18.32 where the numbers in *italics* are weights. Hence, 18 years is used as the capital service life in this paper.

The data for computation of capital service life in US and Mexico and the final series used in this paper are available upon request.

FIGURE B1
PLOT OF TFP GAP FOR EACH INDUSTRY

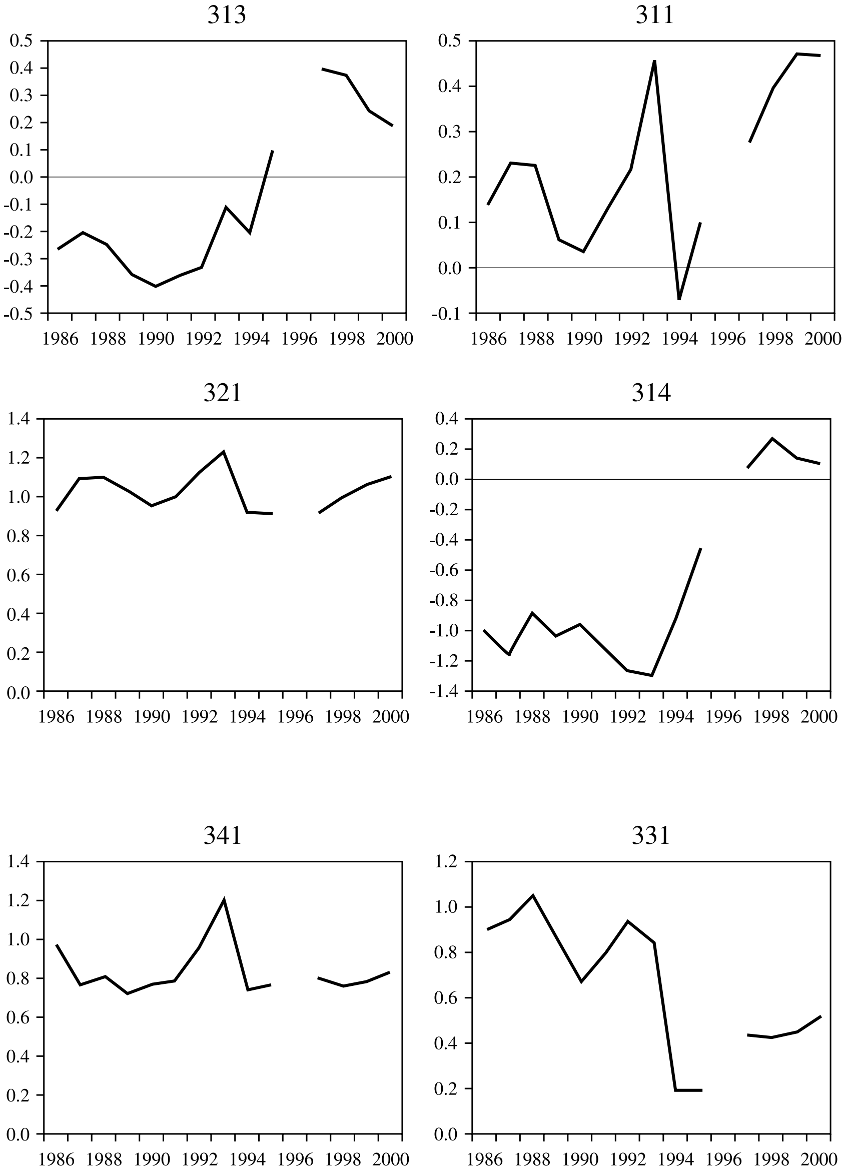


FIGURE B1 (continued)

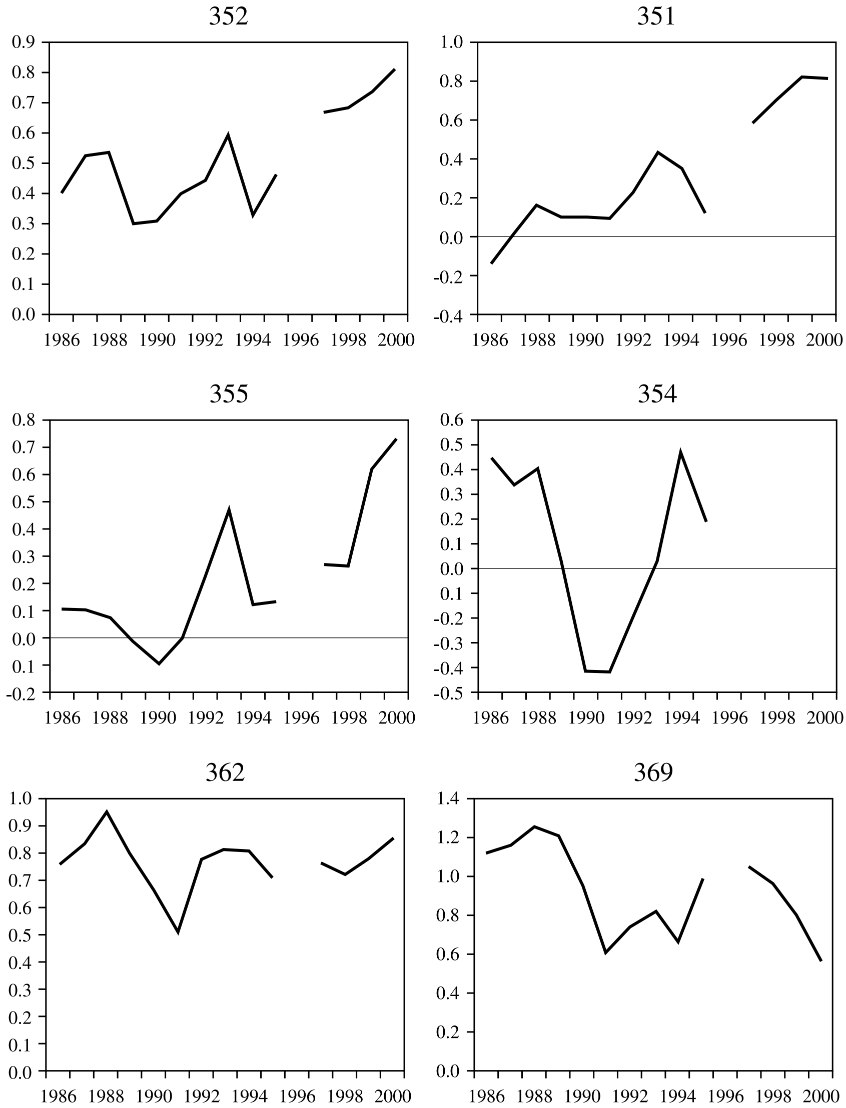
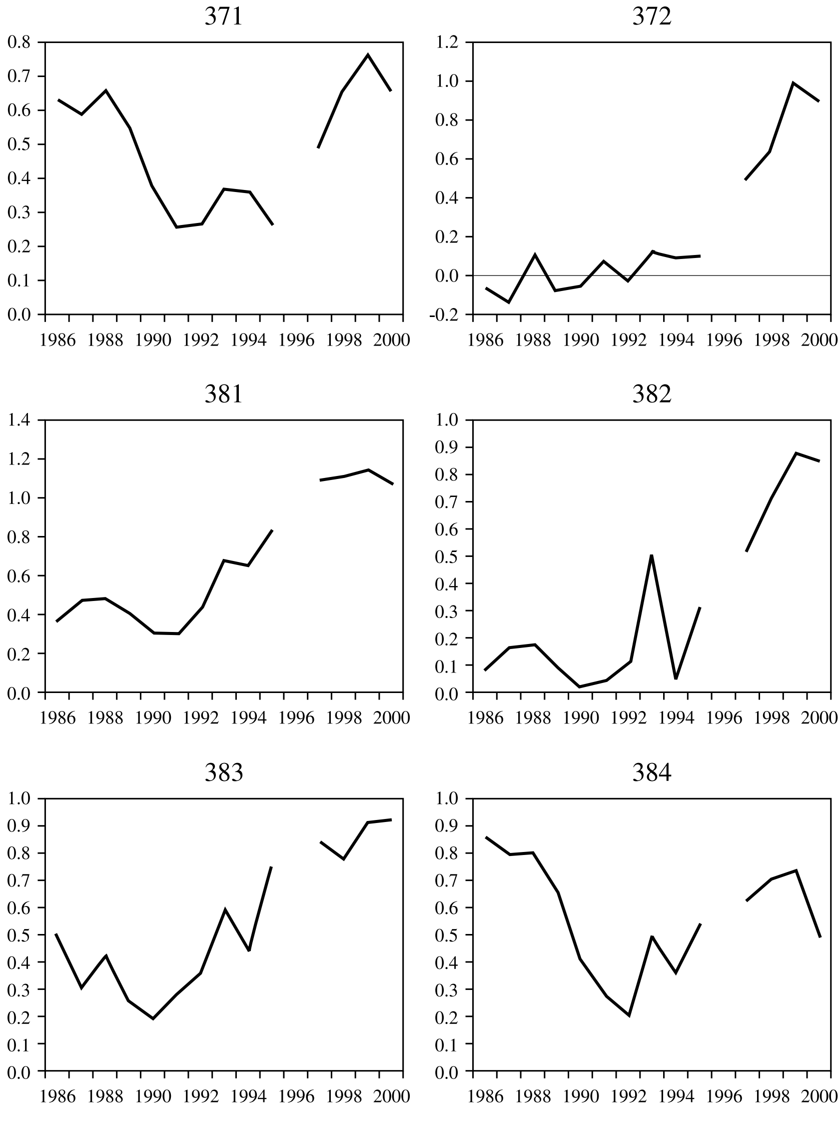


FIGURE B1 (continued)



Source: Author's elaboration.

C. VARIOUS REGRESSION RESULTS

TABLE C1
PERPETUAL INVENTORY METHOD 5 PERCENT 10 YEARS, INDUSTRY SPECIFIC PPPS

	(1) OLS	(2) Fixed effects	(3) A-B difference GMM	(4) System GMM	(5) System GMM with collapse option
Lagged TFP gap	0.980^{***}	0.820^{***}	0.526^{***}	0.990^{***}	0.852^{***}
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Slope NAFTA	-0.252^{***}	-0.326^{***}	-0.489^{***}	-0.236^{**}	-0.282^{***}
	(0.000)	(0.000)	(0.000)	(0.008)	(0.001)
NAFTA dummy	0.353^{***}	0.355^{***}	0.128^{*}	-0.0134	0.110
	(0.000)	(0.000)	(0.019)	(0.873)	(0.151)
Constant	-0.138^{***}	-0.0652		0.205^{***}	0.224^{***}
	(0.000)	(0.080)		(0.000)	(0.000)
R^2	0.924	0.830			
Hansen test *p*-value			0.936	0.997	0.247
A-B second order serial correlation *p*-value			0.181	0.540	0.471
Number of observations	213	213	178	213	213

Source: Own estimation.
Notes: A-B: Arellano-Bond , *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE C2
HYPERBOLIC DEPRECIATION FUNCTION, GDP BASED PPPS

	(1) OLS	(2) Fixed effects	(3) A-B difference GMM	(4) System GMM	(5) System GMM with collapse option
Lagged TFP gap	0.937***	0.909***	0.552***	0.923***	0.840***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Slope NAFTA	-0.253***	-0.309***	-0.511***	-0.254**	-0.339***
	(0.000)	(0.000)	(0.000)	(0.008)	(0.000)
NAFTA dummy	-0.00463	0.191***	-0.104	-0.0524	0.0294
	(0.911)	(0.000)	(0.077)	(0.344)	(0.547)
Constant	0.0551	-0.0269		0.192***	0.175***
	(0.065)	(0.380)		(0.000)	(0.000)
R^2	0.906	0.855			
Hansen test *p*-value			0.955	0.992	0.469
A-B second order serial correlation *p*-value			0.0861	0.337	0.237
Number of observations	213	213	178	213	213

Source: Own estimation.
Notes: A-B: Arellano-Bond , *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE C3
HYPERBOLIC DEPRECIATION RATE 15YEARS, INDUSTRY SPECIFIC PPPS

	(1) OLS	(2) Fixed effects	(3) A-B difference GMM	(4) System GMM	(5) System GMM with collapse option
Lagged TFP gap	0.987***	0.868***	0.430***	0.958***	0.948***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Slope NAFTA	-0.241***	-0.308***	-0.449***	-0.219*	-0.357***
	(0.000)	(0.000)	(0.000)	(0.026)	(0.000)
NAFTA dummy	0.179***	0.290***	0.128**	0.0538	0.146**
	(0.000)	(0.000)	(0.004)	(0.504)	(0.008)
Constant	0.0191	0.0435		0.162***	0.177**
	(0.521)	(0.177)		(0.000)	(0.001)
R^2	0.937	0.844			
Hansen test *p*-value			0.376	0.918	0.926
A-B second order serial correlation *p*-value			0.599	0.854	0.779
Number of observations	213	213	178	213	213

Source: Own estimation.
Notes: A-B: Arellano-Bond , *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE C4
HYPERBOLIC DEPRECIATION RATE 10YEARS, INDUSTRY SPECIFIC PPPS

	(1) OLS	(2) Fixed effects	(3) A-B difference GMM	(4) System GMM	(5) System GMM with collapse option
Lagged TFP gap	0.981***	0.872***	0.422***	0.990***	0.881***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Slope NAFTA	-0.195***	-0.231***	-0.449***	-0.199	-0.253*
	(0.000)	(0.000)	(0.000)	(0.053)	(0.048)
NAFTA dummy	0.310***	0.247***	0.0926	-0.0281	-0.0306
	(0.000)	(0.000)	(0.071)	(0.692)	(0.637)
Constant	-0.148***	0.00768		0.187***	0.280**
	(0.000)	(0.836)		(0.000)	(0.002)
R^2	0.926	0.818			
Hansen test p-value			0.0731	0.626	0.334
Arellano-Bond second order serial correlation p-value			0.982	0.767	0.945
Number of observations	213	213	178	213	213

Source: Own estimation.
Notes: A-B: Arellano-Bond , p-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

TABLE C5
PERPETUAL INVENTORY METHOD 5PCT 15YEARS, INDUSTRY SPECIFIC PPPS

	(1) OLS	(2) Fixed Effects	(3) A-B Difference GMM	(4) System GMM	(5) System GMM with Collapse Option
Lagged TFP gap	0.987^{***}	0.873^{***}	0.375^{**}	0.944^{***}	0.903^{***}
	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)
Slope NAFTA	-0.232^{***}	-0.295^{***}	-0.419^{***}	-0.208^{*}	-0.314^{**}
	(0.000)	(0.000)	(0.000)	(0.042)	(0.001)
NAFTA dummy	0.159^{***}	0.267^{***}	0.109^{*}	0.0394	0.124^{*}
	(0.001)	(0.000)	(0.012)	(0.633)	(0.020)
Constant	0.0250	0.0411		0.159^{***}	0.188^{***}
	(0.402)	(0.204)		(0.000)	(0.000)
R^2	0.935	0.828			
Hansen test *p*-value			0.437	0.921	0.869
A-B second order serial correlation *p*-value			0.459	0.911	0.815
Number of observations	213	213	178	213	213

Source: Own estimation.
Notes: A-B: Arellano-Bond , *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

D. LIST OF COUNTRIES INCLUDED IN THE DIFFERENCE-IN-DIFFERENCE APPROACH

The selection criterion of the countries is:

First, OECD countries because of the data quality. UNIDO INDSTAT data includes many developing countries, even very poor countries, such as Malawi, Tanzania. Most and at least some parts of the data of developing countries show very strange numbers. So, we should exclude them. In order not to be arbitrary for the exclusion, we have chosen OECD countries. Second, those countries which have the data at least for 18 industries, which is the number of industries for which the data are available for Mexico.

Australia	Austria	Belgium	Canada	Spain	Finland	France
U.K.	Greece	Hungary	Ireland	Italy	Japan	Korea
Mexico	Netherlands	Norway	Poland	Portugal	Sweden	Turkey

E. An Analysis by Industry

TABLE E1
GROUPING OF INDUSTRIES BY RAJAN AND ZINGALES
EXTERNAL DEPENDENCE

Industry code	Industry name	Rajan Zingales external dependence	Grouping
314	Tobacco	-0.45	Group 1
372	Nonferrous metal	0.01	
369	Nonmetal products	0.06	
313	Beverages	0.08	
371	Iron and steel	0.09	
311	Food products	0.14	
341	Paper and products	0.18	Group 2
352	Other chemicals	0.22	
351	Industrial chemicals	–	
355	Rubber products	0.23	
381	Metal products	0.24	
331	Wood products	0.28	
384	Transportation equipment	0.31	Group 3
354	Petroleum and coal products	0.33	
321	Textile	0.40	
382	Machinery	0.45	
362	Glass	0.53	
383	Electric machinery	0.77	

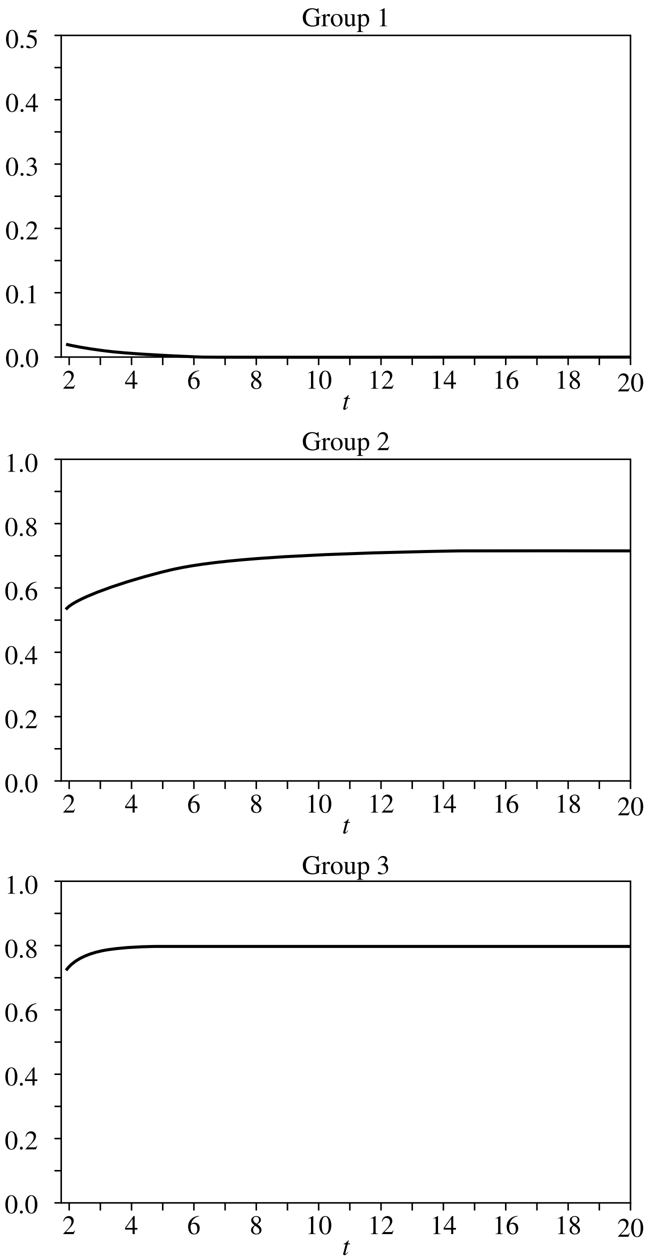
Source: Own estimation.
Note: Rajan and Zingales External Dependence is missing for 351: Industrial chemicals. I have placed it between 352: Other chemicals and 355: Rubber products, since these two are also chemical industries.

TABLE E2
ESTIMATION RESULTS BY RAJAN
AND ZINGALES INDUSTRY CLASSIFICATION
Fixed effects

	(1) Group 1 Low external dependency	(2) Group 2 Medium external dependency	(3) Group 3 High external dependency
Lagged TFP gap	0.849***	0.958***	0.707***
	(0.000)	(0.000)	(0.000)
Slope NAFTA	-0.273***	-0.227*	-0.473***
	(0.000)	(0.040)	(0.000)
NAFTA dummy	0.161	0.0513	0.436**
	(0.113)	(0.597)	(0.001)
Constant	-0.00760	0.192**	0.174*
	(0.891)	(0.002)	(0.028)
R^2	0.870	0.858	0.770
Number of observations	72	72	69

Source: Own estimation.
Notes: *p*-values in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$,

FIGURE E1
TIME PROFILES OF TFP GAPS FOR EACH GROUP
(Rajan and zingales industry classification)



Source: Own estimation.