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NAFTA and Convergence in North America: High Expectations, Big Events, Little Time

The North American Free Trade Agreement (NAFTA) was formally implemented on 1 January 1994 by the United States, Canada, and Mexico. This treaty instantly gained global notoriety following the initiation of formal negotiations in 1991, not only because the initiative represented one of the most comprehensive trade agreements in history, but also because it seemed to be a breakthrough in establishing free trade in goods and services among developed and developing countries. The high expectations were that trade liberalization would help Mexico catch up with its northern neighbors. The ratio of Mexican GDP per capita to that of the United States did increase after unilateral trade reforms were implemented in 1986 and also after the implementation of NAFTA in the aftermath of the so-called tequila crisis. However, other Latin American economies also grew faster than the U.S. economy after the mid-1980s, especially Chile and, to a lesser extent, Costa Rica. Thus it is not obvious that NAFTA was particularly important in helping Mexico catch up with the United States.[1]

Easterly is with New York University. Fiess and Lederman are with the World Bank.

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1. The experience of Puerto Rico offers an interesting counterpoint, in that this economy started with a level of development similar to Mexico's in the late 1950s and achieved an unprecedented level of economic and institutional integration with the United States in 1952. It subsequently experienced the fastest rates of economic growth in the developing Latin American economies. An analysis of the Puerto Rican experience is beyond the scope of this paper as it would require the use of historical data for many years prior to 1952, when the island became a commonwealth territory of the United States. We thank Patricio Meller for suggesting this analysis.

This paper assesses the extent to which these high expectations seem to be materializing. It examines trends and determinants of income and productivity gaps observed in North America, both across countries as well as within Mexico. The high expectations for NAFTA were supported by neoclassical growth and trade theories. The seminal work of Solow states that capital-poor countries grow faster than rich countries owing to the law of diminishing returns, as long as production technologies, population growth, and preferences are the same across countries.[2] The neoclassical trade model (the Stolper-Samuelson theorem) similarly predicts that as the prices of goods and services converge, so will factor prices, including real wages. Hence income levels across borders will also tend to converge as prices converge. A key simplifying assumption of neoclassical economics is that all countries use the same production technologies, exhibiting either constant or diminishing returns to scale.

There is a lively debate about the evidence concerning the impact of trade liberalization on income convergence across countries, as well as an extensive literature on economic convergence within countries.[3] At least since the publication of Barro's early work, the economics profession has been aware that convergence might be conditioned by convergence in certain fundamentals that are believed to cause economic growth.[4] While there is admittedly much uncertainty about what these fundamentals are, the evidence of conditional convergence can be interpreted as evidence in favor of the neoclassical growth model or as evidence that there are fundamental differences that prevent income convergence.[5]

For Easterly and Levine, as well as Pritchett, the "big story" in international income comparisons is that the rich grew richer while the poor got poorer.[6] Some studies focusing on cross-country differences in the *levels* of income per capita (or GDP per worker) argue that these differences are largely explained by institutional factors.[7] Other factors besides different fundamentals, however, might impede economic convergence among geographic areas even in the presence of free trade.

2. Solow (1956).
3. On cross-country convergence, see Slaughter (2001) and Ben-David (2001, 1996). On within-country convergence, see Barro and Sala-i-Martin (1995) and Sala-i-Martin (1996).
4. Barro (1991).
5. Doppelhofer, Mille, and Sala-i-Martin (2000).
6. Easterly and Levine (2001); Pritchett (1997).
7. Hall and Jones (1999); Acemoglu, Johnson, and Robinson (2001).

More recent theories of growth with increasing returns or technological differences across regions predict divergence in income levels and growth rates across regions.[8] Trade flows might help international technology diffusion when technical knowledge is embodied in goods and services, and theories of technology diffusion via trade have been the subject of a fast-growing literature.[9] A related literature focuses on the barriers that impede technological adoption to explain differences in the levels of per capita income.[10] The liberalization of trade can thus facilitate convergence even when production technologies differ across countries, although this would tend to be detected in convergence (divergence) of total factor productivity (TFP) levels within industries across countries.[11] Even if trade liberalization allows poor countries to import production technologies from advanced countries, productivity levels might not converge if the factor endowments are different, owing to the mismatch between labor skills available in poor countries and the sophisticated technologies imported from the rich countries. Productivity gaps within industries across countries might therefore persist even if trade facilitates technological convergence.[12]

The recently resurgent literature on economic geography, transport costs, economies of scale, and knowledge spillovers is not optimistic about the impact of trade liberalization on economic convergence.[13] For example, transport costs will remain as barriers to trade and economic integration even if all policy distortions are removed.[14] In addition, if learning and innovation depend on trade, then geography will also be an impediment to convergence via technological diffusion.[15] These factors might hamper income convergence across countries.[16] Economies of scale and knowledge spillovers might make some geographic regions more prosperous than others simply because of the cumulative effects of initial conditions such as the density of economic activity.[17]

8. See the pioneering work of Romer (1986, 1990); Lucas (1988); and Grossman and Helpman (1991).
9. Eaton and Kortum (1999); Keller (2001).
10. Parente and Prescott (2000).
11. Bernard and Jones (1996).
12. Acemoglu and Zilibotti (2001).
13. Krugman (1991); Fujita, Krugman, and Venables (1999).
14. Eaton and Kortum (2002).
15. Keller (2002); Eaton and Kortum (2002).
16. Redding and Venables (2001).
17. Ciccone and Hall (1996).

In the case of Mexico, the Zapatista rebels took up arms in the southern state of Chiapas on the day of NAFTA's implementation. Later that year, in December 1994, Mexico was forced to float the peso, which was followed by a deep banking crisis and severe recession. Domestic investment underwent a sharp deterioration before the Mexican economy began to recover in late 1995.[18] These big events coincided with the implementation of NAFTA. Moreover, from a long-run perspective, the post-NAFTA period is still short. This combination of big events and a short experience with NAFTA increases the difficulty of empirically identifying the impact of the agreement on income and productivity gaps in North America. Nevertheless, we use various methodologies to assess NAFTA's effect on income and productivity differences.

The rest of the paper is organized as follows. The next section uses times series techniques to identify the impact of NAFTA on the income gap between Mexico and the United States. To deal with the big-events-little-time problem, we apply two time series methods. First, we follow Harvey in conducting a structural time series exercise that might be able to separate transitory effects (such as the tequila crisis) from the long-term effects expected from NAFTA.[19] Second, following Bernard and Durlauf, we apply cointegration analysis to see whether there is an observable process of income convergence between the United States and Mexico.[20] We do this recursively to test for any structural change in the equilibrium condition between U.S. and Mexican GDP using quarterly data from 1960 to 2001. We find that the debt crisis in the early 1980s and the tequila crisis temporarily interrupted a process of economic convergence, which resumed after 1995. Convergence after Mexico's trade liberalization in the late 1980s and after NAFTA might have been faster prior to the debt crisis. However, given that other Latin American economies also grew quickly during this period, we also provide econometric annual estimates of the differences between Mexico-specific and Latin American income effects. These results indicate that Mexico's performance between 1986 and 1993 was not that different from the average Latin American economy, but it was significantly more positive after NAFTA, with the obvious exception of 1995.

18. Lederman and others (2003).
19. Harvey (2002).
20. Bernard and Durlauf (1995, 1996).

The subsequent section looks at the per capita income differentials across countries in 2000 and estimates the extent to which institutional differences explain observed income differences. This exercise follows Acemoglu, Johnson, and Robinson in using settlers' mortality rates from colonial times as instruments for currently observed differences in institutional quality, based on data from Kaufmann and Kraay.[21] We find that the income gap between the United States and Mexico can largely be explained by the institutional gap plus geographic variables. We then examine the evolution of the institutional gap with respect to the United States in Mexico by, again, comparing annual estimates of Mexican effects to the average Latin American effect; our results indicate that Mexico's institutions did not improve more than those of other Latin American countries in the post-NAFTA period. Accelerating convergence will thus require a major effort to improve Mexico's institutions—NAFTA is not enough.

The following section studies the impact of NAFTA on TFP differentials within manufacturing industries across the United States and Mexico. Based on a panel estimation of the rate of convergence across twenty-eight manufacturing industries, we find that the post-NAFTA period was characterized by a substantially faster rate of productivity convergence than in previous years. At this time, however, we cannot say whether the productivity-convergence result was due to increased imports of intermediate goods from the United States (as argued by Schiff and Wang), competitive pressures and preferential access to the U.S. market (as argued by López-Córdova), or increased Mexican innovation resulting from a variety of factors, including increased domestic research and development (R&D) efforts and patenting aided by the enhanced protection of intellectual property rights contained in NAFTA (as argued by Lederman and Maloney).[22]

The paper then looks at the impact of NAFTA on economic convergence across Mexican states. This issue is of particular interest to many Latin American economies in view of the proposed Free Trade Area of the Americas (FTAA). This hemispheric economic integration would theoretically lead to the establishment of free trade and in some cases, such as in Central America and perhaps in the Southern Common Market (MERCOSUR), to deeper forms of economic integration among countries, which would resemble a single economic entity. The unequal economic performance of

21. Acemoglu, Johnson, and Robinson (2001); Kaufmann and Kraay (2002a).
22. Schiff and Wang (2002); López-Córdova (2002); Lederman and Maloney (2003a).

Mexican states under NAFTA might thus be a prelude of differential effects under the FTAA or other proposed arrangements, such as the Central American Free Trade Agreement (CAFTA). We test the conditional convergence hypothesis across Mexican states, but focus exclusively on initial conditions that might explain why some Mexican states grew faster than others during 1990–2000. We find that the initial skill level of the population and telephone density played an important role. We interpret these results as evidence that trade liberalization might indirectly induce divergence within countries, even if it induces convergence across countries. The final section summarizes the main findings and proposes a research agenda focusing mainly on the questions raised by our findings related to TFP convergence in manufacturing.

Time Series Evidence

A simple way to gain insight into the convergence process is to separate trends and cycles from the relative output gap between the United States and Mexico, whereby a decreasing trend in the output gap indicates convergence. The Hodrick-Prescott filter can create serious distortions, however, as can the Baxter-King band pass filter.[23] We therefore follow Harvey and Trimbur and, in a later work, Harvey, who argue that trends and cycles are best estimated by structural time series models.[24] We estimate a bivariate structural time series model, in which convergence between two economies is captured through a similar-cycle model that allows the disturbances driving the cycles to be correlated across countries.[25] Harvey provides a direct link between cointegration, common factors, and balanced growth models.[26] He also shows that the balanced growth model results as a special case of the similar-cycle model, when a common trend restriction is imposed.[27]

The analysis in this section is based on quarterly data on real per capita GDP for the United States and Mexico over the period 1960:1 to 2002:4.

23. On the distortions associated with the Hodrick-Prescott filter and the Baxter and King (1999) band-pass filter, see references in Harvey (2002).

24. Harvey and Trimbur (2001); Harvey (2002).

25. Harvey and Koopman (1997).

26. Harvey (2002).

27. Harvey and Carvalho (2002).

The per capita GDP figures are adjusted for purchasing power parity (PPP) and are taken from the Penn World Tables 5.6. We applied the following procedure to create a quarterly PPP-adjusted data series. Quarterly GDP data were obtained from the Organization for Economic Cooperation and Development (OECD), and the population series were constructed as quarterly moving averages of annual figures spread across four quarters. U.S. GDP data were seasonally adjusted by the provider; Mexican GDP data were seasonally adjusted using X-12-ARIMA. We converted the Mexican data into U.S. dollars using quarterly average nominal exchange rates. Both series were then deflated by the U.S. consumer price index (CPI) to 1995 U.S. dollars. For the PPP adjustment of the quarterly series, we estimated the exchange rate bias following Summers and Ahmad, by regressing the annual PPP-adjusted GDP figures on an annual exchange rate adjusted GDP series from the *World Development Indicators*.[28] In a final step, we applied the predicted exchange rate bias to our series of quarterly exchange-rate-adjusted per capita GDP figures.[29]

We then fit a similar-cycle bivariate model to the logarithms of quarterly per capita GDP in the United States and Mexico.[30] A model with two cycles appears to describe the data well, and the second cycle appears to capture large movements in Mexico around the 1980s.

Figure 1 shows the ratio of the two trends. This PPP-adjusted gap exhibits convergence until the setback of the 1980s associated with the debt crisis. Convergence resumed around 1987, which coincides with the unilateral liberalization of the Mexican economy implemented in 1986, although this might also reflect the recovery after the recession of 1982–1984. The data also indicate that the tequila crisis represented a temporary setback. The downward slope of the income gap is somewhat steeper after the 1980s, suggesting that convergence between Mexico and the United States occurred at a faster rate after trade liberalization. Convergence appears to have lost momentum during 2000–2002, however.

28. Summers and Ahmad (1974); World Bank (2003).

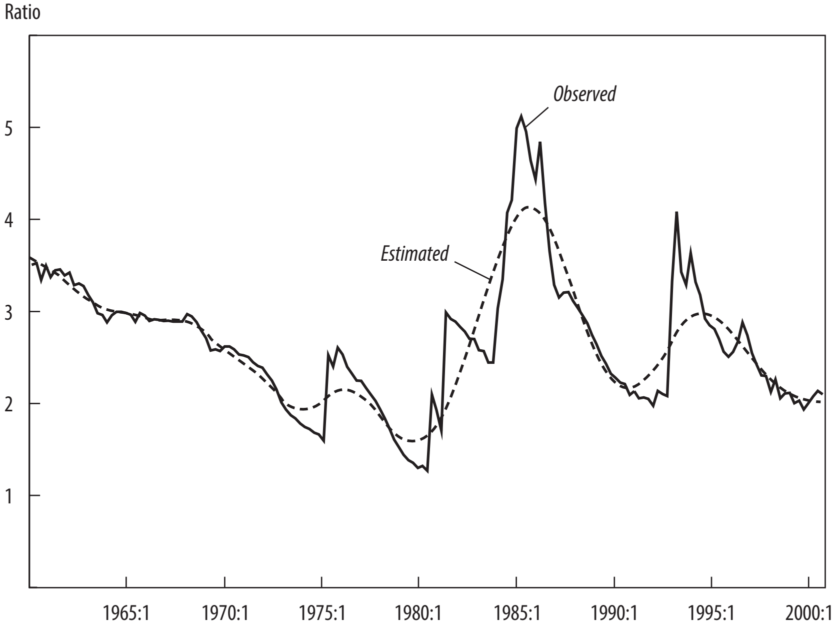
29. To estimate the exchange rate bias, we regressed log-transformed PPP-adjusted GDP (yPPP) on exchange rate adjusted GDP (y_e). Standard errors are in parentheses:

$$\text{Mexico: } y_{\text{PPP}} = \underset{(0.1608)}{\pm 0.2944} + \underset{(0.0200)}{1.111} * y_e, \quad R^2 = 0.987;$$

$$\text{United States: } y_{\text{PPP}} = \underset{(0.1203)}{\pm 0.2944} + \underset{(0.0121)}{1.111} * y_e, \quad R^2 = 0.992.$$

30. Following Harvey (2002).

FIGURE 1. The U.S.-Mexico GDP per Capita Gap: Similar-Cycle Model with Quarterly PPP-Adjusted Data, 1960 to 2002[a]



Source: Authors' calculations.

a. The dotted line is the ratio of the U.S./Mexico trend components of GDP per capita; the solid line is the observed ratio.

To investigate the speed of convergence further, we estimated the following model:

$$\begin{aligned} \text{GAP}_t = \underset{(0.092)^*}{0.162} + \underset{(0.032)^{**}}{0.935}\text{GAP}_{t\pm1} \pm \underset{(0.013)^*}{0.025}\text{NAFTA\_GAP}_{t\pm1} \\ + \underset{(0.016)}{0.005}\text{LIB\_GAP}_{t\pm1} + 1.083\text{TEQUILA}_t, \end{aligned}$$

where $R^2 = 0.91$ and where GAP is the U.S.-Mexico income gap, TEQUILA is a dummy for the 1994 tequila crisis (1994:4–1995:1), and NAFTA_GAP and LIB_GAP are dummies for Mexico's unilateral trade liberalization (1986:1–1993:4) and NAFTA (1994:1–2002:4), both of which are interacted with the lagged income gap. Standard errors are in parentheses, one asterisk means statistical significance at 5 percent, and two mean significance at 1 percent. We find that NAFTA, but not unilateral trade liberalization, had a significant positive impact on the speed of convergence. With NAFTA, the half-life of a one unit shock to the income gap appears to have fallen from 2.6 to 1.8 years. The fact that unilateral liberalization does not appear to be significant for income convergence is interesting. We find a similar result later in the paper, when analyzing the impact of unilateral liberalization and NAFTA on productivity growth.

Cointegration Analysis

According to Bernard and Durlauf, long-run convergence between two or more countries exists if the long-run forecasts of output differences approach zero.[31] In other words, two economies are said to have converged if the difference between them, y_t, is stable. If we abstract from initial conditions, stability implies that the difference between two series is stationary. Absolute convergence requires that the mean of y_t is zero, while relative or conditional convergence requires that the difference between the two series has a constant mean. If two series are cointegrated, but with a vector different from (1, –1), the economies are comoving (that is, they are driven by a common trend) but not necessarily converging to identical levels of output. Cointegration between economies alone is therefore a necessary, but not sufficient condition for absolute convergence. If a constant is introduced into the cointegration space, it is possible to test for absolute and relative convergence by restricting the constant to zero. A zero constant supports absolute convergence.[32] Following Fuss, we intend to interpret evidence of a cointegration vector of the form (1, –1) at the end of the sample, together with a rejection of this vector parameterization in subsamples, as evidence of an ongoing process of convergence.[33]

A cointegration analysis between U.S. and Mexican GDP, with a constant and four lags in the cointegration space over the full sample from 1960 to 2002, reveals one significant cointegration vector (see table 1).

31. Bernard and Durlauf (1995, 1996).

32. Introducing a trend into the cointegration space makes it possible to distinguish between stochastic and deterministic convergence, where a homogeneity (1,–1) restriction on the GDP coefficients with a trend corresponds to stochastic convergence and homogeneity (1,–1) without a trend to deterministic convergence. As we reject stochastic convergence in favor of deterministic convergence in our data, we only report the findings based on a constant in the cointegration space, which we view as a test of deterministic conditional convergence.

33. Fuss (1999) postulates that if y and x are cointegrated at the end of the period, with $y = a + bx + u$, then the results provide evidence of the following:

TABLE 1. Cointegration Analysis for the United States and Mexico, 1960:4 to 2002:4

Eigenvalue	*L-max*	*Trace*	*H0: r*	*p – r*	*L-max90*	*Trace90*
0.1644	29.64***	32.49***	0	2	10.29	17.79
0.0171	2.85	2.85	1	1	7.50	7.50

Source: Authors' calculations.
***Statistically significant at the 1 percent level.

A restriction of the cointegration space according to (1, –1) cannot be rejected ($\chi^2[1] = 1.45, p = 0.23$) over the full sample; this provides evidence in favor of convergence during 1960–2002: $\text{GDP}_{\text{US}} - \text{GDP}_{\text{MX}} = 0.720$, with a standard error of 0.082.[34]

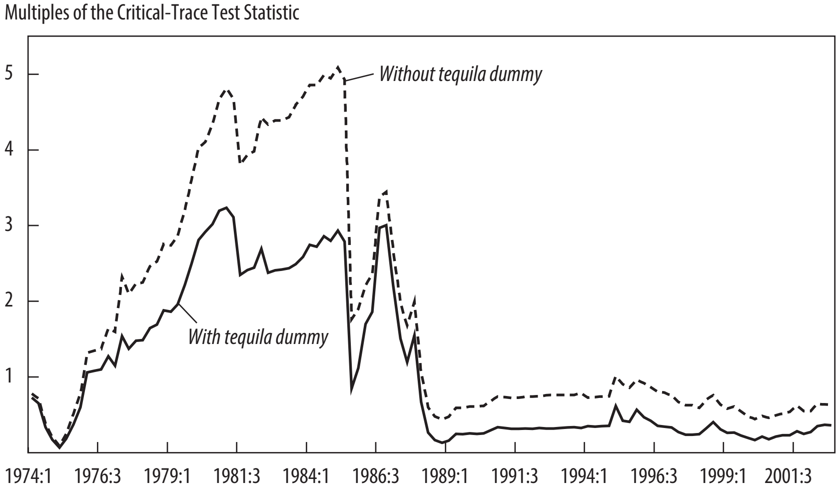
The estimate of the constant in the cointegration vector is greater than zero, and the standard error for the constant is relatively small. We interpret this as evidence of incomplete convergence, in the sense that Mexico is converging toward the U.S. level of income up to a point. That is, the observed process of convergence is likely to lead not to absolute convergence, but rather to a constant income differential. The estimated constant suggests that Mexico will reach a maximum of about 40 to 50 percent of the U.S. per capita GDP. Whereas the evidence applies to the whole period, this process of conditional convergence may hold only for certain years.

Recursive cointegration analysis reveals that the (1, –1) restriction does not hold in all subsamples (see figure 2). The graph in figure 2 is scaled in such a way that unity represents the 5 percent level of significance. A test statistic below one thus indicates that the hypothesis of convergence cannot be rejected. We find strong evidence for divergence during the 1980s (debt crisis), in spite of the fact that we estimated the cointegration

$a = 0$ and $b = 1$ indicates that the series are converging;
$a <> 0$ and $b = 1$ indicates that the two series are converging up to a constant;
$a > 0$ and $b < 1$ implies that x converges toward y;
$a < 0$ and $b > 1$ implies that y converges toward x;
$a > 0$ and $b > 1$ implies divergence (x falls behind y); and
$a < 0$ and $b < 1$ implies divergence (y falls behind z).

34. A similar result is obtained for annual data: GDP*US* – GDP*MX* = 0.881, with a standard error of 0.044.

FIGURE 2. Trace Tests for Cointegration between U.S. and Mexico (Log) Quarterly GDP, 1960:4 to 2002:4 (Recursive Estimates)



Source: Authors' calculations.

vector with dummies that properly identify the key first and fourth quarters of 1982.[35]

To assess the impact of the 1994 tequila crisis on the convergence process, we perform a recursive cointegration analysis with and without a dummy for the tequila crisis. As shown in figure 2, which plots the cointegration trace test over time, the tequila crisis had an impact on the convergence process. The inclusion of a crisis dummy reveals a resumed

35. The relevant model specification tests showed that other dummy variables for the debt crisis tended to bias the estimates of the cointegration rank and coefficient restrictions. A separate analysis of three subsamples finds a result similar to that reported above. A test of the (1,–1) restriction can be rejected in the following subsamples:

1961:01 to 1975:04 ($\chi^2(1) = 1.12$, $p = 0.29$),
1976:01 to 1988:04 ($\chi^2(1) = 8.86$, $p = 0.00$), and
1989:01 to 2002:04 ($\chi^2(1) = 0.61$, $p = 0.43$).

This supports a similar convergence/divergence pattern as a recursive analysis over the whole sample (figure 2).

convergence process from 1987 onward. Without the tequila dummy, the convergence hypothesis is rejected around the time of the crisis. This suggests that the tequila crisis temporarily interrupted an ongoing convergence process in the late 1980s.

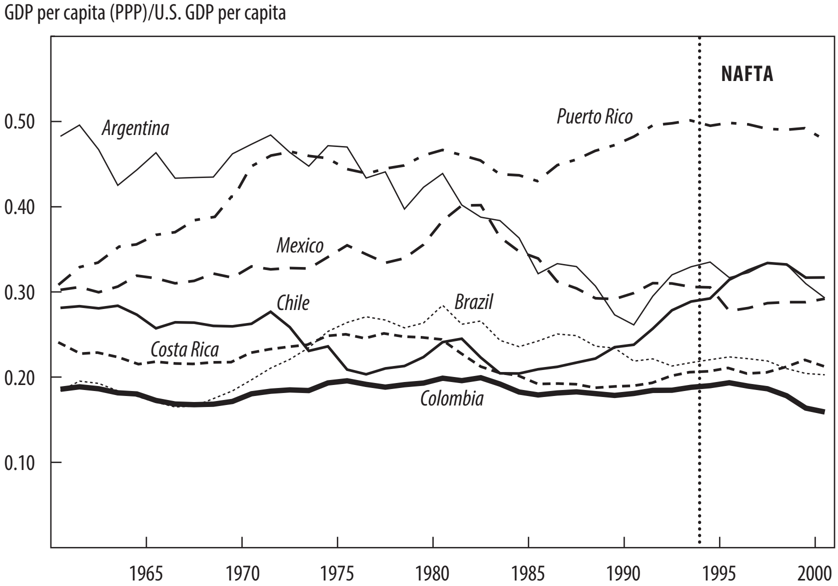
The evidence from time series analyses can be summarized as follows. Structural time series modeling and recursive cointegration analysis both identify periods of convergence and divergence between Mexico and the United States during 1960–2002. Both econometric techniques find evidence that the tequila crisis only temporarily interrupted a convergence process that started in the late 1980s. However, the estimates of structural changes in the autoregressive coefficient of the U.S.-Mexico income gap indicate that the speed of convergence seems to be faster than in the rest of the sample only after the implementation of NAFTA. In any case, this process of convergence seems to have a limit.

Mexico's Performance Relative to Other Latin American Countries

As highlighted in figure 3, other economies in the region may have grown just as fast as or even faster than Mexico relative to the United States after the late 1980s. To better identify the Mexico-specific process of convergence toward the U.S. level of development, we compared Mexico's performance in closing the per capita income gap relative to the United States with the equivalent performance of Latin American countries that reformed their economic policies but did not enjoy the benefits of NAFTA. This involved testing for a significant statistical difference between the year effects for a group of Latin American countries and the year effects specific to Mexico. The dependent variable was the (log) ratio of per capita GDP of the countries relative to the United States. The test was conducted with two samples of Latin American countries that include Mexico: Group 1, consisting of twenty-two countries, and Group 2, with nine countries.[36]

36. The twenty-two Group 1 countries are Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela. The nine Group 2 countries are Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Uruguay, and Venezuela.

FIGURE 3. Per Capita GDP Relative to the United States, Selected Economies, 1960 to 2001



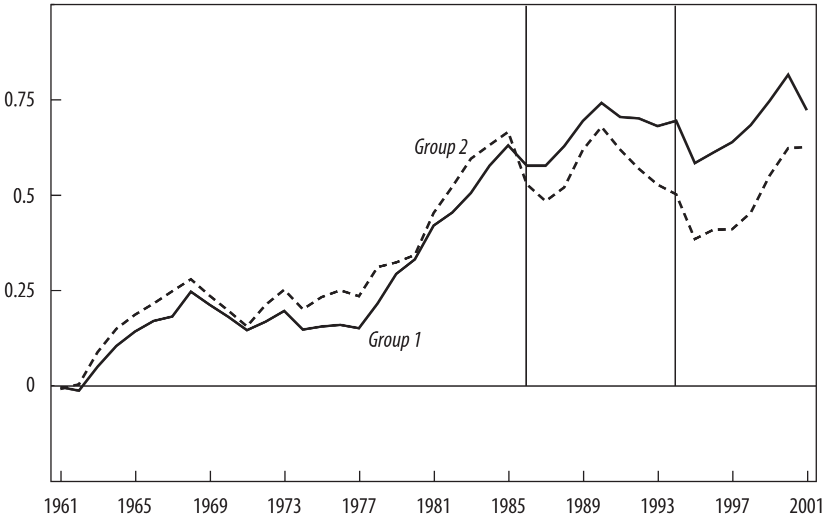
Source: Loayza, Fajnzylber, and Calderón (2002); Penn World Tables 5.0; World Bank (2003).

The results are shown in figure 4.[37] Mexico's year effects are statistically significantly different from the rest of Group 1 at a 10 percent confidence level from 1982 onward. In other words, the annual observations shown in figure 4 are significantly different from zero only after 1982. With respect to the smaller comparator group, Mexico's annual effects are also different during 1982–1994 and 1999–2001.[38] However, these differences simply reflect the fact that Mexico tended to be significantly richer than other regional economies during these years. The real question is

37. The estimated model was $yc,t = c + \beta_t \bullet D_t + \beta_{t,\mathrm{MEX}} D_t \bullet D_{\mathrm{MEX}}$, where y is the log of the per capita GDP ratio with respect to the United States, D_t is a year dummy, and D_{MEX} is a Mexico dummy. Figure 4 plots $\beta_{t,\mathrm{MEX}} - \beta_t$.

38. Wald tests for significance of the difference between Mexico and average Latin American and Caribbean effects are not reported.

FIGURE 4. Mexico Year Effect Minus Regional Year Effect[a]



Source: Authors' calculations.

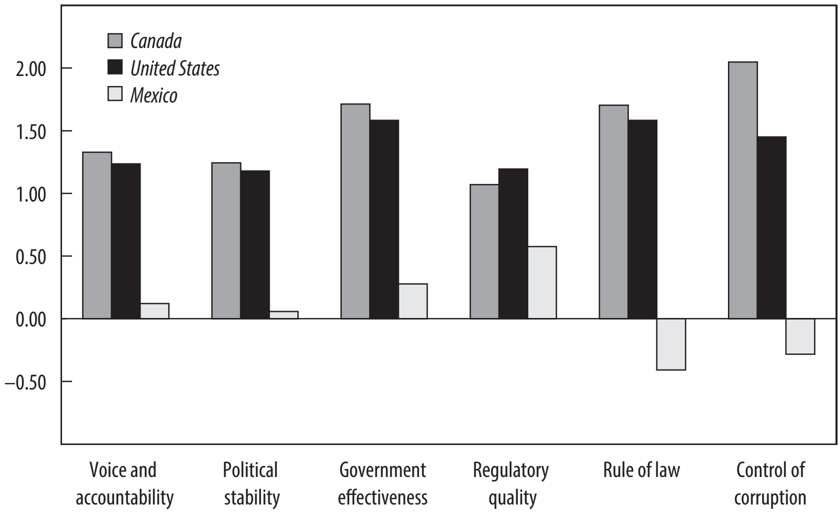
a. Log (GDP per capita/U.S. GDP per capita) (PPP). The excluded year is 1960. See table A1 in the appendix for summary statistics for data used and definition of the groups.

whether Mexico grew significantly richer than other Latin American economies during these years, which should be reflected in upward movements of the country-effects differentials shown in figure 4. This only occurs after 1995 with respect to both comparator groups. For the larger group of Latin American and Caribbean economies, this might also have occurred in 1986–1993.

The fact that Mexico did not catch up to the United States significantly faster than other middle-income countries (the eight included in Group 2) raises doubts about the possibility that Mexico's unilateral reforms spurred convergence with the United States to a greater extent than reforms in countries such as Chile or Costa Rica. In contrast, the post-NAFTA period is characterized by a declining Mexico-U.S. income gap, which declined faster than for the average Latin economies included in both samples. This result is consistent with previously discussed estimates of the acceleration of convergence only after 1994. The following sections identify the underlying constraints of the U.S.-Mexico convergence process.

FIGURE 5. Institutional Gaps in North America, 2000 to 2001

Variable ranges from -2 to +2 for all countries



Source: Kaufmann and Kraay (2002a).

Income Gaps and Institutional Gaps

As discussed in the introduction, a substantial literature highlights the role of institutional differences in producing cross-country variation in per capita income.[39] Despite trade liberalization and the institutional harmonization requirements imposed by NAFTA (for example, intellectual property rights, investor protection, and environmental standards), obvious institutional gaps remain between the United States and Mexico. Figure 5 draws on data from Kaufmann and Kraay to show the gaps along six dimensions.[40] In 2000–2001, Mexico clearly lagged behind its North American partners along all institutional dimensions, especially corruption and rule of law. If these institutional differences persist, absolute income convergence, as predicted by neoclassical economics, will probably never materialize even if trade is completely liberalized. These types of impediments to convergence

39. Hall and Jones (1999); Acemoglu, Johnson, and Robinson (2001).
40. Kaufmann and Kraay (2002a).

are difficult to identify with time series analyses, such as those presented in the previous section, mainly because institutional gaps can be rooted in history and tend to vary little over time.

The experience of Puerto Rico (recall figure 3) can provide a useful medium-term perspective on how institutional convergence might affect economic convergence. When Puerto Rico became a commonwealth territory of the United States in 1952, it gained not only free trade in goods and factors of production, but also some of the political and regulatory institutions available in the United States. In addition, firms received tax incentives for setting up operations in the island. Consequently, the income gap between mainland United States and Puerto Rico narrowed significantly over the next 50 years, especially compared with the income gaps of Mexico and other Latin American countries. The remainder of this section estimates the role of institutional gaps in maintaining long-run income gaps.

Data and Methodology

To investigate the impact of institutional gaps, we follow the methodology of Acemoglu, Johnson, and Robinson.[41] This basically involves using a set of exogenous variables related to geographic characteristics (namely, regional dummy variables, landlocked-country dummy, latitude, and dummies for oil and commodity exporters), a constructed trade share indicator that takes into consideration countries' size and geographic factors, an indicator of ethnolinguistic fractionalization, and a composite index of the Kaufmann-Kraay indicators of institutional quality from 2000–2001 as explanatory variables of per capita income (in PPP-adjusted U.S. dollars) as of 2000.[42] Table A2 in the appendix contains the summary statistics for our data set. Our methodology is two-stage least squares (2SLS).

Since the indicators of institutions and the corresponding composite index can be endogenous to the level of development, we need to find instruments for this variable. Also, the institutional variables are measured with error, as explained by Kaufmann and Kraay and Acemoglu, Johnson, and Robinson. A priori, it is difficult to say which effect will predominate, since the endogeneity problem could bias the estimates upward if income

41. Acemoglu, Johnson, and Robinson (2001).

42. The trade share indicator is from Frankel and Romer (1999); the composite index is the average of the six individual components.

improves institutions, whereas the measurement error problem could produce an attenuation bias.

Acemoglu, Johnson, and Robinson show that the (log) mortality rates of settlers can be a good instrument for current institutions. These authors rely on a long historical literature linking the importation of political and economic institutions to the extent to which colonies were settled by their European colonizers, as opposed to becoming sources for the extraction of high-priced commodities. Where Europeans settled, they imported "good" institutions. At the same time, Europeans had incentives not to settle in places where the climate and other historical factors reduced life expectancy. It thus seems logical to use settler mortality rates in the eighteenth and nineteenth centuries as instruments for institutions in the present.

Results

Tables 2, 3, and 4 present our results. Table 2 presents the 2SLS estimated effects of the key variables on the (log) PPP-adjusted per capita income as of 2000. Table 3 shows the first-stage regressions, in which the composite index of institutional quality is the dependent variable. Table 4 shows the corresponding ordinary least squares (OLS) regressions, which depend on the assumption that institutions are exogenous.

In the five specifications shown in table 2, the instrumented composite index of institutions is positively and significantly correlated with income. In fact, across the four models the relevant coefficient is quite stable, ranging from 1.35 to 1.94. The only other robust explanatory variable is the dummy for oil exporters, which appears consistently with positive and significant coefficients. The Frankel-Romer trade openness indicator is not a significant determinant of income per capita: virtually identical results were obtained when we used the Sachs-Warner policy openness index average for 1965–1990 instead of the Frankel-Romer constructed trade share.[43] These results can be interpreted as an indication either that the long-run level of development of countries is mainly determined by the quality of domestic institutions or that the correlation between the instruments used by Frankel and Romer to estimate the exogenous portion of the trade-to-GDP ratios (the so-called geographic gravity variables) and the

43. Sachs and Warner (1995).

TABLE 2. Two-Stage Least Squares Regressions of Log GDP per Capita 2000[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Institutional index	1.94***	1.35***	1.39***	1.40***	1.37***
	(0.53)	(0.19)	(0.20)	(0.20)	(0.25)
Net oil exporters	0.87***	0.69***	0.72***	0.73***	0.71***
	(0.30)	(0.18)	(0.21)	(0.20)	(0.21)
Net commodity exporters	–0.22	–0.16	–0.16	–0.16	–0.16
	(0.18)	(0.13)	(0.16)	(0.16)	(0.16)
Africa	0.22	–0.21	–0.12	–0.10	–0.14
	(0.59)	(0.35)	(0.38)	(0.38)	(0.42)
South Asia	0.98	0.45	0.59	0.60	0.55
	(0.73)	(0.38)	(0.43)	(0.43)	(0.48)
East Asia and the Pacific	0.70	0.53*	0.61*	0.62*	0.59
	(0.53)	(0.30)	(0.33)	(0.33)	(0.38)
Americas	0.43	0.26	0.27	0.28	0.26
	(0.43)	(0.24)	(0.27)	(0.27)	(0.30)
Log constructed trade share	–0.04	0.02	0.00		
(Frankel-Romer)	(0.12)	(0.09)	(0.10)		
Ethnolinguistic fractionalization			0.00	0.00	0.00
			(0.00)	(0.00)	(0.00)
Landlocked	0.26				–0.05
	(0.39)				(0.28)
Latitude	–0.02				
	(0.01)				
R^2	0.72	0.84	0.84	0.83	0.84

Source: Authors' calculations.

* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level; *** statistically significant at the 1 percent level.

a. Robust standard errors are in parentheses.

settlers' mortality rates is so high that it is quite difficult to really identify the marginal effects of institutions and trade separately.[44]

The results for the first-stage OLS regressions in table 3 show that the (log) settlers' mortality rates are good predictors of institutional quality in 2000. The mortality variable is always statistically significant and has the expected negative sign. A comparison of the OLS and 2SLS estimates of the institutional coefficient shows that the OLS estimates are significantly lower. These results suggest that OLS estimates suffer from attenuation bias owing to measurement errors afflicting the institutional variable.

Figure 6 illustrates how these econometric results shed light on the income gap observed between the United States and Mexico. The last bar on the right is the income gap (the difference in the log of PPP-adjusted

44. Dollar and Kraay (2003).

TABLE 3. First-Stage Regression for Institutional Index[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Log mortality	–0.17**	–0.17**	–0.18**	–0.18**	–0.18**
	(0.07)	(0.07)	(0.08)	(0.08)	(0.08)
Oil production dummy	–0.37**	–0.37**	–0.42**	–0.45**	–0.45**
	(0.18)	(0.18)	(0.20)	(0.18)	(0.18)
Commodity dummy	0.04	0.04	0.03	0.00	0.00
	(0.16)	(0.16)	(0.20)	(0.18)	(0.18)
Africa	–0.65**	–0.65**	–0.69**	–0.69**	–0.69**
	(0.30)	(0.30)	(0.34)	(0.34)	(0.34)
South Asia	–1.00***	–1.00***	–1.07**	–1.12***	–1.12***
	(0.34)	(0.34)	(0.41)	(0.39)	(0.39)
East Asia and the Pacific	–0.52	–0.52	–0.45	–0.48	–0.48
	(0.33)	(0.33)	(0.45)	(0.44)	(0.44)
Americas	–0.35	–0.35	–0.35	–0.36	–0.36
	(0.24)	(0.24)	(0.26)	(0.26)	(0.26)
Log constructed trade share	0.04	0.04	0.05		
(Frankel-Romer)	(0.11)	(0.11)	(0.12)		
Ethnolinguistic fractionalization			0.00		0.00
			(0.00)		(0.00)
Landlocked	–0.43**	–0.43**	–0.43*	–0.45**	–0.45**
	(0.20)	(0.20)	(0.22)	(0.22)	(0.22)
Latitude	0.02**	0.02**	0.02**	0.02**	0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
R^2	0.62	0.62	0.63	0.63	0.63

Source: Authors' calculations.

* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level; *** statistically significant at the 1 percent level.

a. Robust standard errors are in parentheses.

per capita GDP) as of 2000, which is approximately 1.2. The penultimate bar shows the model's estimated income gap (from column one of table 2). The other bars show the marginal effects of the statistically significant variables on the (log of) the U.S.-Mexico income gap. Mexico's status of a net exporter of oil tends to reduce the income gap by about 0.88. In contrast, the first six bars on the left side of the graph show the contribution of each institutional dimension. The sum of the individual institutional contributions is about 2.5, but gaps in rule of law and corruption seem to be a bit more important than the other institutions. The measurement errors in each category probably make this last observation less meaningful, however, since we cannot be sure that these institutional gaps are significantly different from the others. In any case, the large income gap observed between the United States and Mexico is readily explained by institutional features. Moreover, if Mexico were not an oil exporter, it would probably

TABLE 4. OLS Estimates of Log GDP per Capita 2000[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Institutional index	1.10***	1.11***	1.11***	1.11***	1.08***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
Oil production dummy	0.51***	0.58***	0.59***	0.60***	0.57***
	(0.16)	(0.16)	(0.20)	(0.17)	(0.17)
Commodity dummy	–0.17	–0.15	–0.14	–0.14	–0.12
	(0.13)	(0.13)	(0.16)	(0.16)	(0.15)
Africa	–0.65**	–0.57**	–0.56*	–0.56*	–0.57*
	(0.29)	(0.28)	(0.29)	(0.30)	(0.30)
South Asia	0.00	0.12	0.18	0.19	0.12
	(0.33)	(0.32)	(0.38)	(0.36)	(0.36)
East Asia and the Pacific	0.16	0.25	0.29	0.29	0.24
	(0.24)	(0.22)	(0.24)	(0.24)	(0.24)
Americas	–0.02	0.05	0.03	0.02	0.01
	(0.20)	(0.21)	(0.22)	(0.22)	(0.22)
Log constructed trade share	–0.03	0.01	–0.01		
(Frankel-Romer)	(0.09)	(0.09)	(0.10)		
Ethnolinguistic fractionalization			0.00	0.00	0.00
			(0.00)	(0.00)	(0.00)
Landlocked	–0.18				–0.20
	(0.17)				(0.19)
Latitude	–0.01				
	(0.00)				
No. observations	68	68	61	61	61

Source: Authors' calculations.
* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level; *** statistically significant at the 1 percent level.
a. Robust standard errors are in parentheses.

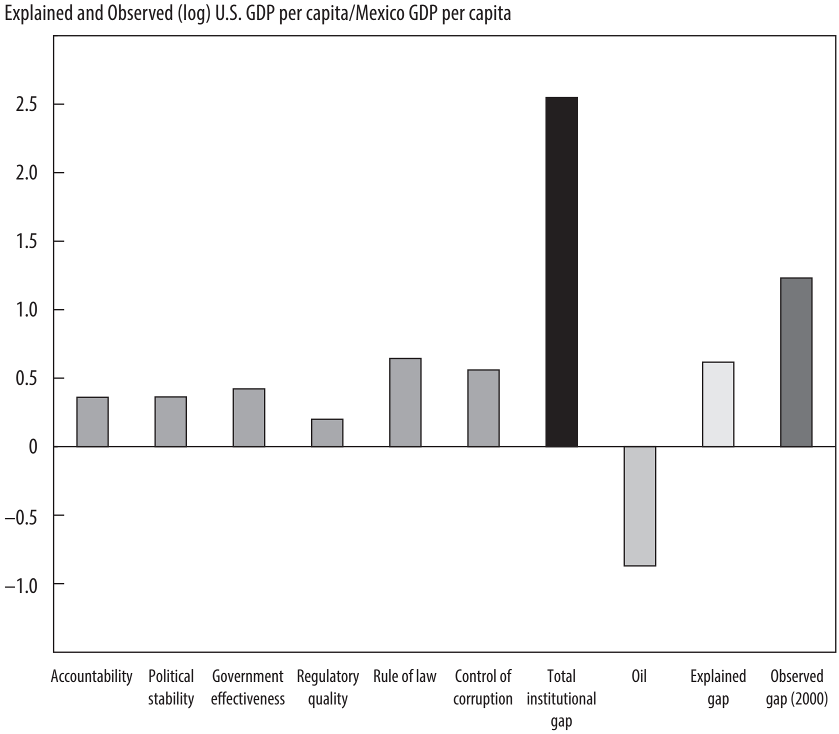
be poorer than it actually is. Finally, the full model predicts a log ratio of U.S. over Mexican GDP per capita of about 0.62, which translates into a 0.54 ratio of Mexican GDP per capita over the U.S. GDP per capita. It is perhaps a coincidence that this is more or less the limit to the convergence process estimated with the cointegration analysis above.

Institutional gaps might thus hamper convergence in North America. This does not mean that NAFTA, in particular, did not have an effect on institutional convergence. Our time series analyses suggest that convergence was in fact present after NAFTA. Was this due to institutional convergence?

Institutional Performance in Mexico versus the Rest of the Region

The previous estimates of the impact of institutions on the level of development presumed that institutions tend to change little over time, and thus

FIGURE 6. The Contribution of Institutional Gaps to the U.S.-Mexico Income Gap

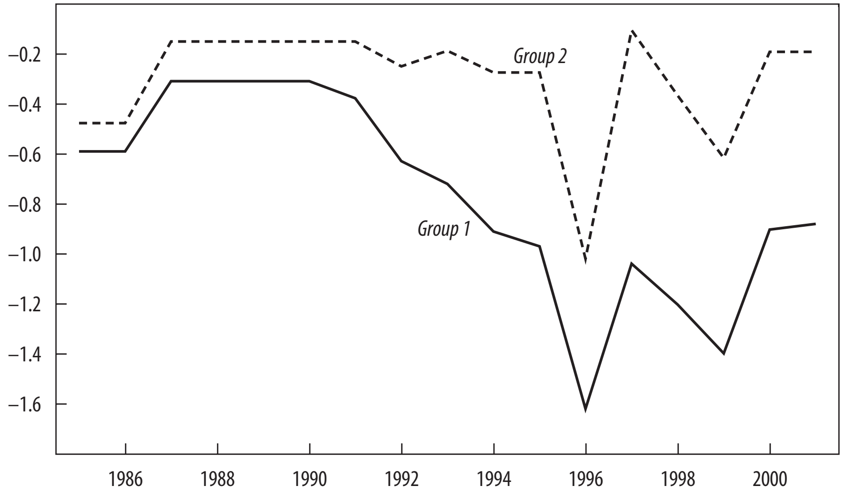


Source: Authors' calculations.

that the instrument proposed by Acemoglu, Johnson, and Robinson—namely, the settlers' mortality rate—is appropriate.[45] However, some analysts expected that NAFTA would exert direct and indirect pressures on Mexico to improve its institutions.[46] The direct pressures came from specific elements of the trade agreements, including those related to investor protection, intellectual property rights, labor, and the environment, which explicitly focus on Mexico's enforcement of its own laws. The indirect pressure could have emanated from the political debate in the United States regarding Mexico's ability to implement its commitments. Our view is that

45. Acemoglu, Johnson, and Robinson (2001).
46. An anonymous reviewer suggested that this might be the strongest impact from NAFTA.

FIGURE 7. Mexico Year Effects Relative to Regional Year Effects, Institutional Index (ICRG)



Source: Authors' calculations (see text).
a. The excluded year is 1984. See table A1 in the appendix for summary statistics for data used and definition of the groups.

institutions probably change little over time, although rare but profound changes in political institutions or other uncommon events might change the quality of public institutions.[47] We therefore analyze what happened to Mexican institutions before and after 1994.

To test whether Mexican institutions changed more than those of other Latin American countries, we estimated regressions similar to those concerning the income gaps presented in figure 4. The dependent variable was the difference between the country's composite institutional indicator,

47. Although it might sound contradictory to use the Acemoglu instrument while also believing that institutions might change over time, it does not necessarily follow that the instrument is useless and that the regressions on the level of per capita income are uninformative. The exogenous portion of institutional quality most probably contains various components, some related to long-term historical heritage and some related to more recent exogenous innovations. This implies that the variation in institutions over time might not be fully stationary. The historical instrument can still be valid, however, since it captures an exogenous component of the level of the institutional index. We are grateful to Roberto Rigobon for highlighting this issue.

TABLE 5. Institutional Changes in Latin America

Country or group	*Before NAFTA (1984–93)*	*After NAFTA (1994–2001)*	*Change*
Mexico	–1.80	–1.46	0.34
Argentina	–1.49	–1.05	0.43
Brazil	–1.00	–1.57	–0.57
Chile	–1.55	–0.73	0.82
Colombia	–1.80	–1.91	–0.11
South America	–1.68	–1.59	0.09
Central America	–2.51	–1.61	0.90
Andean countries	–1.98	–1.60	0.39
Latin American countries	–1.83	–1.53	0.30

Source: Authors' calculations, based on data from International Country Risk Guide.

composed of three indexes of institutional quality provided by the International Country Risk Guide (ICRG) and the U.S. value of this index. The index was constructed using factor analysis of ICRG's bureaucratic quality, law and order, and absence of corruption variables. These data cover 1984–2001. Again, for the comparisons we used the Group 1 and Group 2 samples (Group 1 includes Cuba in this analysis). Figure 7 shows the results. Mexico's year effects for the whole period were not statistically different from the first group of Latin American countries, but they were statistically different from the group average after 1994. Mexico seems to have underperformed relative to the regional average during this period, which is reflected in a declining or stable negative difference between Mexico and the average regional effects.

Even though Mexico improved its institutions relative to the United States in the post-NAFTA period, the results in figure 7 are due to the fact that other countries in the region also improved their institutions without benefiting from NAFTA. Table 5 shows the changes in the gap relative to the United States of the composite institutional index before and after 1994. The countries that improved their institutional gap the most after 1994 were Chile and the Central American group, whereas Mexico's improvement was rather the norm for the whole region. Moreover, Mexico's big improvement took place after 1999 and thus was probably related to the political transition, as was the case in Chile and Central America. These data are consistent with the findings of Lederman, Loayza, and Soares, who find that political democratization has a positive effect in terms of reducing corruption in a large sample of countries.[48] NAFTA alone is unlikely to contribute to the institutional development of Mexico outside the specific areas covered by the agreement. Consequently, Mexico's policy efforts to combat corruption and improve general institutions need to be pursued further.

Productivity Gaps within Industries, across the United States and Mexico

If NAFTA trade liberalization helped technological adoption and modernization in Mexico, we should observe an acceleration in the rate of TFP convergence between the United States and Mexico within industries. To examine this channel of convergence, we calculated TFP differentials between the United States and Mexico in manufacturing sectors. The following paragraphs discuss the data, methodologies, and econometric results concerning the impact of NAFTA on TFP convergence.

Data and TFP Estimates

We measure differences in total factor productivity (TFP) following the approach suggested by Caves, Christensen, and Diewert, which is used in the cross-country context by Keller.[49] They calculate a multilateral (bilateral in our present case) and flexible TFP index of the following form:

$$\begin{aligned} \ln \mathrm{TFP}_{cit} &= \left(\ln Y_{cit} \pm \overline{\ln Y_{it}}\right) \pm \overline{\sigma}_{cit}\left(\ln L_{cit} \pm \overline{\ln L_{it}}\right) \\ &\quad \pm \left(1 \pm \overline{\sigma}_{cit}\right)\left(\ln K_{cit} \pm \overline{\ln K_{it}}\right), \end{aligned} \tag{1}$$

where c is the country index (Mexico and the United States), i represents industries, and t is time. Y is total output, L is labor, and K is capital stock, while σ is the cost-based labor share of output. The Caves, Christensen, and Diewert approach entails de-meaning of the log output, labor, and capital series, using the geometric averages of both countries. The resulting TFP index in each country and industry is based on a vector of outputs and inputs that are common to both countries. An intuitive reading is that this

48. Lederman, Loayza, and Soares (2002).
49. Caves, Christensen, and Diewert (1982); Keller (2002).

index tells us what the productivity level in each country and industry would be if they had the same labor cost shares.

Data on production and factor shares come from the OECD and the United Nations Industrial Development Organization (UNIDO) and cover twenty-eight manufacturing industries at the three-digit International Standard Industrial Classification (ISIC) code.[50] The output data were deflated using the U.S. industry deflators from Bartelsman, Becker, and Gray (2000). The capital stock data were constructed using the permanent inventory method, assuming a 5 percent depreciation rate per year, based on fixed investment data from UNIDO, and were deflated using the PPP investment price levels from the Penn World Tables 6.0.[51] Tables A3 and A4 in the appendix contain summary statistics for the industry-level data for Mexico and the United States, respectively.

Estimation Strategy

To assess how the rate of (log) TFP convergence changed after the implementation of NAFTA, we estimated an autoregressive model with structural change in the autoregressive coefficient and with industry fixed effects and year effects:

$$y_{i,t} = \alpha_i + \gamma_t + \beta \cdot y_{i,t\pm1} + \lambda D_{\text{FTA}} y_{i,t\pm1} + \delta D_{\text{FTA}} + \varepsilon_{i,t}, \tag{2}$$

where $i = 1, 2, \ldots, N$ and $t = 1, 2, \ldots, T$.

As mentioned, our maximum number of industries is $N = 28$, and the maximum number of years is $T = 25$. In the context of the fixed-effects estimator, which is designed to control for industry-specific effects, α_i, by de-meaning both the left- and right-hand-side variables could produce a bias in the estimated coefficients owing to the correlation between the lagged mean of y and the contemporaneous error, $\varepsilon_{i,t}$. The bias is inversely proportional to T. Also, as mentioned, there are no good data on Mexico's unit price for industry-level output, such that the use of the U.S. deflator might have introduced a measurement error that is endogenous to (that is,

50. We got our data from UNIDO, which, in turn, received the Mexico and U.S. data directly from the OECD.

51. Output and capital inputs were expressed in constant 1987 prices. The investment PPP deflator series from the Penn World Tables and the industry deflators from Bartelsman, Becker, and Gray (2000) end in 1996. We applied the average growth rate of the investment PPP deflator for the available years to the rest of our sample ending in 1999.

is affected by) the trade liberalization efforts. This is a concern because trade reforms reduced the prices of capital goods in Mexico, and thus the TFP estimates for Mexico are biased upward after liberalization. We therefore used the Arellano-Bond differences estimator to estimate the model in equation 2.[52] This estimator helps reduce the influence of the biases induced by measurement errors by using lagged levels of the TFP differentials to instrument the changes in these differentials. Hence we also control for unobserved industry-specific effects. Time effects, γ_t, are controlled for by the inclusion of year dummy variables.

In equation 2, the autoregressive coefficient, β, provides an indication of the speed of convergence. A coefficient of less than 1 can be interpreted as evidence of convergence in TFP levels between the United States and Mexico. If NAFTA was associated with an acceleration of TFP convergence, then the estimated coefficient of the corresponding interactive variable should be negative.

Results

Table 6 reports the results from the Arellano-Bond differences estimator applied to the model suggested by equation 2 plus additional controls for the potential effect that Mexico's unilateral liberalization (from 1985) might have had on TFP convergence. The second model focuses on the gap in labor productivity for comparisons, since these data are not affected by the lack of a Mexican fixed investment deflator for the twenty-eight manufacturing industries. In both cases, the models pass the specification tests, indicating that the instrument set is adequate and there is no serial correlation. This suggests that the coefficients are not biased owing to measurement error in the output series. Also, in both cases, NAFTA was associated with a faster rate of manufacturing productivity convergence, as indicated by the highly significant and negative coefficients of the NAFTA dummy variable interacted with the lagged productivity differential. The TFP results (column 1, table 6) imply that the half-life of a unit shock to the TFP gap fell from 1.6 years prior to NAFTA to 0.7 afterward. The corresponding change for labor productivity (column 2, table 6) was from 2.5 to 1.7 years. These results are consistent with the estimates of the change in the degree of persistence of the U.S.-Mexico income gap discussed above.

52. Arellano and Bond (1991).

TABLE 6. The Effect of NAFTA on Manufacturing TFP Convergence[a]

Explanatory variable	*(1)*	*(2)*
Log productivity differential (*t* – 1)	0.65***	0.76***
NAFTA × Log productivity differential (*t* – 1)	–0.28***	–0.09***
LIB × Log productivity differential (*t*– 1)	–0.03	0.04
Specification test		
Sargan overidentification test (*p* value)	0.25	0.39
Second-order serial correlation test (*p* value)	0.32	0.87
Summary statistic		
No. observations	462	482
No. industries	28	28

Source: Authors' calculations.

*** Statistically significant at the 1 percent level.

a. The dependent variable in column 1 is the log TFP differential (United States and Mexico); in column 2 it is the log output per worker differential (United States and Mexico). The figures reported are first-step estimates of regressions run using Arellano-Bond general method of moments. The sample period is 1980 to 2000. Year dummies are not reported.

In sum, the econometric results strongly suggest that the NAFTA period was associated with a significantly faster convergence in manufacturing TFP levels. We are tempted to postulate that the trade agreement had an important positive effect on Mexican manufacturing TFP. These results are consistent with firm-level evidence provided by López-Córdova and industry-level data presented by Schiff and Wang.[53] However, the former study argues that this effect was related to preferential market access to the United States and import competition, but not to imports of intermediate goods. In contrast, the study by Schiff and Wang argues that Mexico benefited from imported intermediate goods from the United States, depending on the extent of R&D efforts in the United States. Our results seem to indicate that NAFTA brought something to the table that was not necessarily accomplished by unilateral liberalization, but we have not speculated about the exact channels of influence. In our view, this issue remains an open question for future research.

Initial Conditions and Divergence within Mexico

Having reviewed the times series evidence concerning income convergence and the panel evidence concerning TFP convergence between the

53. López-Córdova (2002); Schiff and Wang (2002).

United States and Mexico, we now turn to the impact of NAFTA within Mexico.[54] If geography and initial conditions play an important role in economic convergence, then NAFTA might have had a notable impact on income differentials across Mexican states.

It is standard practice in the analytical work on economic growth to examine potential determinants of growth in a set of geographic entities using econometric techniques.[55] Both Esquivel and Messmacher apply this approach to the case of Mexico.[56] Here we use the same standard approach, but we focus on a small set of policy-related variables that determined initial conditions in each Mexican state. The following paragraphs describe the data and methods used to address these questions.

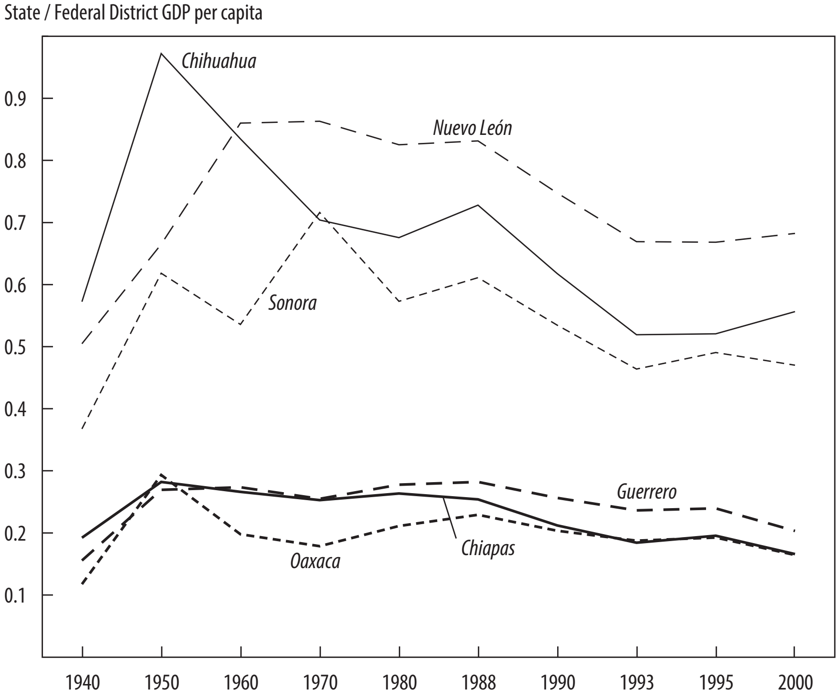
Data and Methodologies

We want to explain the growth rate of state GDP per capita during 1990–2000 (at constant 1993 prices).[57] This is the period during which trade liberalization and NAFTA must have been felt, and it is sufficiently long that the cumulative growth rate during this whole period could reflect medium-term phenomena, rather than just short-lived conditions such as the economic crisis of 1995. Figure 8 shows the evolution of the ratio of per capita GDP in a selection of northern and southern states relative to the Federal District (the capital of the Republic) since 1940. The big story is, again, that the Federal District was richer and stayed richer for the last sixty years or so. None of these states managed to catch up significantly in absolute terms, despite the fact that free trade within Mexico has existed for a long time. Also, it looks like the 1990s were characterized by a slight catch-up by the northern states and continuing divergence of the southern states relative to the Federal District.

What factors might explain why some states grew more than others? Given the issues raised by the literature concerning the role of geography and transport or coordination costs in hampering convergence, one set of key

54. This section is based on Esquivel and others (2002).
55. See the textbook by Barro and Sala-i-Martin (1995).
56. Esquivel (1999); Messmacher (2000).
57. The data were graciously provided by Gerardo Esquivel from El Colegio de México, Mexico City. The GDP series were adjusted for the allocation of oil revenues, which in the original series (from the National Institute of Statistics, Geography, and Information, INEGI) had been periodically allocated to different states, although in practice they are probably allocated according to population shares.

FIGURE 8. Ratio of State GDP per Capita Relative to the Federal District, 1940 to 2000



Source: Authors' calculations.

explanatory variables encompasses indicators of transport and communications infrastructure, which we measured by the kilometers of paved highways per worker and telephone density.[58] We also used the distance from the U.S. border as an additional explanation of economic growth to assess the argument that being far from the United States was an impediment to growth.[59]

58. The coverage of paved roads could be measured with respect to the surface area of each state. This measure might also be imprecise, however, because we would need to know the surface area of economically meaningful territory. In any case, when we used the ratio of paved roads or highways over surface area of each state, the results are virtually identical to those discussed herein.

59. The distance from the U.S. border was measured in two alternative ways: (1) by the distance from the major city in each state to the closest major city near the border, plus the distance of the latter to the border itself; and (2) by the geographic distance from the capital city of each state to the closest major U.S. city.

It is conventional wisdom that the level of education of the adult population might be related to the growth rate. Hence, we also examine the impact of educational attainment in 1990 as an explanation of growth rates during the subsequent period 1990–2000. In this way we can be sure that growth did not cause the level of education. We also experimented with literacy rates of the adult population instead of the years of schooling.

It is often argued that poor states grow slower because they receive insufficient public resources to finance their growth. One such argument, for example, is that private capital markets do not provide sufficient financing for the development of lagging regions owing to various types of obstacles to private financing related to insufficient information about the capacity of firms operating in those areas to pay back loans. However, it is also possible that large public sectors can be a drain on economic growth by distorting the local labor markets (for example, raising wages above what private enterprises can pay) or by raising the costs of capital that would otherwise have gone to the private sector (that is, the so-called crowding out effect of public expenditures). To assess these alternative arguments we look at the impact of the size of the public sector, measured as the share of public employment in total employment, on the growth rates of Mexican states.

To assess whether the really poor states—Chiapas, Guerrero, and Oaxaca—had other characteristics that hampered their prospects for development, we included a dummy variable that identifies these states. Finally, we included the initial level of per capita GDP to test the conditional convergence hypothesis.

Results

Table 7 reports some of our results, based on standard statistical techniques. The first two columns report results based on ordinary least squares, and the third and fourth columns report results from an alternative technique, median regressions, which is less sensitive to outliers. The table shows evidence of conditional convergence; the initial per capita GDP has a negative and statistically significant coefficient in all four exercises. It thus seems that poor states do grow faster if they have similar policies to the rich states.

The other explanatory variables, except the variable that identifies the southern states (Chiapas, Guerrero, and Oaxaca), also seem to be important for growth, and they are generally statistically significant. As expected, tele-

TABLE 7. Potential Determinants of Growth of State GDP per Capita, 1990 to 2000[a]

Explanatory variable	*(1)*	*(2)*	*(3)*	*(4)*
Initial GDP per capita, 1990	−0.15**	−0.15**	−0.14**	−0.12**
(in natural logarithm)	(−2.35)	(−2.32)	(−3.95)	(−2.09)
Initial education (years of schooling	0.24	0.22	0.27**	0.27*
of population over 15 years of age), 1990	(1.38)	(1.09)	(3.40)	(1.86)
Telephone density, 1990	0.08*	0.08*	0.05**	0.05
	(1.93)	(1.91)	(2.86)	(1.39)
Public employment (log of share of	−0.12**	−0.12*	−0.07*	−0.09
total employment), 1990	(−2.13)	(−1.98)	(−1.97)	(−1.54)
States of Chiapas, Guerrero, and Oaxaca	Not included	−0.01	Not included	−0.021
(dummy variable)		(−0.02)		(−0.33)
Summary statistic				
Adjusted R^2	0.31	0.28		
Pseudo R^2	0.21	0.21		
No. observations	32	32	32	32

Source: Authors' calculations.

* Statistically significant at the 10 percent level; ** statistically significant at the 5 percent level.

a. The regressions estimate the effect of a 1 percent increase in the corresponding variable on the cumulative GDP growth rate per capita, 1990–2000. Columns 1 and 2 are estimated using OLS; columns 2 and 3 are estimated using median regressions. A constant was included in the regressions, but its coefficients are not reported. Numerous additional specifications in OLS and median regressions were estimated using the following explanatory variables: (a) literacy rates instead of years of education; (b) two alternative measures of distance from the United States instead of and in addition to the Chiapas, Guerrero, and Oaxaca dummy; (c) paved roads and double-lane highways over surface area or per worker instead of telephone density; (d) the share of manufacturing GDP over total GDP in 1988; and (e) urbanization rates. See the text for a discussion of the alternative results. Finally, *t* statistics are in parentheses.

phone density has a positive effect on growth. However, estimates using paved roads and paved two-lane roads per worker (or over surface area) reveal that these variables were negatively correlated with growth during the period.[60] Hence there is no evidence suggesting that building more roads will lead to higher growth in the future. This result might be due to the existence of economically unnecessary infrastructure that does not serve a useful purpose for existing economic activity.

The results concerning the role of distance from the U.S. border (not reported here) indicate that this variable was not a statistically significant impediment to economic growth in most exercises, although the coefficient is always negative.[61] However, introducing the distance variables

60. These OLS results did not change when we used a sample excluding the Federal District, which has low paved roads per worker owing to high population density and which had relatively high rates of growth.

61. We estimated four models with the two distance variables discussed above in footnote 37. Two regressions were estimated via OLS and two via median regressions. In only one of these four models was the distance variable significant at the 10 percent level,

drove down the statistical significance (but not the direction of the estimated effects) of the other explanatory variables. This evidence indicates that the states located farther from the United States suffer from low levels of education and telephone density, which hamper their growth prospects.

The level of education at the beginning of the period has no statistically important impact on growth in the OLS estimates. This result might be due to the fact that human capital can migrate to dynamic regions, and thus this variable does not have any discernible impact on the states for which it was calculated in 1990. When literacy rates were used instead of educational attainment, the estimated coefficient was positive and statistically significant. Moreover, the estimates based on median regressions forcefully show that educational attainment does matter. The correlation between telephone density, initial GDP per capita, and initial education might make the identification of the impact of education rather difficult.

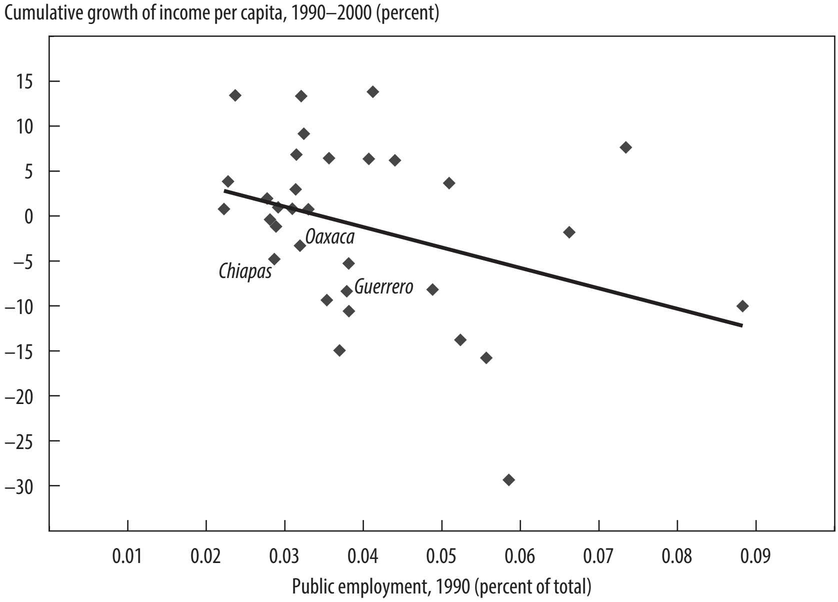
The share of public employment had a negative effect on economic activity. Figure 9 shows the simple correlation between these two variables; it is negative. This negative correlation might be due to some observations that appear in the lower right of the chart. However, the median regression estimates, which are less likely to be disproportionately influenced by strange observations, also show that this variable had a negative effect on economic growth although it is not statistically significant, after controlling for other unobserved characteristics of the southern states (see the fourth column of table 7).

To be sure that these explanations of the observed differences in growth rates across Mexican states are not misleading, we conducted additional exercises in which we controlled for the share of manufacturing production over total state GDP in 1990. As discussed in Esquivel and others, the southern states have never had a high share of manufacturing production, and for the country as a whole some manufacturing industries (and some services) grew quite rapidly in the 1990s.[62] The performance of manufacturing relative to natural resource or agricultural industries could have been

although several of the other explanatory variables were also not significant in these specifications. These results are due to the correlation between the distance variables and the other explanatory variables.

62. Esquivel and others (2002).

FIGURE 9. Relation between Growth and Public Employment in Mexican States, 1990s[a]



Source: Authors' calculations.
a. $y = -2.2719x + 0.0787$; $R^2 = 0.1282$.

due to changes in relative prices. For example, the international price of coffee began to decline in the late 1980s. Our statistical analyses indicated that the qualitative nature of the OLS results presented in table 7 are not affected by the inclusion of the manufacturing share of production. However, in the relevant median regressions, the inclusion of the share of manufacturing production affected the sign of the education and public employment variables, although none of them were statistically significant. This influence of manufacturing production on the estimated effect of education and public employment could stem from a positive correlation between education and manufacturing production (which is 0.5) and a negative correlation with the share of public employment (which is, coincidentally, –0.5). In other words, manufacturing production seems to be concentrated in states with either high levels of education or low levels of public employment. The combination of the high mobility of new capital and the relative irreversibility of past investment probably makes capital-intensive activities particularly sensitive to the initial economic environment in a state, such that manufacturing is implicitly capturing things such as the rule of law, instability, crime, or excessive intervention by the state.

Our evidence thus suggests that hope for the southern states is not lost: there is some evidence of conditional convergence, and some key policy-sensitive variables help explain the patterns of economic growth observed across Mexican states during 1990–2000. In particular, communications infrastructure (measured by telephone density) is more likely to have been positively associated with economic activity than paved roads or highways. Also, the evidence does not support the idea that increasing the size of the public sector can be a force for economic convergence. However, the big story remains: initial conditions seem to have had important effects on economic growth within Mexico in the 1990s. States that were initially better prepared to reap the benefits of NAFTA grew faster during this period, while the poor states of the south fell further behind.

Conclusions and Final Remarks

This paper has analyzed the dynamics and sources of convergence between Mexico and the United States. Time series analyses of the convergence process produced interesting stylized facts about the U.S.-Mexican convergence process and identified periods of convergence and divergence. While convergence suffered a major setback in the 1980s as a result of the debt crisis, the tequila crisis only temporarily interrupted a convergence process that started in the late 1980s when Mexico opened its economy. However, we only found evidence of incomplete convergence, in the sense that the constant in the cointegration space was greater than zero, indicating that Mexico is converging toward a constant income differential of about 50 percent of the U.S. GDP per capita. The comparison between annual Mexican relative income effects and average Latin American effects indicated that Mexico's convergence toward the United States was especially important after 1995.

The cross-country evidence showed that differences in institutional features inherited from history play an important role in producing income gaps. The 2SLS estimates produced much larger estimated effects of institutions on incomes than the OLS estimates, thus indicating that measurement error is an important source of attenuation bias in these relationships.[63] The use of historical instruments for current institutional quality is also interesting on its own, since institutions tend to persist over time and thus might remain a source of income divergence for a long time. Future research could yield additional practical insights if it focuses on the determinants of institutional quality. In particular, further understanding about the role of political institutions in determining the quality of governance and economic policy could help identify what types of reforms may help overcome the weight of history. Recent research along these lines has already proved fruitful.[64] Yet little is known about how accountability mechanisms can help improve national institutions. In the case of North America, international economic convergence in the long run might depend on Mexico's capacity to catch up to the standards of its neighbors. In fact, the econometric analyses indicated that the model with institutions, geography, and trade predicts an income gap of the Mexico-U.S. GDP per capita ratio of about 54 percent, which is coincidentally similar to the incomplete convergence estimated using cointegration analysis. Furthermore, the quality of Mexican institutions did not improve significantly more than those of other Latin American countries during the post-NAFTA period.

The analysis of TFP convergence within manufacturing industries produced more optimistic results concerning the impact of NAFTA. The evidence indicates that NAFTA was associated with improvements in the rate of TFP convergence between the United States and Mexico. While these results are broadly consistent with other studies, these studies contradict each other in terms of the channels through which NAFTA is thought to have improved Mexican manufacturing TFP.[65] Namely, López-Córdova argues that it was preferential access to the U.S. market (for example, the tariffs faced by Mexican exporters to the United States) and import penetration, but not imports of inputs from the United States. Schiff and Wang argue that TFP improvements were due to the R&D content of imported inputs. We can also think of other alternative hypotheses.

One possibility is that NAFTA, either through its demanded improvement in the protection of intellectual property rights or through increased

63. This is consistent with previous studies, including Acemoglu, Johnson, and Robinson (2001) and Kaufmann and Kraay (2002b).

64. Persson (2002); Lederman, Loayza, and Soares (2002).

65. López-Córdova (2002); Schiff and Wang (2002).

international competition (for import-competing and exporting industries), provided incentives for improvements in private R&D efforts and patenting. Meza and Mora, as well as Lederman and Maloney, find that the post-NAFTA period was, in fact, characterized by significant increases in R&D expenditures.[66] Patenting activity by Mexican inventors improved significantly during this period, as well. Yet the existing literature remains silent about this particular force toward convergence. An examination of these issues would require empirical work on the determinants of patenting across countries, with a special focus on the impact of trade policies and innovation policies. Much work remains to be done in this area, although there is an emerging literature.[67] Lederman and Maloney show that, in fact, the protection of intellectual property rights tends to increase R&D efforts relative to GDP in a broad panel of countries and that these expenditures are cyclical in the sense that they tend to rise with improvements in short-term growth.[68] It is thus very likely that NAFTA helped Mexico improve its innovation through its intellectual property rights regime and by helping Mexico recover after the tequila crisis. On the other hand, Lederman and Maloney also show that the emerging manufacturing sectors under NAFTA (namely, road vehicles, telecommunications equipment, and appliances) are not yet characterized by significant improvements in patenting activity, which suggests the presence of significant efficiency problems related to the lack of linkages between R&D performed by the public and higher-education sectors and the productive sector.[69]

Our study of growth patterns within Mexico during 1990–2000 showed that initial conditions determined which Mexican states grew faster. We interpret this evidence as showing that trade liberalization might be associated with economic divergence within countries owing to differences in initial conditions. In the Mexican case, telecommunications infrastructure and human capital were especially important. In addition, it is commonly understood that the poor states suffer from poor public institutions and political instability.[70] The poor states might have grown faster during this period if they had been adequately prepared to reap the benefits of free trade. Economic convergence in North America might not materialize under

66. Meza and Mora (2002); Lederman and Maloney (2003a).
67. Furman, Porter, and Stern (2002).
68. Lederman and Maloney (2003b).
69. Lederman and Maloney (2003a).
70. Esquivel and others (2002).

free trade or under any trade regime as long as fundamental differences in initial conditions persist over time. Fortunately, some of these fundamentals should be sensitive to policy changes.

Appendix: Supplementary Data

TABLE A1. Summary Statistics for Data Used for Econometric Results on Institutional Gaps and Income Gaps (Figures 4 and 7)

Sample[a]	*Variable*	*No. observations*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Group 1	ICRG variables[b]	414	−0.4069638	0.558766	−1.75361	0.6972296
	Log (country's GDP per capita/USA GDP per capita)	923	−1.715673	0.579324	−3.65967	−0.3095284
Group 2	ICRG variables[b]	162	−0.1312372	0.4356544	−1.00386	0.6972296
	Log (country's GDP per capita/USA GDP per capita, PPP adjusted)	378	−1.328616	0.3673385	−2.19757	−0.3095284

a. Group 1: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, Trinidad and Tobago, Uruguay, and Venezuela; Cuba is not included in the GDP sample. Group 2: Argentina, Brazil, Chile, Colombia, Costa Rica, Mexico, Peru, Uruguay, and Venezuela.

b. Weighted average of the ICRG variables (absence of corruption, law and order, and bureaucratic quality).

TABLE A2. Summary Statistics for Data Used in Analysis of Institutional Gaps and Income Gaps

Variable	*No. observations*	*Mean*	*Standard deviation*	*Minimum*	*Maximum*
Landlocked	68	0.1323529	0.3413936	0	1
Openness (Sachs and Warner, 1995)	63	0.2252768	0.3423797	0	1
Log constructed trade share (Frankel-Romer)	68	2.721456	0.7672238	0.94	4.586000
Latitude	68	6.318064	19.691030	−41.81407	61.06258
Ethnolinguistic fractionalization	61	46.377050	29.430240	1	90
Africa	68	0.3382353	0.4766266	0	1
South Asia	68	0.0588235	0.2370435	0	1
East Asia and the Pacific	68	0.0735294	0.2629441	0	1
Americas	68	0.3970588	0.4929263	0	1
Oil production dummy	68	0.2647059	0.4444566	0	1
Commodity dummy	68	0.6764706	0.4713010	0	1
Institutional index	68	−0.1134657	0.7704978	−1.978333	1.585833
Log mortality	68	4.588946	1.2550750	2.145931	7.986165
Log GDP per capita	68	7.794468	1.1091530	5.252923	10.031100

TABLE A3. Mexico: Summary Statistics of Variables and Data Used for TFP Convergence Analysis, by Industry

Industry code[a]	*(Log) output*	*Obs*	*(Log) labor*	*Obs*	*(Log) capital*	*Obs*	*Labor share*	*Obs*
311	15.77	25	12.98	25	13.87	25	0.06	25
313	15.08	25	12.72	25	13.68	25	0.10	25
314	13.65	25	10.36	25	11.50	25	0.04	25
321	14.35	25	12.50	25	13.41	25	0.16	25
322	13.11	17	11.33	17	11.44	17	0.17	17
323	12.52	7	10.01	7	10.87	7	0.08	7
324	12.86	17	11.19	17	11.70	17	0.19	17
331	11.91	25	9.85	25	11.77	25	0.13	25
332	12.49	17	10.49	17	10.55	17	0.14	17
341	14.61	25	12.08	25	14.35	25	0.08	25
342	13.29	17	11.38	17	11.67	17	0.15	17
351	14.98	25	12.48	25	14.16	25	0.09	25
352	15.09	25	12.89	25	13.49	25	0.11	25
353	13.23	7	10.49	7	11.94	7	0.07	7
354	12.72	25	9.84	25	12.44	25	0.06	25
355	13.66	25	11.69	25	12.90	25	0.14	25
356	14.00	17	11.83	17	12.70	17	0.12	17
361	12.08	17	10.13	17	9.04	17	0.14	17
362	13.81	25	11.86	25	13.12	25	0.15	25
369	14.41	25	12.05	25	14.36	25	0.10	25
371	15.38	25	12.59	25	14.84	25	0.07	25
372	14.31	25	11.34	25	12.73	25	0.06	25
381	14.24	25	12.08	25	12.58	25	0.12	25
382	14.02	25	11.78	25	11.97	25	0.11	25
383	14.64	25	12.57	25	13.02	25	0.13	25
384	15.95	25	13.15	25	14.22	25	0.07	25
385	12.15	17	9.76	17	10.19	17	0.10	17
390	12.21	17	10.34	17	10.86	17	0.16	17

Source: United Nations Industrial Development Organization (UNIDO).

a. See table A5 for a list of the industries by code.

TABLE A4. United States: Summary Statistics of Variables and Data Used for TFP Convergence Analysis, by Industry

Industry code[a]	*(Log) output*	*Obs*	*(Log) labor*	*Obs*	*(Log) capital*	*Obs*	*Labor share*	*Obs*
311	19.47	25	17.06	25	18.08	25	0.09	25
313	17.50	25	15.19	25	16.74	25	0.10	25
314	16.85	25	14.03	25	15.37	25	0.06	25
321	18.14	25	16.45	25	17.21	25	0.18	25
322	17.64	25	16.12	25	15.86	25	0.22	25
323	15.35	25	13.66	25	14.11	25	0.19	25
324	15.32	25	13.81	25	14.72	25	0.22	25
331	17.64	25	15.92	25	16.79	25	0.18	25
332	17.27	25	15.86	25	15.61	25	0.24	25
341	18.46	25	16.58	25	18.15	25	0.15	25
342	18.57	21	17.21	21	17.48	21	0.26	21
351	18.67	25	16.36	25	18.54	25	0.10	25
352	18.46	25	16.36	25	17.34	25	0.12	25
353	18.62	25	14.86	25	17.90	25	0.02	25
354	16.58	21	13.88	21	15.12	21	0.10	21
355	16.99	25	15.45	25	16.20	25	0.21	25
356	17.95	25	16.32	25	16.93	25	0.19	25
361	14.72	25	13.56	25	14.03	25	0.32	25
362	16.64	25	15.14	25	16.15	25	0.23	25
369	17.62	25	15.97	25	16.92	25	0.19	25
371	18.09	25	16.43	25	18.15	25	0.19	25
372	17.74	25	15.69	25	16.97	25	0.13	25
381	18.73	25	17.25	25	17.62	25	0.23	25
382	19.31	25	17.78	25	18.21	25	0.22	25
383	19.15	25	17.60	25	18.07	25	0.22	25
384	19.66	25	17.88	25	18.43	25	0.17	25
385	18.21	25	16.81	25	16.98	25	0.25	25
390	17.25	25	15.71	25	16.10	25	0.21	25

Source: United Nations Industrial Development Organization (UNIDO).
a. See table A5 for a list of the industries by code.

TABLE A5. List of Codes and Industries Used in TFP Convergence Analysis

ISIC Code	*Industry*
311	Food products
313	Beverages
314	Tobacco
321	Textiles
322	Wearing apparel, except footwear
323	Leather products
324	Footwear, except rubber or plastic
331	Wood products, except furniture
332	Furniture, except metal
341	Paper and products
342	Printing and publishing
351	Industrial chemicals
352	Other chemicals
353	Petroleum refineries
354	Miscellaneous petroleum and coal products
355	Rubber products
356	Plastic products
361	Pottery, china, earthenware
362	Glass and glass products
369	Other nonmetallic mineral products
371	Iron and steel
372	Nonferrous metals
381	Fabricated metal products
382	Machinery, except electrical
383	Machinery, electric
384	Transport equipment
385	Professional and scientific equipment
390	Other manufactured products