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This paper studies whether NAFTA contributed to the productivity convergence between Mexico and the US. Using data from the manufacturing sector and introducing a number of refinements in the computation of the total factor productivity and estimation methods, it shows that NAFTA is associated with a higher speed of convergence of productivity levels than the previous literature found. The paper also finds that under NAFTA the industries which have smaller productivity gap experienced higher speed of convergence (catch-up) than the industries which have larger productivity gap.

Key words: NAFTA, Productivity

JEL Classfication: F15, F43

2. 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 countries. 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 nations.

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 hope to promote via trade and 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,

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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.

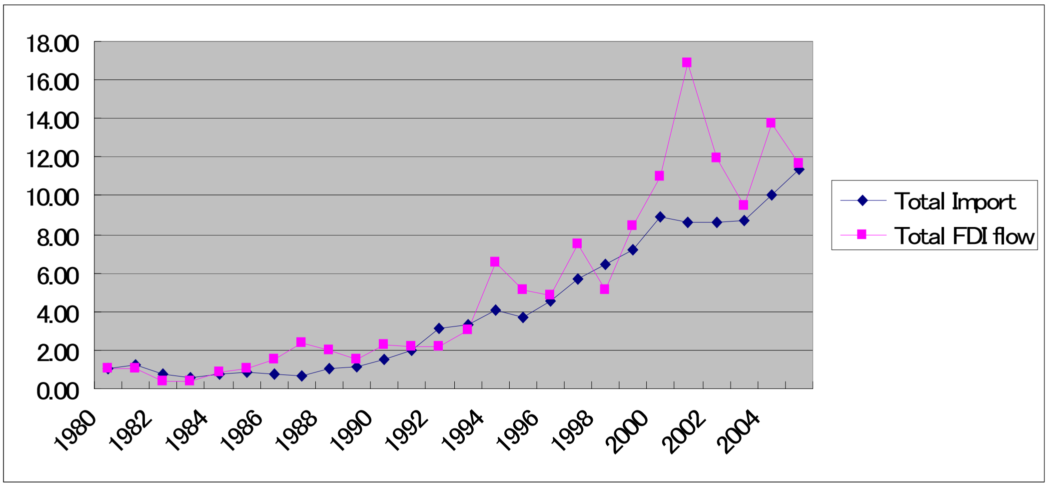

Figure 1: Mexican imports and FDI inflows, 1980-2005.

Source: Author's calculation based on the data from INEGI (Instituto Nacional de Estadística, Geografía e Informática)

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 the NAFTA's effect on productivity is stronger than previously believed. The paper also shows that the speed of convergence in productivity differs across industries; notably the industries which have smaller TFP-gap levels enjoyed higher convergence of TFP.

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1 All these figures for import and export amounts are by the author's computation from UNCOMTRADE data. 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 (1995), Tybout and Westbrook (1995), Clerides, Lach and Tybout (1998), Alvarez and Robertson (2001). 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.

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 Malaysia 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 project in 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 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 can not 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 (TFP) 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.

The paper in the literature that is closest to the present study looks at NAFTA's effect on productivity convergence. This paper –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 It does not include Mexico.

Plan of paper

The next section, Section 2, describes the methodology to be employed in this paper. Section 3 discusses the result of TFP gap analysis of the simple model argued in Section 2. Section 4 argues the difference in the speed of convergence across industries. The final section concludes.

3. METHODOLOGY

In this paper, the Total Factor Productivity (TFP) and the value added per employee (VA per employee) are used as measures of productivity level. For an international comparison of productivity, we should bear in mind two issues. The first is which production function we assume. Obviously this is relevant only to TFP, not to VA per employee. The other is the currency conversion and the nominal-to-real conversion. The importance of these issues is elaborated below.

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[4]. 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 & 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:

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

where Y, L and K represents Value added, Labour input and Capital stock, respectively. Subscripts in c, i, t represents country, industry and time, respectively. The bars on Y, L and K denote average of each variables across countries at a given time, namely, $\overline{\ln Z_{it}} = (1/C)\sum_c \ln Z_{cit}$, 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, $\overline{\sigma_{it}} = (1/C)\sum_c \sigma_{cit}$

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 he modified for empirical purpose to apply to discrete time. Widely used approach is due to Thörnquist (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.

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. Sorensen (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 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[5].

The computation of the Industry-Specific PPPs in this paper follows the methodology used by Van Biesebroeck (2004)[6], 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[7]. Third, adjustments are made for trade[8]. More details on the process of computation and the computed Industry-Specific PPPs are described in the Appendix A1. 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.[9] As we can see 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).

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5 'Comment' by Dale Jorgenson on van Ark and Pilat (1993) p.53

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

7 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).

8 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.

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

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

3.3.1. Data source and data construction

Data of Y (Value added), K (Capital), L (Hours Worked) and the factor shares are computed using the data from UNIDO INDSTAT 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 BLS[10]. 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. 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

10 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.

time comparison) using the Producer Price Index for each three digit industries drawn from US Bureau of Labor Statistics (BLS). L is computed as the number of employment drawn from INDSTAT multiplied by the average hours worked taken from the OECD.

3.3.2. 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:

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

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[11]. 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[12]:

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

where S_n = the relative efficiency of a n-year old asset

L =the service life

n =the age of the asset

B =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 (=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:

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

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.

As is shown in the Appendix A3, 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

11 The detailed explanation of the capital service life computation is in the Appendix A2.

12 Detailed explanation is provided at the web-site of Bureau of Labor Statistics, U.S. Department of Labor, www.bls.gov/opub/hom/homch11_e.html.

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. Thus, we can predict that this refinement leads to more convergence of TFP than EFL (2003) finds since the refinement yields smaller estimated capital stocks of the post-NAFTA Mexico.

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).

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

where, $G_{i,t}$: The gap in TFP of industry i at time t between Mexico and the US.

NAFTA: NAFTA year dummy for 1994-2000

$G_{i,t-1} \cdot NAFTA$: Slope NAFTA dummy (Interaction term between the lagged dependent variable and NAFTA dummy

η_i: Industry-Specific effects

λ_t: Time (year) specific effects

$\varepsilon_{i,t}$: 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 $G^*_{i,t-1} = G_{i,t-1} - \frac{1}{T-1}(G_{i,2} + ... + G_{i,T})$, while, defining the composite error as $\zeta_{i,t} \equiv \eta_i + \lambda_t + \varepsilon_{i,t}$, it becomes $\zeta^*_{i,t} = (\lambda_t - \frac{1}{T-1}\sum_{t=2}^{T}\lambda_t) + (\varepsilon_{i,t} - \frac{1}{T-1}(\varepsilon_{i,2} + \varepsilon_{i,3} ... + \varepsilon_{i,T}))$. Here, the $G_{i,t-1}$ term in the explanatory variable $G^*_{i,t-1}$ is correlated with $\varepsilon_{i,t-1}$ 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 IV. 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 this IV satisfies the two conditions of IV, namely 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 $G_{i,t-2}, G_{i,t-3}, \dots, G_{i,1}$ as IV for $G_{i,t-1} - G_{i,t-2}$. This is so called the 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

4.1. Estimation result using TFP as the measure of productivity

The current literature, e.g. EFL (2003), uses the Arellano-Bond Difference GMM. As it turns out, there is a problem with this estimator for the data set used by EFL (2003) and in this paper.

4.1.1. 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. Arellano-Bond tests for autocorrelation shows 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[13].

Table 2: Estimation results of various estimation methods

Dependent variable: Gap in TFP (US TFP – MEX TFP)

Independent variables	OLS	Fixed effects	Arellano-Bond Difference GMM
Lagged Gap in TFP (t-1)	0.985 *** (0.023)	0.842 *** (0.042)	0.391 *** (0.120)
NAFTA x Lagged Gap in TFP (t-1)	-0.218 *** (0.044)	-0.282 *** (0.044)	-0.418 *** (0.095)
NAFTA dummy	0.273 *** (0.053)	0.287 *** (0.051)	0.206 *** (0.069)
Number of observations	213	213	178
Number of industries	18	18	18

Specification test for Arellano-Bond Difference GMM

1st order serial correlation (p-value) : 0.022

2nd order serial correlation (p-value): 0.235

Notes: Standard errors in parentheses. *** indicates statistical significance at 0.1% level.

13 Due to the large number of combinations of the minor changes, the estimation results from the minor changes are not reported here.

4.1.2. 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, $G_{i,t-2}$ and $G_{i,t-3}$) and the variables instrumented (the differenced variable, $G_{i,t-1} - G_{i,t-2}$) is weak. To address this so-called 'weak instruments problem', the system GMM of Blundell and Bond (1998) proposes to add new moment conditions. That is, past differences are used as instruments for current levels since 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. A notable point is that the coefficient estimate lies within the 'hoped-for-range'. The specification test indicates that the instrument set is valid.

Table 3: Estimation result of the System GMM

Dependent variable: Gap in TFP (US TFP – MEX TFP)

Independent variables	System GMM
Lagged Gap in TFP (t-1)	0.945 *** (0.051)
NAFTA x Lagged Gap in TFP (t-1)	-0.275 *** (0.060)
NAFTA dummy	0.029 (0.053)
Number of observations	213
Number of industries	18

Specification test

Hansen test of overidentifying restrictions (p-value): 1.000

1st order serial correlation (p-value) : 0.006

2nd order serial correlation (p-value): 0.484

Notes: Standard errors in parentheses. *** indicates statistical significance at 0.1% level.

Therefore, the System GMM is considered to be better than the Difference GMM for the current data. The coefficient estimate of 0.945 with the standard error of 0.051 indicates that there was no convergence in TFP without NAFTA, while the slope dummy coefficient of -0.278 suggests that NAFTA contributed considerably to the acceleration of the speed of convergence.

Although the System GMM yields plausible estimates, there is one potential concern. In large N and small T panel data, the Arellano-Bond Difference GMM and the System GMM should not yield very different coefficient estimates. The large difference of the estimates found above suggests that the GMM methods are suffering from substantial bias caused by non-large N. Therefore, it might be even more sensible to use the fixed effect estimation and perform a rough bias correction.[14].

As argued above, the coefficient estimate of the fixed effect estimation is downward biased. However, a rough estimation of the true parameter can be possible, using the bias formula shown by Nickell (1981).

$$\hat{\gamma}_{FE} = \gamma - \frac{(1+\gamma)}{T} \qquad \textbf{(6)}$$

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.[15] Thus, we reach the same conclusion with the case of the System GMM. Namely, without NAFTA there was almost no convergence as the coefficient of 0.97 indicates.

As to the NAFTA's effect on the productivity gap, there are two effects, one on the slope coefficient and the other on the level. The coefficient estimate of the NAFTA interaction dummy, -0.282, indicates that NAFTA caused an acceleration of the speed of adjustment. Based on the above rough estimate of 0.97 for γ, before NAFTA it takes about 22.8 years for one unit shock to dwindle to 0.5 (A half life of one unit shock is 22.8 years.)[16], while with NAFTA it takes only 1.9 years[17]. On the other hand, the coefficient of NAFTA dummy, 0.287 means that there was a one-time upward level shift in the level of the productivity gap. In other words, NAFTA has accelerated the speed of convergence as expressed in the negative number of slope coefficient while at the same time increasing the gap in levels.

The following numerical example can help us interpret the relative impact of these NAFTA effects: one on the slope, the other on the level. The average TFP gap *level* before NAFTA, namely from 1986 to 1993, is 0.334. As argued above, without NAFTA, 22.8 years are needed to halve this gap from 0.334 to 0.167. NAFTA caused this gap of 0.334 to rise to 0.621 (=0.334+0.287) (level shift) but, on the other hand, accelerated the speed of adjustment to 0.695 (=0.97-0.275). It takes 3.6 years to come down to the same level of 0.167[18]. Namely, NAFTA reduced the time needed to reach the TFP gap of 0.167 from 22.8 years to 3.6 years. It can be concluded that NAFTA substantially contributed to the productivity convergence between the US and Mexico, more than what EFL (2003) finds. The crucial difference between the results of EFL (2003) and this paper comes from the choice of estimation methods. By comparing several potential estimation methods, this paper reaches the more plausible

14 I thank an advice of Professor Arellano for this argument.

15 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.

16 $1 \cdot (0.97)^x = 0.5 \rightarrow x \approx 22.8$

17 $1 \cdot (0.97 - 0.282)^x = 0.5 \rightarrow x \approx 1.9$

18 $0.621 \cdot (0.695)^x = 0.167 \rightarrow x \approx 3.6$

estimate of NAFTA effect. Both of the System GMM and the fixed effect panel regression have shown stronger productivity convergence than the result of EFL (2003).

4.1.3. The effect of the refinement in data construction on the estimation results

As mentioned in the introduction, this paper proposes some refinements on TFP calculation. It employs the industry-Specific PPPs in the currency conversion and the 18-year capital life and hyperbolic depreciation rate of capital in the computation of capital stocks. Table 4 provides the comparison between the coefficient estimates derived from the TFP data based on the refinement of data treatment in this paper and those derived from GDP-based PPPs and 10 year-5 percent depreciation rate of capital as EFL (2003) does. The estimation method employed is the fixed effect panel regression, as justified in the argument above. The former regression coefficients indicate a slower speed of convergence than the latter regression coefficients. Roughly speaking, the impact of NAFTA slope dummy is 0.335 (=0.282 / 0.842) for the case (1), the industry-Specific PPPs and the hyperbolic depreciation rate of capital, while it is 0.406 (=0.363 / 0.893) for the case (2), the GDP-based PPPs and 10 year-5 percent depreciation rate of capital. Namely, the use of the industry-Specific PPPs and the hyperbolic depreciation rate of capital in the calculation of TFP leads to less convergence estimate than the case of 10 year-5 percent depreciation rate of capital.

We have seen above that the refinement on capital stock computation is likely to lead to more convergence post-NAFTA while the refinement on the use of the Industry-Specific PPPs may lead to less convergence post-NAFTA. The above overall result of less convergence estimate shown is considered to be reflecting the net effect of these two forces.

Therefore, this paper's finding of higher convergence phenomenon than the previous literature comes from the fact that a stronger convergence force resulted from the switch to the fixed effect panel estimation or the System GMM from the Arellano-Bond difference GMM more than off-sets a weaker convergence force resulted from the refinement of data construction.

Table 4: Comparison of the estimation results from the different ways of TFP computation

Dependent variable: Gap in TFP (US TFP – MEX TFP)

Independent variables	(1)	(2)
Lagged Gap in TFP (t-1)	0.842 *** (0.042)	0.893 *** (0.045)
NAFTA x Lagged Gap in TFP (t-1)	-0.282 *** (0.044)	-0.363 *** (0.071)
NAFTA dummy	0.287 *** (0.051)	0.304 *** (0.055)
Number of observations	213	213
Number of industries	18	18

Notes: (1): the industry-Specific PPPs and 18 year - hyperbolic depreciation rate of capital

(2): the GDP-based PPPs and 10 year-5 percent depreciation rate of capital

4.2. Productivity measured by Value added per employee

The same model is run for Value added per employee, the other commonly used measure of productivity. Table 5 summarises the results, which are almost identical to the case of TFP above.

The coefficient estimates are similar. This finding of no difference between the use of TFP and Value added per employee is in line with the standard result in the literature.

Table 5: Estimation results using VA per employee as the measure of productivity

Dependent variable: Gaps in Value added per employee (US VA/employee – Mexico VA/employee)

Independent variables	OLS	Fixed effects	Arellano-Bond Difference GMM	System GMM
Lagged Gap in VA (t-1)	0.964*** (0.022)	0.953*** (0.035)	0.550*** (0.063)	0.986*** (0.037)
NAFTA x Lagged Gap in VA (t-1)	-0.129*** (0.039)	-0.231*** (0.043)	-0.580*** (0.095)	-0.298** (0.096)
NAFTA dummy	0.291*** (0.058)	0.355*** (0.066)	0.888*** (0.127)	0.425** (0.132)
No. observations	296	296	244	296
No. of industries	26	26	26	26

Standard errors in parentheses. *** indicates statistical significance at 0.1% level while ** indicates statistical significance at 1% level.

5. THE DIFFERENCE IN SPEED OF CONVERGENCE ACROSS INDUSTRIES

The above analysis shows a higher speed of convergence of productivity gaps than what the previous literature found. One interesting question to be further explored in the above analysis is which industries have contributed most for the acceleration of the speed of convergence.

To study the issue, we plot the predicted and actual values of TFP by year. The plots suggest that industries which have low TFP gap *levels* contributed more to the acceleration of the speed of convergence while the industries of high TFP gap *levels* contributed less (See the appendix A4 for the plots). To test this hypothesis, the eighteen industries are divided into three groups by the average TFP gap levels and the fixed effect panel regressions are performed for each sub-sample. Table 6 shows the grouping of the eighteen industries. The regression results are in Table 7.

As the rows 3 and 4 of Table 7 show, the impact of NAFTA on the acceleration of speed of convergence is lower for the industries of high TFP gap levels than the industries of low TFP gap levels. Under the NAFTA regime, it is easier for the low TFP gap level industries to catch up than the high TFP gap level industries. This confirms the hypothesis.

The association between large TFP gaps and lower convergence hints at a number of intriguing possible mechanisms. In the literature of international economics, trade is considered to be one of the channels of technology diffusion.[19] This standard explanation, however, does not seem to be present in this data set. The last two columns of Table 6 show the average import and export ratios of each

19 Theoretical research on technology diffusion was pioneered by Nelson and Phelps (1966), Krugman (1979) and Grossman and Helpman (1991) among others. The principal idea is that developing countries can catch up with developed countries by imitating technology of developed countries since the cost of imitation is lower than that of innovation. The first attempt to econometrically assess the phenomenon of international technology diffusion is by Coe and Helpman (1995). Following suit, Eaton and Kortum (1997), Coe, Helpman and Hoffmaister (1997), Lumenga-Neso, Olarreaga and Schiff (2001), and Olarreaga, Schiff and Wang (2003) all find statistically significant effect of trade on technology diffusion.

industry[20]. The industries of low TFP gap levels, which have been shown above to have enjoyed stronger acceleration of speed of convergence have smaller import and export ratios. The increased trade between Mexico and the US does not seem to explain the evolution of productivity gaps found above. As a more rigorous check, the panel data regressions are run, using export and import ratios as explanatory variables. The results did not yield statistically significant coefficient estimates.

One explanation may be possible, following Aghion et al. (2005). It shows an inverted-U relation between degree of competition and innovations: Firms do not have incentives to innovate when they face very little competition because they do not need to innovate thanks to their dominant status in the market. As the degree of competition increases, firms engage more and more in innovative activities. When the degree of competition reaches an extreme, firms lose incentives to innovate since they can not expect any mark-up profit from innovations. Aghion et al. (2005) further argues that the upward sloping part of the inverted-U curve is steeper for industries which are close to technological frontier. This last argument may explain the above findings of this paper.

NAFTA obviously increased the degree of competition, which in turn raised innovation activities. The increase of innovation activities is higher for the industries of low technology gaps vis-à-vis frontier technology, namely the US, which is represented by the steeper slope. Mexican industries that were closer to frontier technology of the US engaged in more innovative activities because of a threat of imports from the gigantic neighbour. On the other hand, Mexican industries whose technology was farther away from technological frontier of the US were less encouraged to innovate. To econometrically corroborate this hypothesis is a future work to be done.

Table 6: Industry grouping by the average TFP gap levels

	indcode	industry description	TFP GAP (average 1994-2000)	Average import ratio (1994-2000)	Average import ratio (1994-2000)
Group 1	314	Tobacco	-0.1300	0.0%	0.0%
	313	Beverages	0.1787	0.1%	0.9%
	311	Food products	0.2736	5.1%	5.8%
	354	Misc. petroleum and coal product:	0.3251	0.4%	1.4%
	355	Rubber products	0.3580	1.6%	0.4%
	331	Wood products, except furniture	0.3697	0.6%	0.6%
Group 2	371	Iron and steel	0.5279	3.8%	2.3%
	372	Non-ferrous metals	0.5313	2.6%	1.6%
	382	Machinery, except electrical	0.5507	18.7%	16.2%
	351	Industrial chemicals	0.5677	7.1%	1.8%
	384	Transport equipment	0.5793	14.8%	25.7%
	352	Other chemicals	0.6130	1.7%	0.7%
Group 3	362	Glass and products	0.7690	0.6%	0.8%
	383	Machinery, electric	0.7776	28.4%	34.4%
	341	Paper and products	0.7837	4.1%	0.9%
	369	Other non-metallic mineral produ	0.8421	0.5%	0.6%
	381	Fabricated metal products	0.9837	5.1%	3.2%
	321	Textiles	0.9838	4.8%	2.7%

Source: Author's computation

20 Trade data are taken from UNCOMTRADE. We convert SITC rev.2 two digit data of UNCOMTRADE into ISIC rev.2, using Jon Haveman's correspondence table.

Table 7: Estimation results by sub-samples according to the average TFP gap levels

Dependent variable: Gap in TFP (US TFP – MEX TFP)

	Group 1	Group 2	Group 3
1 Lagged TFP GAP (t-1)	0.865	0.825	0.939
2 Slope NAFTA dummy	-0.508	-0.422	-0.418
3 = 1 – 2 : Slope post-NAFTA	0.357	0.403	0.521
4 = (Absolute value of 2)/ 1	0.587	0.512	0.445
Number of observations	69	72	72
Number of industries	6	6	6

6. CONCLUDING REMARKS

This paper has introduced improved procedures for generating TFP data and applied more appropriate econometric methods to the issue of how NAFTA has affected productivity convergence between Mexican and US manufacturing sector. With these refinements, the findings suggest that NAFTA is associated with a higher speed of convergence of productivity gaps than the previous literature suggested. It also shows that the industries which have low TFP gap levels experienced higher speed of convergence than the industries of high TFP gap levels. This association between large TFP gaps and slow convergence hints at a number of intriguing possible mechanisms, but the most obvious one – involving trade flows – does not seem to be in operation in this case, as was checked with the data. One possible underlying force of this paper's finding is a steeper slope of an inverted-U curve for industries which are closer to the technological frontier discussed by Aghion et al. (2005). Namely, an increased degree of competition brought by NAFTA led to more innovation for industries which had lower technology gaps. Verifying this hypothesis and a further investigation on the underlying forces of the evolution of the productivity gap is the work to be done in the future.

APPENDIX

A1. Computation of the Industry Specific PPPs[21]

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

$$PPP_{c,t} = \frac{P_{c,t}^{peso}}{P_{c,t}^{dollars}}, \qquad \textbf{(A 1)}$$

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:

$$PPP_{i,t} = \frac{P_{i,t}^{peso}}{P_{i,t}^{dollars}} \qquad \textbf{(A 2)}$$

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,

$$PPP_{expend} \times Consumption = PPP_{prod} \times \Pr oduction + ex.rate \times \operatorname{Im} ports - ex.rate \times Exports \qquad \textbf{(A 3)}$$

since total consumption is domestic production plus imports minus exports.

In Mexican pesos the following identity holds as well,

$$\text{Consumption} = \text{Production} + \text{Imports} - \text{Exports} \qquad \textbf{(A 4)}$$

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

$$PPP_{prod} = PPP_{expend} + (ex.rate - PPP_{expend}) \times \frac{Exports - \operatorname{Im} ports}{\Pr oduction} \qquad \textbf{(A 5)}$$

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.

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

$$PPP_{i,h} = PPP_{i,t} \times \frac{(P_{i,h}/P_{i,t})^{peso}}{(P_{i,h}/P_{i,t})^{dollars}} \qquad \textbf{(A 6)}$$

The data of deflation rates come from US Bureau of Labor 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. In

21 The description here draws on Van Biesebroeck (2004)

fact, as is always the case for correspondence between different classification codes, a perfect match is impossible, especially when the data on highly disaggregated codes are unavailable as in the current case. 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.

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

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.

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 specific PPPs

Industry code	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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	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

Remarks: Industry code is ISIC rev.2.

Industry description

ISIC rev.2 code	Description
311	Food products
313	Beverages
314	Tobacco
321	Textiles
331	Wood products, except furniture
341	Paper and products
351	Industrial chemicals
352	Other chemicals
354	Misc. petroleum and coal products
355	Rubber products
362	Glass and products
369	Other non-metallic mineral products
371	Iron and steel
372	Non-ferrous metals
381	Fabricated metal products
382	Machinery, except electrical
383	Machinery, electric
384	Transport equipment

A2. Computation of capital service life

The detailed data of capital service life used by BLS is available from Barbara 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 categories: 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.

A3. Computation of capital stocks

1. US Capital stock (18 years capital life and the hyperbolic depreciation rate)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311	6.06E+10	6.23E+10	6.43E+10	6.63E+10	6.91E+10	7.23E+10	7.53E+10	7.92E+10	8.24E+10	8.58E+10	9.07E+10	9.6E+10	1.02E+11	1.08E+11	1.16E+11
313	1.81E+10	1.82E+10	1.82E+10	1.83E+10	1.83E+10	1.81E+10	1.81E+10	1.82E+10	1.81E+10	1.83E+10	1.87E+10	1.94E+10	2.05E+10	2.15E+10	2.26E+10
314	5.83E+09	6.24E+09	6.39E+09	6.47E+09	6.49E+09	6.36E+09	6.35E+09	6.33E+09	6.3E+09	6.24E+09	6.17E+09	6.26E+09	6.5E+09	6.28E+09	6.02E+09
321	2.66E+10	2.65E+10	2.67E+10	2.72E+10	2.78E+10	2.84E+10	2.87E+10	2.94E+10	3.04E+10	3.2E+10	3.35E+10	3.5E+10	3.67E+10	3.79E+10	3.89E+10
331	1.82E+10	1.8E+10	1.81E+10	1.81E+10	1.81E+10	1.8E+10	1.77E+10	1.75E+10	1.75E+10	1.8E+10	1.88E+10	1.99E+10	2.14E+10	2.29E+10	2.47E+10
341	6.23E+10	6.48E+10	6.65E+10	6.97E+10	7.57E+10	8.19E+10	8.57E+10	8.84E+10	9.01E+10	9.14E+10	9.35E+10	9.59E+10	9.85E+10	1.01E+11	1.02E+11
351	8.73E+10	8.62E+10	8.54E+10	8.63E+10	8.93E+10	9.37E+10	9.75E+10	1E+11	1.02E+11	1.03E+11	1.07E+11	1.12E+11	1.19E+11	1.26E+11	1.32E+11
352	3.01E+10	3.12E+10	3.28E+10	3.5E+10	3.75E+10	3.99E+10	4.28E+10	4.74E+10	5.19E+10	5.61E+10	6.05E+10	6.56E+10	7.13E+10	7.71E+10	8.25E+10
354	3.29E+09	3.4E+09	3.52E+09	3.59E+09	3.71E+09	3.8E+09	3.84E+09	3.99E+09	4.04E+09	4.17E+09	4.23E+09	4.3E+09	4.37E+09	4.44E+09	4.51E+09
355	1.02E+10	9.98E+09	9.82E+09	9.86E+09	1.03E+10	1.05E+10	1.05E+10	1.07E+10	1.1E+10	1.13E+10	1.16E+10	1.21E+10	1.28E+10	1.37E+10	1.46E+10
362	9.61E+09	9.68E+09	9.77E+09	9.88E+09	1.03E+10	1.04E+10	1.06E+10	1.09E+10	1.1E+10	1.12E+10	1.16E+10	1.22E+10	1.31E+10	1.42E+10	1.52E+10
369	2.38E+10	2.37E+10	2.36E+10	2.33E+10	2.33E+10	2.32E+10	2.26E+10	2.22E+10	2.18E+10	2.18E+10	2.22E+10	2.32E+10	2.5E+10	2.71E+10	2.97E+10
371	4.99E+10	4.74E+10	4.56E+10	4.45E+10	4.44E+10	4.41E+10	4.4E+10	4.31E+10	4.19E+10	4.19E+10	4.23E+10	4.28E+10	4.34E+10	4.41E+10	4.47E+10
372	2.13E+10	2.09E+10	2.08E+10	2.09E+10	2.13E+10	2.16E+10	2.16E+10	2.19E+10	2.19E+10	2.26E+10	2.3E+10	2.38E+10	2.49E+10	2.6E+10	2.71E+10
381	4.24E+10	4.28E+10	4.33E+10	4.34E+10	4.42E+10	4.48E+10	4.45E+10	4.5E+10	4.56E+10	4.68E+10	4.91E+10	5.34E+10	5.95E+10	6.66E+10	7.38E+10
382	9.31E+10	9.46E+10	9.67E+10	9.84E+10	1.01E+11	1.03E+11	1.04E+11	1.06E+11	1.07E+11	1.1E+11	1.12E+11	1.16E+11	1.21E+11	1.27E+11	1.33E+11
383	8.17E+10	8.66E+10	8.88E+10	9.19E+10	9.57E+10	9.96E+10	1.02E+11	1.05E+11	1.09E+11	1.15E+11	1.26E+11	1.39E+11	1.54E+11	1.67E+11	1.78E+11
384	9.87E+10	1.06E+11	1.13E+11	1.15E+11	1.19E+11	1.23E+11	1.27E+11	1.31E+11	1.35E+11	1.39E+11	1.45E+11	1.52E+11	1.61E+11	1.71E+11	1.79E+11

2. US Capital stock (10 years capital life and 5 percent depreciation rate)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311	4.32E+10	4.45E+10	4.59E+10	4.72E+10	4.95E+10	5.2E+10	5.47E+10	5.79E+10	6.11E+10	6.39E+10	6.78E+10	7.22E+10	7.67E+10	8.19E+10	8.85E+10
313	1.32E+10	1.31E+10	1.29E+10	1.27E+10	1.23E+10	1.18E+10	1.17E+10	1.18E+10	1.16E+10	1.18E+10	1.24E+10	1.33E+10	1.46E+10	1.56E+10	1.67E+10
314	4.62E+09	5E+09	5.09E+09	5.07E+09	5.06E+09	4.82E+09	4.52E+09	4.27E+09	4.06E+09	3.82E+09	3.63E+09	3.63E+09	3.95E+09	3.88E+09	3.78E+09
321	1.74E+10	1.75E+10	1.79E+10	1.84E+10	1.92E+10	1.99E+10	2.02E+10	2.1E+10	2.2E+10	2.33E+10	2.45E+10	2.6E+10	2.73E+10	2.8E+10	2.85E+10
331	1.21E+10	1.2E+10	1.18E+10	1.15E+10	1.14E+10	1.12E+10	1.11E+10	1.13E+10	1.17E+10	1.23E+10	1.33E+10	1.45E+10	1.59E+10	1.73E+10	1.88E+10
341	4.66E+10	4.81E+10	4.88E+10	5.08E+10	5.54E+10	6.01E+10	6.28E+10	6.5E+10	6.67E+10	6.75E+10	6.86E+10	7.02E+10	7.26E+10	7.41E+10	7.2E+10
351	6.08E+10	5.76E+10	5.42E+10	5.39E+10	5.63E+10	6.01E+10	6.4E+10	6.8E+10	7.17E+10	7.47E+10	7.93E+10	8.54E+10	9.26E+10	9.83E+10	1.02E+11
352	2.23E+10	2.32E+10	2.46E+10	2.64E+10	2.84E+10	3.02E+10	3.26E+10	3.66E+10	4.05E+10	4.39E+10	4.75E+10	5.2E+10	5.68E+10	6.12E+10	6.53E+10
354	2.45E+09	2.48E+09	2.56E+09	2.56E+09	2.64E+09	2.7E+09	2.73E+09	2.87E+09	2.9E+09	3.01E+09	2.96E+09	3E+09	3.04E+09	3.1E+09	3.13E+09
355	6.26E+09	6.29E+09	6.29E+09	6.39E+09	6.84E+09	7.15E+09	7.25E+09	7.57E+09	8.03E+09	8.32E+09	8.48E+09	8.94E+09	9.58E+09	1.03E+10	1.09E+10
362	6.63E+09	6.69E+09	6.74E+09	6.75E+09	6.97E+09	6.97E+09	7.22E+09	7.48E+09	7.72E+09	8.02E+09	8.31E+09	8.95E+09	9.83E+09	1.08E+10	1.16E+10
369	1.64E+10	1.63E+10	1.59E+10	1.51E+10	1.49E+10	1.45E+10	1.39E+10	1.39E+10	1.41E+10	1.42E+10	1.47E+10	1.6E+10	1.79E+10	2.01E+10	2.25E+10
371	3.3E+10	3.03E+10	2.82E+10	2.69E+10	2.64E+10	2.58E+10	2.57E+10	2.59E+10	2.59E+10	2.71E+10	2.82E+10	3E+10	3.14E+10	3.24E+10	3.25E+10
372	1.45E+10	1.42E+10	1.4E+10	1.4E+10	1.42E+10	1.44E+10	1.43E+10	1.48E+10	1.48E+10	1.55E+10	1.6E+10	1.7E+10	1.81E+10	1.91E+10	2E+10
381	2.98E+10	3.02E+10	3.02E+10	2.98E+10	3.01E+10	3.02E+10	2.96E+10	3.03E+10	3.13E+10	3.24E+10	3.45E+10	3.87E+10	4.47E+10	5.16E+10	5.81E+10
382	7.06E+10	7.13E+10	7.19E+10	7.15E+10	7.17E+10	7.18E+10	7.05E+10	7.11E+10	7.26E+10	7.42E+10	7.66E+10	8.13E+10	8.66E+10	9.28E+10	9.75E+10
383	6.4E+10	6.87E+10	7.01E+10	7.2E+10	7.41E+10	7.56E+10	7.56E+10	7.68E+10	7.91E+10	8.23E+10	9E+10	1.01E+11	1.16E+11	1.28E+11	1.38E+11
384	7.56E+10	8.24E+10	8.71E+10	8.62E+10	8.77E+10	8.91E+10	8.88E+10	9.22E+10	9.77E+10	1.01E+11	1.05E+11	1.09E+11	1.16E+11	1.26E+11	1.33E+11

3. Difference: 1 divided by 2

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311	1.403	1.401	1.403	1.406	1.395	1.389	1.378	1.367	1.349	1.342	1.338	1.329	1.324	1.317	1.311
313	1.367	1.392	1.417	1.443	1.488	1.531	1.542	1.548	1.558	1.546	1.508	1.463	1.411	1.379	1.353
314	1.260	1.248	1.255	1.275	1.284	1.319	1.404	1.481	1.553	1.631	1.701	1.722	1.643	1.619	1.591
321	1.530	1.516	1.498	1.478	1.449	1.426	1.417	1.396	1.378	1.374	1.365	1.348	1.346	1.354	1.365
331	1.498	1.507	1.531	1.567	1.585	1.602	1.597	1.552	1.495	1.460	1.415	1.370	1.341	1.325	1.314
341	1.336	1.347	1.364	1.372	1.366	1.363	1.365	1.360	1.351	1.354	1.364	1.365	1.356	1.364	1.415
351	1.436	1.497	1.574	1.602	1.587	1.558	1.522	1.477	1.424	1.384	1.347	1.313	1.286	1.280	1.297
352	1.349	1.342	1.333	1.327	1.321	1.319	1.312	1.295	1.280	1.277	1.273	1.262	1.257	1.258	1.264
354	1.344	1.372	1.373	1.402	1.404	1.409	1.405	1.390	1.392	1.386	1.429	1.431	1.436	1.432	1.441
355	1.623	1.587	1.562	1.544	1.510	1.474	1.452	1.411	1.372	1.361	1.371	1.354	1.334	1.325	1.346
362	1.450	1.446	1.450	1.465	1.471	1.495	1.471	1.455	1.426	1.399	1.393	1.364	1.335	1.314	1.319
369	1.453	1.456	1.482	1.542	1.566	1.603	1.624	1.598	1.549	1.534	1.510	1.449	1.396	1.345	1.321
371	1.512	1.566	1.617	1.655	1.682	1.707	1.710	1.665	1.617	1.547	1.500	1.426	1.380	1.361	1.373
372	1.465	1.473	1.486	1.491	1.500	1.495	1.510	1.481	1.478	1.454	1.445	1.403	1.374	1.361	1.356
381	1.421	1.420	1.431	1.457	1.469	1.483	1.504	1.487	1.458	1.444	1.422	1.378	1.332	1.291	1.271
382	1.320	1.328	1.344	1.376	1.408	1.440	1.476	1.489	1.476	1.475	1.468	1.431	1.401	1.372	1.362
383	1.276	1.261	1.267	1.277	1.292	1.319	1.344	1.366	1.378	1.403	1.403	1.376	1.328	1.303	1.290
384	1.306	1.289	1.297	1.331	1.357	1.382	1.426	1.415	1.381	1.375	1.384	1.393	1.389	1.353	1.344

1.442
pre-NAFTA average

1.395
post-NAFTA average

1.420
Overall average

4. Mex Capital stock (18 years capital life and the hyperbolic depreciation rate)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311	1.57E+09	1.65E+09	1.68E+09	1.69E+09	1.72E+09	1.88E+09	2.1E+09	2.76E+09	3.382E+09	4.36E+09	5.3E+09	6.15E+09	7.06E+09	7.9E+09	8.52E+09
313	1.49E+09	1.48E+09	1.49E+09	1.47E+09	1.48E+09	1.54E+09	1.65E+09	1.99E+09	2.303E+09	2.8E+09	3.18E+09	3.46E+09	3.74E+09	3.93E+09	4.47E+09
314	1.4E+08	1.45E+08	1.5E+08	1.54E+08	1.54E+08	1.62E+08	1.62E+08	2.18E+08	270269858	3.7E+08	4.08E+08	4.11E+08	4.27E+08	4.65E+08	4.65E+08
321	1.23E+09	1.2E+09	1.18E+09	1.22E+09	1.24E+09	1.22E+09	1.21E+09	1.28E+09	1.341E+09	1.46E+09	1.78E+09	2.1E+09	2.45E+09	2.71E+09	2.86E+09
331	1.33E+08	1.29E+08	1.23E+08	1.17E+08	1.09E+08	99546173	90762366	86767537	83097615	83035979	94428575	1.29E+08	1.56E+08	1.78E+08	1.9E+08
341	1.71E+09	1.63E+09	1.6E+09	1.53E+09	1.49E+09	1.5E+09	1.6E+09	1.89E+09	2.161E+09	2.59E+09	3.13E+09	3.5E+09	3.66E+09	3.83E+09	4.31E+09
351	2.54E+09	2.71E+09	2.81E+09	2.84E+09	2.93E+09	2.93E+09	3.02E+09	3.27E+09	3.505E+09	3.87E+09	4.49E+09	5E+09	5.43E+09	5.92E+09	6.21E+09
352	1.05E+09	1.11E+09	1.19E+09	1.24E+09	1.31E+09	1.39E+09	1.46E+09	1.8E+09	2.13E+09	2.7E+09	3.21E+09	3.83E+09	4.48E+09	5.47E+09	6.35E+09
354	4.37E+08	3.83E+08	3.37E+08	3.01E+08	2.78E+08	2.52E+08	2.38E+08	2.17E+08	192448900	1.6E+08	1.36E+08	1.32E+08	1.76E+08	1.93E+08	1.79E+08
355	5.16E+08	5.33E+08	5.14E+08	5.04E+08	4.94E+08	4.78E+08	4.78E+08	4.81E+08	484635687	4.91E+08	5.52E+08	5.86E+08	6.45E+08	7.82E+08	8.77E+08
362	1.03E+09	1.03E+09	1.01E+09	1.01E+09	9.84E+08	9.75E+08	1.16E+09	1.32E+09	1.462E+09	1.56E+09	1.59E+09	1.58E+09	1.64E+09	1.73E+09	1.81E+09
369	3E+09	2.91E+09	2.78E+09	2.64E+09	2.54E+09	2.4E+09	2.86E+09	3.23E+09	3.578E+09	3.83E+09	3.78E+09	4.25E+09	4.33E+09	4.28E+09	4.25E+09
371	4.44E+09	4.18E+09	3.94E+09	3.7E+09	3.41E+09	3.18E+09	2.93E+09	2.99E+09	3.025E+09	3.3E+09	3.75E+09	4.59E+09	4.91E+09	5.36E+09	5.47E+09
372	6.45E+08	7.29E+08	6.99E+08	6.81E+08	6.72E+08	6.66E+08	6.64E+08	7.92E+08	913548446	1.14E+09	1.3E+09	1.56E+09	1.62E+09	2.18E+09	2.41E+09
381	3.76E+08	4.39E+08	4.73E+08	5.07E+08	5.32E+08	5.77E+08	6.58E+08	7.82E+08	901729682	1.05E+09	1.23E+09	1.45E+09	1.63E+09	1.95E+09	2.17E+09
382	2.43E+08	2.93E+08	3.28E+08	3.76E+08	4.05E+08	4.35E+08	4.62E+08	7.16E+08	959481823	1.4E+09	1.87E+09	2.47E+09	3.13E+09	3.86E+09	4.24E+09
383	5.79E+08	6.43E+08	7.02E+08	7.43E+08	7.96E+08	8.48E+08	9.63E+08	1.16E+09	1.346E+09	1.59E+09	1.87E+09	2.11E+09	2.37E+09	2.72E+09	2.98E+09
384	2.55E+09	2.86E+09	2.95E+09	2.99E+09	2.97E+09	3.03E+09	3.3E+09	4.3E+09	5.275E+09	6.83E+09	7.85E+09	9.11E+09	1.05E+10	1.18E+10	1.31E+10

5. US Capital stock (10 years capital life and 5 percent depreciation rate)

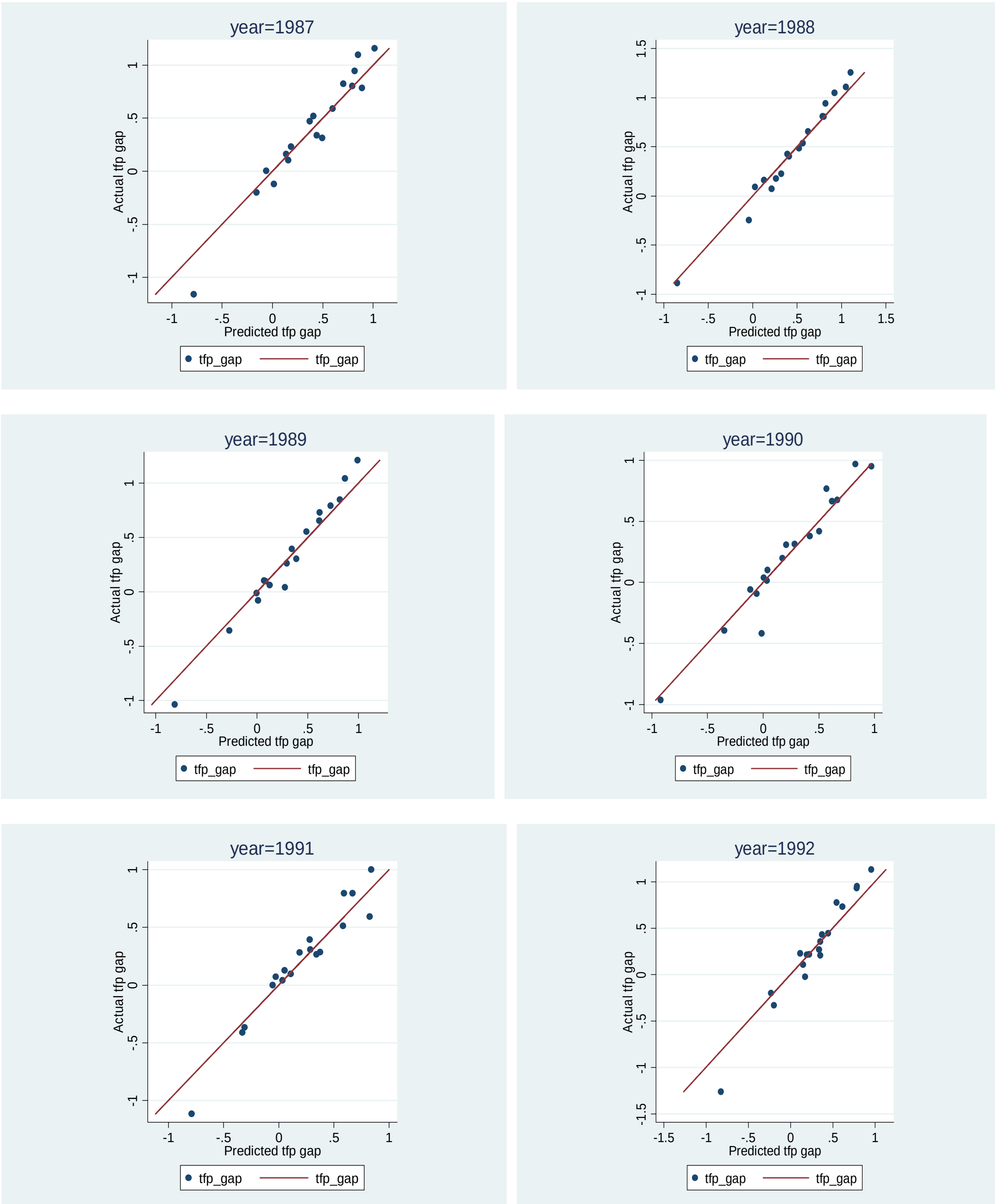
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311	1.14E+09	1.21E+09	1.23E+09	1.23E+09	1.25E+09	1.35E+09	1.51E+09	2.13E+09	2.763E+09	3.72E+09	4.6E+09	5.36E+09	6.2E+09	6.98E+09	7.53E+09
313	1.11E+09	1.1E+09	1.1E+09	1.06E+09	1.04E+09	1.07E+09	1.04E+09	1.35E+09	1.706E+09	2.18E+09	2.58E+09	2.86E+09	3.13E+09	3.33E+09	3.87E+09
314	1.11E+08	1.16E+08	1.22E+08	1.27E+08	1.18E+08	1.22E+08	1.14E+08	1.56E+08	213433854	3.1E+08	3.39E+08	3.37E+08	3.51E+08	3.88E+08	3.89E+08
321	8.56E+08	8.47E+08	8.31E+08	8.8E+08	8.91E+08	8.27E+08	7.87E+08	8.06E+08	891644766	1.05E+09	1.35E+09	1.68E+09	2.04E+09	2.25E+09	2.38E+09
331	96815123	85698310	67790790	64704004	55620853	45553535	42321859	36427900	35203956	44244661	60956907	98331218	1.28E+08	1.51E+08	1.65E+08
341	1.28E+09	1.03E+09	1.03E+09	9.84E+08	9.57E+08	8.81E+08	9.34E+08	1.12E+09	1.491E+09	1.98E+09	2.55E+09	2.95E+09	3.11E+09	3.31E+09	3.78E+09
351	1.75E+09	1.95E+09	1.93E+09	1.76E+09	1.96E+09	1.93E+09	2.05E+09	2.42E+09	2.751E+09	3.05E+09	3.64E+09	4.04E+09	4.36E+09	4.78E+09	4.95E+09
352	8.33E+08	8.74E+08	9.13E+08	9.41E+08	9.86E+08	1.04E+09	1.06E+09	1.38E+09	1.71E+09	2.24E+09	2.72E+09	3.28E+09	3.87E+09	4.81E+09	5.61E+09
354	2.79E+08	2.65E+08	1.21E+08	90636954	86042713	73956315	68324083	76553473	81760401	78130412	84526845	87431678	1.35E+08	1.55E+08	1.43E+08
355	3.89E+08	3.83E+08	3.63E+08	3.5E+08	3.53E+08	3.12E+08	3.08E+08	2.83E+08	288837544	3.03E+08	3.68E+08	3.96E+08	4.71E+08	6.2E+08	7.21E+08
362	7.64E+08	7.61E+08	7.55E+08	7.3E+08	6.85E+08	5.59E+08	7.52E+08	8.9E+08	1.045E+09	1.14E+09	1.19E+09	1.2E+09	1.29E+09	1.39E+09	1.49E+09
369	2.25E+09	2.04E+09	1.93E+09	1.77E+09	1.7E+09	1.52E+09	1.63E+09	1.86E+09	2.268E+09	2.62E+09	2.68E+09	3.26E+09	3.45E+09	3.53E+09	3.6E+09
371	3.49E+09	3.14E+09	2.33E+09	1.79E+09	1.54E+09	1.38E+09	1.2E+09	1.3E+09	1.541E+09	2.08E+09	2.59E+09	3.61E+09	4E+09	4.51E+09	4.69E+09
372	4.63E+08	5.57E+08	5.47E+08	5.35E+08	5.12E+08	4.96E+08	4.68E+08	5.3E+08	653932630	8.9E+08	1.03E+09	1.23E+09	1.31E+09	1.87E+09	2.1E+09
381	2.73E+08	3.32E+08	3.48E+08	3.82E+08	3.99E+08	4.39E+08	5.21E+08	6.36E+08	762036147	9.02E+08	1.05E+09	1.23E+09	1.38E+09	1.67E+09	1.87E+09
382	2.16E+08	2.6E+08	2.9E+08	3.33E+08	3.55E+08	3.73E+08	3.89E+08	6.39E+08	877964216	1.27E+09	1.68E+09	2.23E+09	2.84E+09	3.51E+09	3.84E+09
383	4.61E+08	5.07E+08	5.59E+08	5.98E+08	6.33E+08	6.59E+08	7.38E+08	9.4E+08	1.135E+09	1.35E+09	1.57E+09	1.77E+09	1.99E+09	2.31E+09	2.53E+09
384	1.39E+09	1.83E+09	2.06E+09	2.26E+09	2.22E+09	2.26E+09	2.46E+09	3.47E+09	4.452E+09	5.98E+09	6.89E+09	7.81E+09	9.01E+09	1.01E+10	1.14E+10

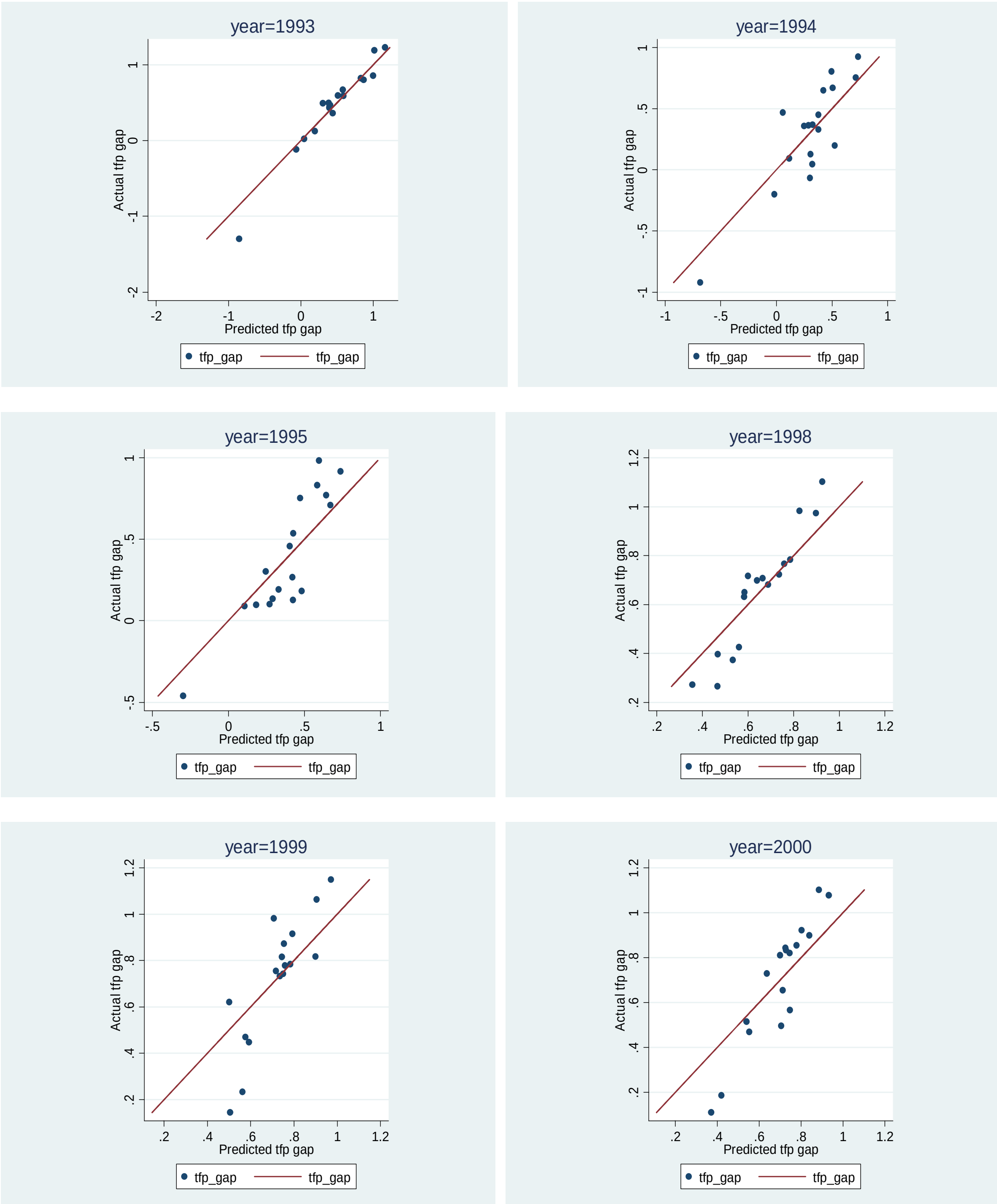
6. Difference: 4 divided by 5

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
311	1.376	1.368	1.371	1.377	1.375	1.386	1.393	1.293	1.224	1.173	1.154	1.149	1.139	1.131	1.132
313	1.335	1.348	1.357	1.387	1.424	1.438	1.597	1.467	1.350	1.284	1.232	1.210	1.194	1.180	1.157
314	1.266	1.244	1.226	1.211	1.302	1.327	1.430	1.391	1.266	1.192	1.203	1.218	1.217	1.200	1.196
321	1.438	1.420	1.418	1.384	1.387	1.479	1.542	1.590	1.504	1.396	1.324	1.253	1.205	1.202	1.204
331	1.376	1.506	1.822	1.807	1.953	2.185	2.145	2.382	2.360	1.877	1.549	1.312	1.218	1.173	1.154
341	1.339	1.582	1.558	1.560	1.561	1.702	1.708	1.682	1.450	1.308	1.226	1.186	1.176	1.157	1.138
351	1.452	1.391	1.456	1.612	1.499	1.520	1.470	1.353	1.274	1.269	1.231	1.237	1.246	1.239	1.254
352	1.263	1.271	1.300	1.318	1.327	1.334	1.369	1.302	1.245	1.206	1.183	1.166	1.157	1.138	1.132
354	1.568	1.446	2.784	3.324	3.228	3.409	3.485	2.831	2.354	2.053	1.607	1.509	1.304	1.247	1.256
355	1.325	1.391	1.416	1.443	1.398	1.533	1.552	1.699	1.678	1.619	1.502	1.480	1.371	1.261	1.218
362	1.350	1.348	1.339	1.379	1.437	1.744	1.548	1.478	1.399	1.369	1.338	1.317	1.274	1.239	1.218
369	1.337	1.428	1.441	1.495	1.494	1.583	1.749	1.732	1.578	1.461	1.413	1.305	1.255	1.213	1.182
371	1.271	1.333	1.695	2.065	2.218	2.305	2.437	2.295	1.963	1.585	1.446	1.273	1.229	1.189	1.165
372	1.392	1.307	1.278	1.273	1.312	1.342	1.419	1.493	1.397	1.286	1.266	1.266	1.239	1.161	1.145
381	1.377	1.324	1.357	1.328	1.333	1.313	1.263	1.229	1.183	1.167	1.165	1.178	1.180	1.167	1.164
382	1.128	1.124	1.130	1.130	1.143	1.168	1.188	1.120	1.093	1.098	1.110	1.105	1.100	1.099	1.105
383	1.256	1.268	1.257	1.244	1.257	1.286	1.305	1.234	1.186	1.183	1.188	1.193	1.191	1.178	1.179
384	1.837	1.567	1.431	1.321	1.337	1.339	1.342	1.238	1.185	1.142	1.139	1.166	1.164	1.161	1.153

1.526	pre-NAFTA average
1.282	post-NAFTA average
1.412	Overall average

A4. Plots of the actual TFP gaps and the predicted TFP gaps by years




year=1993
year=1994
year=1995
year=1998
year=1999
year=2000
Actual tfp gap
Predicted tfp gap
tfp_gap
tfp_gap

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