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Stochastic Convergence amongst Mexican States

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Abstract

In this paper we investigate the convergence process experienced by the Mexican states covering the period 1940-2001. Our analysis indicates that misleading conclusions can be obtained if the presence of structural breaks is not taken into account when testing for the presence of (stochastic) convergence. Thus, after allowing for structural breaks evidence in favour of convergence, in terms of real per capita GDP, is found both using unit root and cointegration tests. Empirical evidence shows that economic convergence has changed along time with mixed effects, although changes were toward convergence in majority of cases, consistent with stochastic convergence.

Keywords: Stochastic convergence, structural breaks, unit root, cointegration, regime shifts

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1. INTRODUCTION

Economic growth differentials have recently been tackled from very diverse perspectives, and have been widely discussed in great detail in the economic literature for both developed and developing countries –see MANKIW *et al.,* 1992, among others. Experience from homogeneous groups of countries has been documented, for instance, for the OECD countries (STRAZICICH *et al.*, 2004), for the European Union (ARMSTRONG, 1995 and FINGLETON, 1997), for G-7 countries (MILLS and WANG, 2003), for Asia (HSIAO and HSIAO, 2004), Latin America (DOBSON and RAMLOGAN, 2002), and in Africa (COLLIER and GUNNING, 1999). There are also analyses that focus on the regional level –see, BARRO and SALA-I-MARTIN, 1991; CARLINO and MILLS, 1993; McGUINNESS and SHEEHAN, 1998; REY and MONTOURI, 1999; TSIONAS, 2000, and COULOMBE, 2000, among others.

Many of these studies have devoted a lot of attention to investigating convergence principally amongst developed countries (OECD and E.U.) and regions (U.S. states and E.U. regions), partly due to availability of data for that group of economies. Notwithstanding, the problem of the disparities in regional incomes is not a trivial matter of concern only to developed economies and is of equal (or almost equal) interest to developing countries. Unfortunately, empirical evidence focusing on developing countries is scarce. Some recent contributions are CÁRDENAS and

PONTÓN, 1995, in Colombian regions; ESQUIVEL, 1999, and CERMEÑO, 2001, in Mexican regions; AZZONI, 2001, in Brazil; ZHANG, *et al.*, 2001, in regions of China; SOLANKO, 2003, in Russia, and MADARIAGA *et al.*, 2004, in Argentina; among others. The aim of this paper is to contribute to the empirical evidence through the analysis of the Mexican regions over a long time period.

There are some previous contributions in the literature that address the case of Mexico, most of them following the approach of beta and sigma convergence –see, for instance, JUAN-RAMÓN and RIVERA-BÁTIZ, 1996; ESQUIVEL, 1999, and CERMEÑO, 2001. These papers conclude that the regional differences have been tinged by two radically different tendencies: a first lapse of time where there has been a convergent process up to 1980, followed by a recent period where the convergence process has been either stopped or reversed (divergence). The methodological framework adopted in this paper increases the evidence on convergence analysis for the Mexican case by means of the stochastic convergence approach in CARLINO and MILLS, 1993, and BERNARD and DURLAUF, 1995, using time series on regional product that covers from 1940 to 2001. To the best of our knowledge, this is the first paper that analyses the convergence hypothesis using the definition of stochastic convergence for the Mexican regions. This approach has the advantage that it allows us identifying not only the existence of a convergence process amongst the investigated series, but also which regions are converging and which are not. This is essential to the examination of the regional differences of a country that has experienced important economic events (debt crisis, devaluations or increase of openness) that have affected the development of the regions in different ways. Furthermore, the use of time series approach allows tailoring the analysis of convergence to each individual.

Standard techniques that have been applied when testing for the presence of unit roots and cointegration indicate the lack of convergence. This result was to be expected, since the period of analysis has been characterized by diverse events that affected economic activity, such as economic crises and reforms. In order to take into account all these features, our analysis considers the presence of these exceptional events, treating them as structural changes. After controlling for the presence of structural breaks evidence in favour of stochastic convergence increases, although some states still show divergence.

The paper is structured as follows. In section 2 we discuss the aspects related to Mexican regional system and the data that is used. Section 3 describes the theoretical model and the different techniques for proving convergence. Section 4 is devoted to the analysis of stochastic convergence with and without structural breaks. Finally, section 5 concludes.

2. MEXICAN REGIONAL SYSTEM AND DATA

The main political-administrative division of Mexico establishes two basic territorial dimensions defined by 32 states (or federative entities) and 2,446 municipalities. Given the available statistical information, in this paper we focus on federative entities. This paper uses the data set on per capita GDP for 32 Mexican federal entities over the period 1940-2001 provided in GERMAN-SOTO, 2005. It is worth noting that due to the lack of regional GDP deflators, the data were transformed in real terms using the implicit deflator of the national GDP, although the use of a common deflator serves no purpose in this case since we are considering relative per capita incomes. This approach has also been followed in CARLINO and MILLS, 1993; EVANS and KARRAS, 1996; LOEWY and PAPELL, 1996, and TSIONAS, 2001, among others, when analysing the U.S. regions. Therefore, the logarithm of annual data on per capita income for the 32 Mexican regions during the period 1940-2001 is used in this study.

Before presenting the methodology and the results of the analysis, we think that some details about economic performance of Mexican region might help to get better understanding of our analysis.

The Mexican states are presented in Figure 1. Mexico's recent growth performance coincides with the regional distribution in the Mexican map: in the Mexican diversity coexist a poor and backward South, with a significant indigenous presence, next to a North and Center relatively prosperous. Almost from any point of view, the most outstanding feature is the inequity among the federative entities: levels of economic, political and social development show huge variance.

-Insert Figure 1 about here-

Real per capita income in Mexico grew to a rate of 4% per year between 1940 and 2001, which allowed tripling the real per capita income in Mexico during this period. Increase of real per capita income has been followed by mild reductions in disparities amongst the states. Table 1 shows that in 1940 the per capita income of the Distrito Federal was of approximately 18 times the income of the Oaxaca's state. In 2001 this gap decreased up to 6 times, which still can be considered as large – for example, by way of comparison, consider ratio between the richest and the poorest states in Brazil, Colombia and Sweden in 1990, around of 6.2, 3.3 and 1.2, respectively.[1] In addition, Table 1 evidences that the Mexican regional development has been characterized by a relative concentration of poor states along time, as shown by the Skewness and Kurtosis measures.

- Insert Table 1 about here-

Figure 2 depicts the coefficient of variation of the difference between per capita income of each state with respect to the national one –hereafter, we refer to this difference as relative regional per capita income. Between 1940 and early-eighties there took place gradual tendency to reduce dispersion in per capita income. All the states with low incomes made substantial earnings, while the states with high revenues were gradually coming down. The effects of Mexico's trade liberalization, which started in the mid-eighties, seem to stop this disparity reduction in terms of real per capita income. This situation has been pointed out in previous studies, which relying on the definition of cross-section-based β and σ-convergence analyses, report low rates of convergence (less than 2% in the whole period) and even divergence in most recent times.[2] This paper aims to extend previous evidence on real per capita convergence for Mexican regions using the definition of stochastic convergence.

–Insert Figure 2 about here–

3. STOCHASTIC CONVERGENCE HYPOTHESIS

The convergence methodology that is explored in this paper is the one developed in CARLINO and MILLS, 1993; BERNARD and DURLAUF, 1995, and EVANS and KARRAS, 1996; *i.e.* the notion of stochastic convergence. Following BERNARD and DURLAUF, 1995, N economies are said to converge if, and only if, a common trend a_t and finite parameters $\delta_1, \delta_2, \ldots, \delta_N$ exist so that

$$\lim_{t\to\infty}\left(y_{i,t} - a_t\right) = \delta_i, \tag{1}$$

for $i = 1,\ldots, N$, where $y_{i,t}$ denotes the real per capita income of the i-th individual. In order to account for the unobservable common trend, we define the average of the N economies so that

$$\lim_{t\to\infty}\left(\bar{y}_t - a_t\right) = \frac{1}{N}\sum_{i=1}^{N}\delta_i, \tag{2}$$

where $\bar{y}_t = N^{-1}\sum_{i=1}^{N} y_{i,t}$ denotes the average per capita GDP. If we define the level of the common trend so that $\lim_{t\to\infty}\left(\bar{y}_t - a_t\right) = 0$, and subtracting (2) from (1), stochastic convergence exists if, and only if,

$$\lim_{t\to\infty}\left(y_{i,t} - \bar{y}_t\right) = \delta_i. \tag{3}$$

In this framework, convergence is said to be absolute if, and only if, the unconditional mean $\delta_i = 0$ in (3), while convergence is said to be conditional when $\delta_i \neq 0$ in (3). In order to capture deviations from relative trend growth, CARLINO and MILLS, 1993, propose to model deviations from the equilibrium (δ_i) as combination of a time trend and a stochastic process:

$$\delta_i = \mu_i + \beta_i\, t. \qquad (4)$$

Therefore, regional output ($y_{i,t}$) is said to converge to the average of regional per capita output ($\bar{y}_t$) if $y_{i,t}$ and $\bar{y}_t$ are (stochastically) cointegrated with cointegrating vector (1, -1)'. Consequently, assessing the presence of stochastic convergence is equivalent to testing for cointegration with the known cointegrating vector, *i.e.* analysing the stochastic properties of $\left(y_{i,t} - \bar{y}_t\right)$ through the application of unit root tests. As pointed out in CARLINO and MILLS, 1993, the specification given by (4) is a dynamic version of the Baumol hypothesis. Thus, β-convergence requires that if a region is initially above its compensating differential (μ_i), it should grow more slowly than the nation, which implies $\beta_i < 0$ in (4). On the other hand, if the region is initially below its compensating differential, then $\beta_i > 0$ in (4). This allows us to investigate the rate at which the different states are converging by studying heterogeneous behaviour. The lack of conditional or absolute convergence as defined above does not prevent both the regional and national output being related, but with cointegration vector other than (1, -1). Thus, these time series may follow each other in the long-run, which will imply examining common trends in output. This involves conducting a cointegration analysis between $y_{i,t}$ and $\bar{y}_t$, estimating the cointegrating vector that relates both variables. This feature is also investigated in this paper.

Instead of defining $\bar{y}_t$ as the average or regional per capita GDP, in this paper we follow CARLINO and MILLS, 1993, and specify the national per capita GDP as numeraire. It should be highlighted that our analysis is conditional to the selection of this numeraire, since in this case we investigate whether or not regions converge to the national per capita GDP. We could select another numeraire to capture the fundamental trend –for instance, the average of regional per capita GDP or the per capita GDP of the leading region– but the analysis would still be conditioned by this selection. However, the presence of a linear time trend in (4) robustifies our analysis to numeraire selection. Since the interest of our approach is the analysis of whether shocks have permanent or transitory effect on deviations from the national per capita GDP, the specification of a time trend will allow controlling systematic deviations from the trend defined by the numeraire.

The presence of unattended structural breaks can bias the integration and cointegration analysis towards non-stationarity. In this regard, we investigate the sensitivity of the conclusions that are obtained using the standard unit root and cointegration techniques allowing for structural breaks. Our approach generalizes the proposal in CARLINO and MILLS, 1993, and LOEWY and PAPELL, 1996, for regions of the U.S. since, first, we apply unit root tests that account for up to two structural breaks and, second, we conduct the cointegration analysis allowing for one structural break. The use of these alternative approaches will allow us to assess if the rate at which states converge has changed during the analyzed period.

4. STOCHASTIC CONVERGENCE ANALYSIS

Before presenting the results of the integration and cointegration analyses with structural breaks, we should mention that, as the first stage, we conducted the study without allowing for structural breaks. In brief, investigation of stochastic convergence without structural breaks relied on the use the so-called *M* unit root tests proposed in NG and PERRON, 2001. Results available upon request, revealed that there was mild evidence of convergence, since the null hypothesis of unit root was not rejected in most cases –we essayed two deterministic specifications, *i.e.* the constant and time trend specifications. Cointegration analysis did not significantly increase the evidence of long-run relationship between $y_{i,t}$ and $\bar{y}_t$.

Visual inspection of relative per capita incomes indicates that the presence of structural changes might be affecting the behaviour of the time series, which would bias the stochastic convergence analysis that has been carried out. Misspecification errors due to the failure to take into account the presence of structural breaks can bias both the unit root and cointegration tests towards the null hypothesis of non-stationarity –see PERRON, 1989, and GREGORY and HANSEN, 1996. Visual inspection of the relative per capita income indicates that there might be some infrequent features that affect the pattern of the time series over a period of time, so that structural breaks should be considered when conducting the integration and cointegration analyses. Thus, the stationary equilibrium might be undergoing a slow transition between steady states, movements probably due, in turn, to changes in the fundamentals of the economies. This situation is reinforced by the conclusions reached in previous studies. In particular, MESSMACHER, 2000, and CHIQUIAR, 2005, have suggested that the recent structural reforms have led to an increase in the regional inequality in Mexico.[3] One of these effects has been the fast growth in the manufacturing sector, in connection with other components of the GDP, and therefore the biggest growth in the states for which manufacturing sector representing a high proportion of the state product. Thus, the regional economic disparities have experienced a slow and discontinuous convergence process, with little evidence with regards to trade integration-regional divergence connection. In order to account for these features, we have considered a second approach of stochastic convergence with structural changes. This is found out in the next section.

4.1. UNIT ROOT TESTS WITH STRUCTURAL BREAKS

In this section we have computed a group of ADF-type unit root tests allowing for structural breaks. These tests can be specified using a general regression equation:

$$y^*_{i,t} = \mu_i + \beta_i t + \sum_{j=1}^{m} \theta_{i,j} DU_{i,j,t} + \sum_{j=1}^{m} \gamma_{i,j} DT_{i,j,t} + \sum_{j=1}^{m} d_{i,j} D(T_b)_{i,j,t} + \alpha_i y^*_{i,t-1} + \sum_{j=1}^{k} c_j \Delta y^*_{i,t-j} + \varepsilon_{i,t}, \quad (5)$$

where $y^*_{i,t} = (y_{i,t} - \bar{y}_t)$ denotes the difference between regional and national real per capita income, $DU_{i,j,t} = 1$ and $DT_{i,j,t} = (t - T_{b,i,j})$ for $t > T_{b,i,j}$, 0 elsewhere; $D(T_b)_{i,j,t} = 1$ for $t = (T_{b,i,j} + 1)$ and 0 elsewhere, and where $T_{b,i,j}$ defines the *j*-th (j = 1,…, m) structural break point for the *i*-th individual.

Let us first deal with the situation in which there is only one structural break. One of the most often used and popular unit root test statistics that takes into account the presence of a structural break is the one proposed by PERRON and VOGELSANG, 1992; ZIVOT and ANDREWS, 1992, and PERRON, 1997.[4] LUMSDAINE and PAPELL, 1997, and CARRION-I-SILVESTRE, *et al*., 2004, extend the analysis in ZIVOT and ANDREWS, 1992, to account for two structural breaks.[5] Throughout this section, the order of the autoregressive correction in (5) has been chosen with the *t*-sig criterion in NG and PERRON, 1995, with k_{max} = 8 maximum lags.

Since for some regions the null hypothesis of unit root is rejected for all different specifications that have been essayed, we have decided to follow MONTAÑÉS *et al*., 2005, and select the type of the break, *i.e.* the Models An, A, C, AAn, AA or CC, using the BIC information criterion –similar results were obtained using the AIC information criterion, which are available upon request. Table 2 reports the results for those states for which the null hypothesis of unit root is rejected –second column in Table 2 indicates the model to which results are referred. For four states we have found evidence against the null hypothesis of unit root when one structural break is included, while for twenty states the best specification suggested by the BIC information criterion is the one with two structural breaks. Eleven of the detected break points are located around the crises of 1976, 1982 and 1994/1995, while three structural breaks are estimated in the age of the Mexican oil boom. Meanwhile, dates selected between 1950 and 1960 correspond to a stage of quick reduction of the per capita income differences that has been broadly documented by VILLARREAL, 1988, among others. These break points evidence this period of high growth, in which Mexican economy passed of being eminently rural to an urban and industrial economy.

Regarding the states for which the model with one structural break has been selected, we can see that only for Baja California Model An –the model for non-trending variables– is the best specification. The estimation indicates that the structural break located in 1950 led to approach the national per capita GDP, although there persist a positive deviation –*i.e.* the constant term after 1950 is 0.049-0.037 = 0.012. For Guanajuato we have chosen Model A. The coefficient of the time trend is almost zero and non-significant, which indicates that there are no significant deviations from the national trend. Moreover, for this state the estimate of the constant term is negative, so the positive sign of the dummy variable indicates that after 1960 Guanajuato has experienced a convergence process towards the national per capita GDP. Finally, for Chiapas and Tabasco the structural break changes both the level and the slope of these time series. Estimates for Chiapas indicates that after 1975 real per capita GDP of this state has been diverging from the national one – positive sign of the dummy variable that partly corrects negative constant term, but negative change in the slope that annuls the previous approaching tendency. Results for Tabasco show that this state evolves following the national per capita GDP –the larger positive sign of the dummy variable corrected negative constant, although the negative sign of the time trend corrected this positive deviation after 1975.

—Insert Table 2 about here—

Similar analysis can be conducted for the two structural break case. Michoacán, Nayarit, Oaxaca and Puebla are states for which Model AAn has been estimated. Looking at these estimates we can observe that constant term is negative and, although the effects of the structural breaks reduced differences, they are below the national per capita GDP. For Campeche, Jalisco, Nuevo León and Querétaro we find the converse situation. Note that most of the structural breaks for these states are around 1950 and 1960. For Coahuila, Colima, Distrito Federal, Morelos, San Luis Potosí and Sonora we have selected Model AA. Note that allowing for a time trend tends to correct deviations of state per capita GDP from the national one –negative slope corrects overall positive deviations estimated from the constant and dummy variables, and the converse round. Finally, for Aguascalientes, Baja California Sur, Quintana Roo and Zacatecas estimation of Model CC indicates that they have been converging towards the national per capita GDP since coefficients of the different dummies tends to cancel deviations. For Tamaulipas and Veracruz the estimations indicates positive deviations from the national per capita GDP. However, the overall coefficient of the slope for Tamaulipas is positive, which indicates that these positive deviations will increase since this state does not follow the national trend. The overall negative slope coefficient for Veracruz shows that these positive deviations tend to disappear.

To sum up, the analysis that has been carried out shows that in 24 states the null hypothesis of unit root is rejected in favour of the stationary alternative when structural breaks are accounted for. Global result from equation (5) suggests that the effects of the structural changes in the most recent stage of the country were not uniform across regions. The initially richer states of the North and Center seem to have improved their relative position after structural change, while Southern states do hardly improve their performance in terms of growth. Regional dynamics of the relative income differences is presented in Figure 3. Darkened colours indicate regions that benefited most after structural changes, while clearest colours –except completely white ones, which there is not convergence– suggest a worsening.

—Insert Figure 3 about here—

Groups 1 and 2 in Figure 3 participate from a convergence process when being approached to the average national income –group 1 is defined by those states which initial level of per capita income was above the national one, while group 2 is for those where the initial level of per capita income was below the national real per capita output. On the other hand, groups 3 and 4 correspond to states that have enlarged their relative income differences.[6] Crises and Mexico's reforms might be thought as major causes that altered growth pattern of the states. For instance, some structural reforms –GATT and NAFTA, in particular– have taken to a regional inequality favouring states with better spatial location –manufacturing firms of states located at the North Frontier have taken advantage of reductions in the cost of transport when trading with the U.S. Also, exit of many industrial firms from metropolitan area of Distrito Federal at the beginning of eighties contributed to reinforce the sectoral differences on economic growth of the states –see MESSMACHER, 2000; SÁNCHEZ-REAZA and RODRÍGUEZ-POSE, 2002; CHIQUIAR, 2005.

4.2. COMMON TRENDS WITH REGIME SHIFTS

So far, the techniques that have been used have provided results that are divided on the phenomenon of the stochastic convergence in the empiric performance of the Mexican states. However, they may be characterized by common trends where this linear relationship has changed in time. In this sense, we carry out cointegration tests on models with regime shifts based on the estimated residuals. Because some relative per capita income series could not reject the null hypothesis of no cointegration it is possible that we are concluding falsely that such a relationship does not exist in the long term if the model is indeed cointegrated with a regime shift in the cointegration vector. GREGORY and HANSEN, 1996, have demonstrated that the power of the conventional ADF test fails when the cointegration relationship present regime shifts. Following GREGORY and HANSEN, 1996, we consider three alternatives to investigate this possibility. Specifically, the model with level change (L), the model with trend (T) and the model of regime shift (S) can be expressed, respectively, as:

Model L: $$y_{i,t} = \mu_i + \theta_i\, DU_{i,t} + \alpha_i\, \bar{y}_t + u_{i,t}, \qquad (6)$$

Model T: $$y_{i,t} = \mu_i + \theta_i\, DU_{i,t} + \beta_i\, t + \alpha_i\, \bar{y}_t + u_{i,t}, \qquad (7)$$

Model S: $$y_{i,t} = \mu_i + \theta_i\, DU_{i,t} + \alpha_{i,1}\, \bar{y}_t + \alpha_{i,2}\, \bar{y}_t DU_{i,t} + u_{i,t}, \qquad (8)$$

where, as before, $y_{i,t}$ denotes the GDP of the i-th Mexican state, i = 1,…, 32, $\bar{y}_t$ is the national GDP, and $DU_{i,t}$ is the dummy variable defined above. The order of integration of the residuals drawn from estimations (6) to (8) is assessed using the ADF-type equation, from which the parametric (ADF) and non-parametric (Z_t) statistics can be computed –see GREGORY and HANSEN, 1996.

Table 3 presents the states for which the null hypothesis of non-cointegration is rejected using one of the specifications. Following BERENGUER-RICO and CARRION-I-SILVESTRE, 2005, selection amongst Models L, T and S is based on the BIC information criterion –second column in Table 3 indicates the selected specification. The results presented in Table 3 show that in 18 states the presence of the regime shift is significant with at least one of the three specified models using either the ADF or Z_t statistics –the estimated break points are reported in parenthesis. These results are in sharp contrast with the ones that do not allow for regime shifts, for which evidence of cointegration was found only for three cases. This indicates that previous inference on cointegration was not correct since the model was misspecified. Thus, the inclusion of a structural break in the model seems to be necessary to understand the stochastic convergence process that has exhibited the Mexican regions. Although not comparable with results of the unit root tests, we observe that for eight states –Campeche, Colima, Chiapas, Distrito Federal, Nayarit, Puebla, Quintana Roo and Tabasco– the estimated break points are close to the ones obtained using unit root statistics. Moreover, in four cases –Chihuahua, Guerrero, Hidalgo and Sinaloa– we find evidence in favour of the presence of a broken common trend between per capita GDP of these states and the national one, where unit root tests with structural breaks were unable to reject the null hypothesis. In all, these results reinforce evidence of convergence that has been obtained in the previous section.

—Insert Table 3 about here—

The structural breaks that have been estimated coincide with the moments of greater prosperity, on one hand, and with the most critical years in the Mexican economy, on the other hand. Before 1970 the break points coincide in two different periods: one between 1949 and 1955, and another group of observations between 1963 and 1969. Both periods registered important rates of growth and a substantial decrease of the per capita dispersions. Meanwhile, after 1970 it is possible to see two groups of break dates estimates, those that are located between 1976 and 1978 that intuitively reflect the effects of the crisis of 1976, and those between 1981 and 1983, coinciding with the crisis of 1982. In both cases the technique that identifies structural changes is appropriate to the depressive cycles of the national economy.

5. CONCLUSIONS

This paper uses the time series approach to examine whether the pattern of relative regional per capita incomes in Mexico over the past sixty years is consistent with the convergence hypothesis. Conclusions depend on the specification of the deterministic component that is used. Generally speaking, we are generally unable to find evidence in favour of convergence in the majority of states using standard unit root and cointegration statistics. However, this evidence is reversed in most of cases when the presence of structural breaks is accounted for.

The paper has analysed the non-stationarity of relative per capita incomes allowing for up to two structural breaks, concluding that either the unit root or non-cointegration can be rejected in most of cases. However, this finding is not always consistent with convergence towards real per capita national GDP. Thus, although evidence against unit root tests has been found for some states, the estimation of the deterministic component reveals that they do not share the common trend defined by the national mean. In these states recurrent shocks that affect their economies are transitory, but they evolve according a different time trend than the one given by the national mean.

The results of the analysis have, however, real important implications. For example, in order to achieve greater territorial cohesion and to reduce the gap with North states –increasingly integrated with the U.S. economy– greater efforts for the policy-makers to promote economic development –in the South of Mexico, mainly– may be needed. Evolution of economic factors –such as the composition of physical and human capital, differences in investment and education and migratory processes, among others– that might be limiting convergence and slowing down the process of reduction of disparities between the states also deserves to be investigated in greater depth because of findings suggest that trade reforms have not reduced the heterogeneity across states. Instead, trade liberalization have accentuated them when favoring those states initially endowed with, or able to attract, higher levels of human and physical capital and better infrastructure. This is left for further research.

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Figure 1. Mexican regions' territory

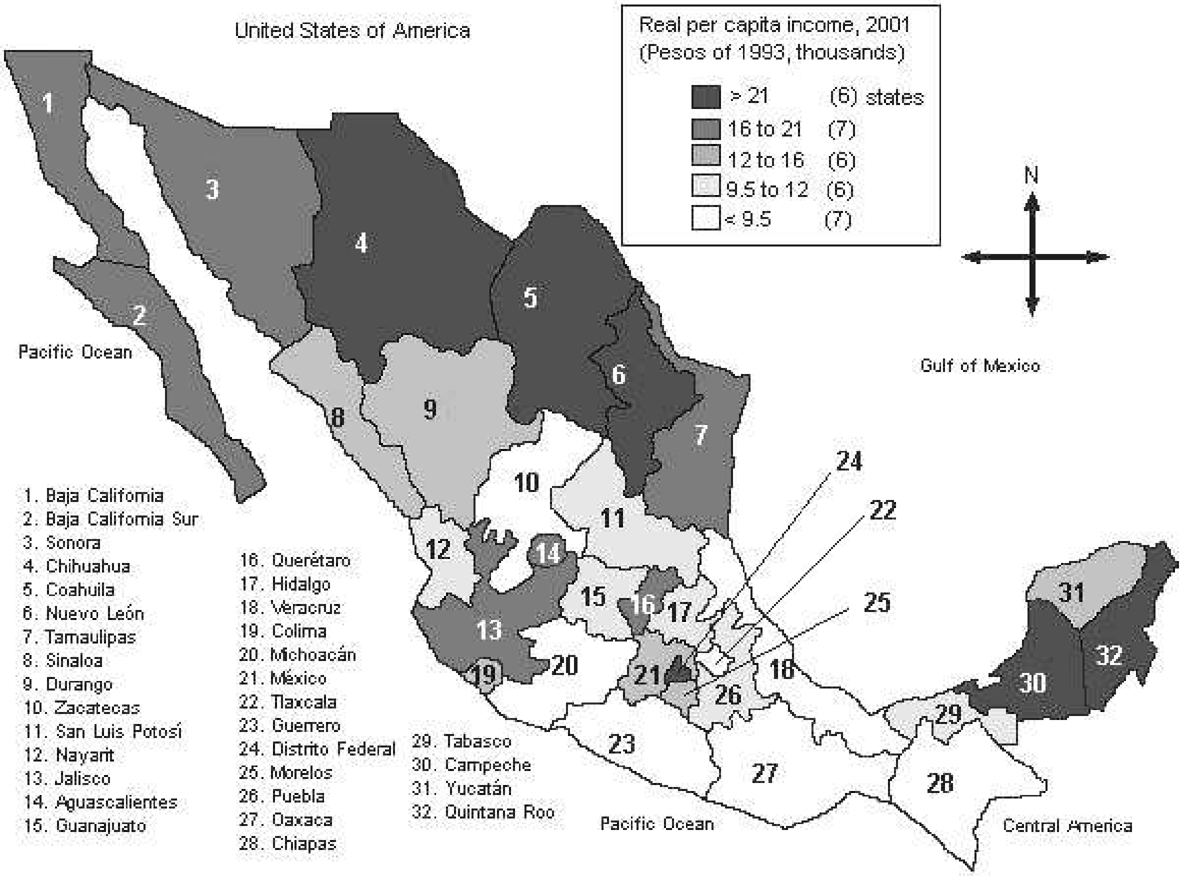

Figure 2. Dispersion of relative regional per capita incomes

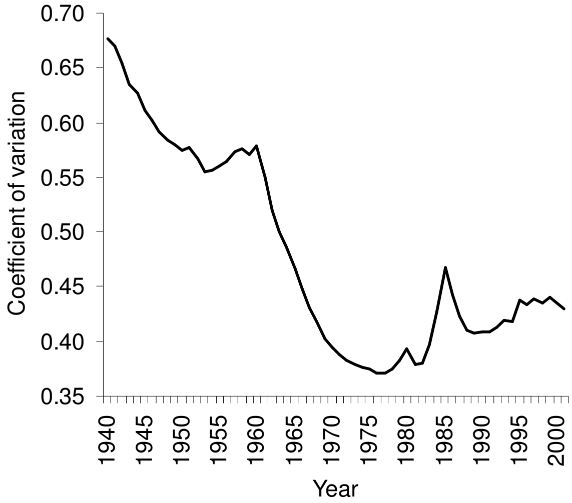

Figure 3. Regional deviations in relative income

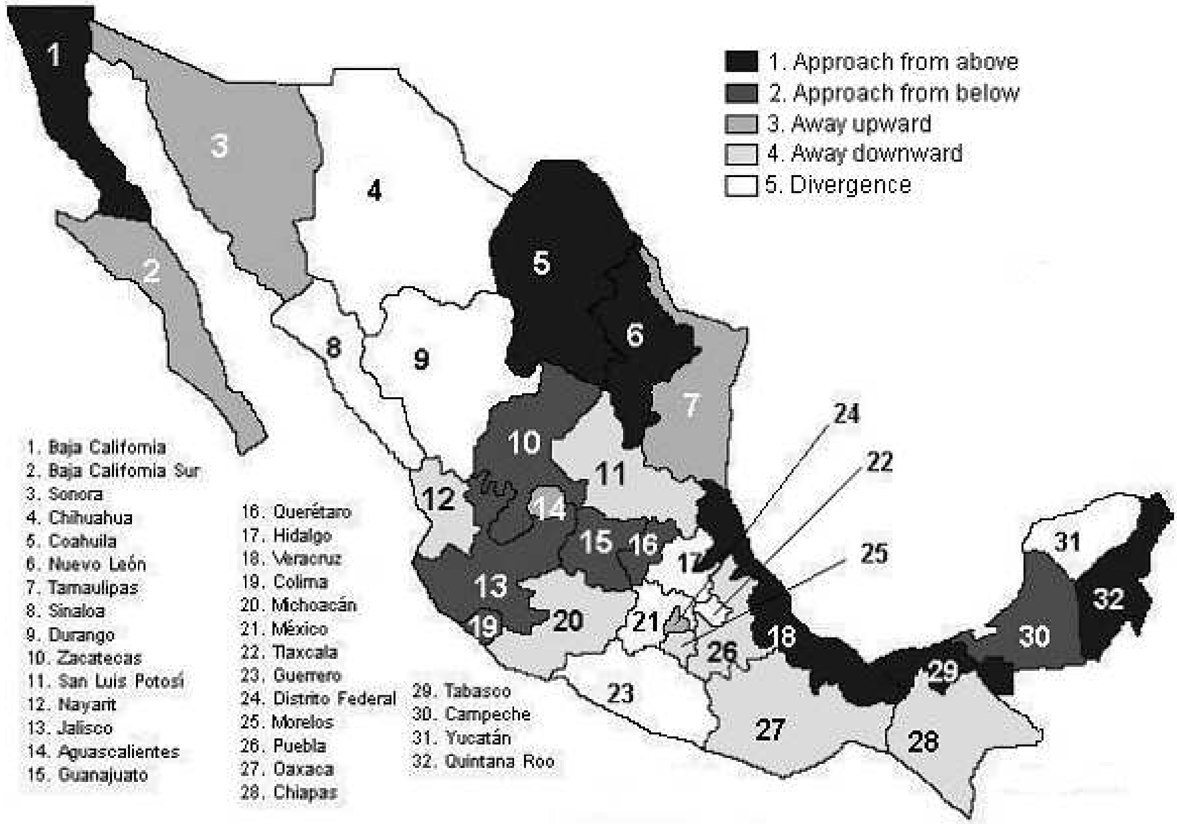

Table 1. Real per capita income of the Mexican states, 1940-2001 (Pesos of 1993)

State	1940	1950	1960	1970	1980	1990	2001
Aguascalientes	4,135.3	2,482.7	3,470.4	8,291.3	10,534.5	13,124.9	19,822.3
Baja California	16,392.5	15,378.2	13,096.5	15,127.3	17,135.5	18,326.6	20,027.7
Baja California Sur	3,782.9	6,327.5	6,601.7	14,469.8	17,095.5	17,959.2	20,534.2
Campeche	3,443.6	4,516.2	5,429.0	8,757.0	10,238.5	37,329.3	25,698.8
Coahuila	6,083.5	6,893.5	8,778.6	12,528.0	15,322.7	17,270.9	21,052.4
Colima	5,072.7	4,441.1	4,431.7	8,927.1	12,175.1	14,483.4	15,402.0
Chiapas	1,532.5	2,161.2	2,757.8	5,137.2	11,661.1	6,744.7	6,891.9
Chihuahua	4,626.0	7,548.5	8,771.7	10,556.2	12,613.9	16,538.5	22,429.8
Distrito Federal	14,684.1	14,110.1	19,100.6	20,072.2	25,547.1	31,298.5	41,372.3
Durango	5,526.5	4,035.6	4,247.0	7,462.8	9,635.7	11,208.0	13,869.9
Guanajuato	1,901.0	2,482.4	3,583.5	7,431.4	8,683.7	9,625.4	11,126.6
Guerrero	1,289.9	2,146.1	2,951.0	5,390.9	7,101.5	8,260.4	8,437.9
Hidalgo	1,968.1	2,315.7	2,853.1	5,619.4	8,753.2	9,898.9	9,787.8
Jalisco	2,472.2	3,833.3	4,635.0	10,828.3	13,480.4	14,557.3	16,071.2
México	1,887.4	2,753.7	5,014.1	11,258.6	12,973.7	12,885.2	12,877.1
Michoacán	1,437.3	2,277.6	2,265.5	5,471.3	7,410.7	7,931.8	9,214.3
Morelos	3,267.4	4,221.9	4,945.9	8,776.0	10,229.4	13,121.3	14,797.8
Nayarit	2,562.6	3,981.8	4,038.1	7,914.3	9,512.6	9,805.6	10,039.3
Nuevo León	6,645.5	8,416.1	14,735.5	17,370.9	21,060.5	23,683.7	28,101.1
Oaxaca	808.8	1,940.3	1,770.2	3,676.5	5,339.0	6,462.8	6,873.7
Puebla	1,584.3	2,847.7	2,904.1	6,467.2	8,681.9	8,811.8	10,624.7
Querétaro	4,424.2	2,232.2	2,854.5	8,249.3	11,522.3	14,779.9	19,086.7
Quintana Roo	7,897.7	10,337.3	3,479.4	10,223.2	15,878.0	21,227.4	24,340.4
San Luis Potosí	2,171.9	3,742.0	3,198.9	6,092.2	7,770.6	10,462.5	11,837.5
Sinaloa	3,693.3	5,083.9	7,335.4	9,763.8	10,134.9	11,904.4	13,120.9
Sonora	5,165.5	8,350.6	9,794.4	14,444.7	14,518.9	17,033.2	20,060.4
Tabasco	2,543.7	3,067.9	5,164.9	7,558.7	33,503.5	12,326.2	9,821.6
Tamaulipas	6,029.4	6,855.0	6,731.9	10,928.1	13,750.7	14,157.6	16,861.3
Tlaxcala	1,724.0	1,984.0	2,069.2	4,760.9	7,413.7	8,242.7	9,076.0
Veracruz	3,533.3	6,888.4	7,745.2	8,476.7	9,673.7	9,533.5	9,403.6
Yucatán	4,411.1	4,675.1	5,584.2	7,460.0	9,529.3	10,331.1	12,978.9
Zacatecas	1,718.8	2,962.1	2,679.4	5,367.2	6,312.6	8,574.2	9,171.2
National	3,919.8	5,348.8	7,136.5	10,379.4	13,373.9	14,148.8	16,123.0
Descriptive statistics							
Maximum	16,392.5	15,378.2	19,100.6	20,072.2	33,503.5	37,329.3	41,372.4
Minimum	808.8	1,940.3	1,770.2	3,676.5	5,339.0	6,462.8	6,873.7
Mean	4,200.5	5,040.3	5,719.3	9,214.3	12,349.8	13,996.9	15,650.4
Standard deviation	3,469.5	3,380.4	3,934.0	3,833.3	5,803.8	6,809.3	7,445.0
Skewness	2.2	1.6	1.8	1.0	1.9	1.8	1.4
Kurtosis	8.0	5.1	6.0	3.7	7.2	6.4	5.5

Source: Data from GERMAN-SOTO, 2005.

Table 2. Unit root tests with one and two structural breaks
(States for which the null hypothesis of unit root was rejected)

	Model	$T_{b,1}$*	$T_{b,2}$*	μ	β	θ_1	γ_1	θ_2	γ_2	d_1	t_α^*	k
Aguascalientes	CC	1951	1960	0.263	-0.047	0.148	0.024	0.123	0.030		-7.421[a]	8
				(1.470)	(-2.826)	(5.489)	(1.489)	(6.257)	(6.402)			
Baja California	An	1950		0.049		-0.037				0.047	-5.110[b]	0
				(2.698)		(-2.745)				(2.045)		
Baja California Sur	CC	1951	1960	0.616	-0.057	0.149	0.041	0.203	0.016		-7.398[a]	7
				(3.877)	(-3.844)	(4.402)	(2.649)	(6.918)	(3.702)			
Campeche	AAn	1980	1995	-0.065		0.435		-0.160			-8.627[a]	6
				(-4.640)		(8.790)		(-4.228)				
Coahuila	AA	1957	1994	0.235	-0.001	-0.046		0.108			-6.326[b]	7
				(5.185)	(-2.404)	(-3.030)		(5.777)				
Colima	AA	1953	1964	-0.109	0.002	-0.123		0.147			-6.267[b]	7
				(-4.931)	(2.111)	(-4.123)		(4.207)				
Chiapas	C	1975		-0.245	0.002	0.110	-0.009				-7.236[a]	3
				(-7.091)	(4.612)	(5.669)	(-6.511)					
Distrito Federal	AA	1985	1995	0.177	-0.002	0.048		0.038			-7.991[a]	3
				(7.608)	(-7.220)	(7.696)		(5.024)				
Guanajuato	A	1960		-0.092	0.000	0.035					-5.606[b]	3
				(-5.354)	(1.317)	(4.927)						
Jalisco	AAn	1950	1960	-0.041		-0.021		0.064			-6.934[a]	4
				(-4.580)		(-2.786)		(6.769)				
Michoacán	AAn	1950	1960	-0.105		-0.045		0.075			-7.174[a]	5
				(-6.083)		(-4.625)		(7.790)				
Morelos	AA	1953	1976	-0.140	0.003	-0.056		-0.029			-6.057[b]	5
				(-5.922)	(5.249)	(-4.320)		(-2.514)				
Nayarit	AAn	1968	1994	-0.191		0.037		-0.065			-5.582[b]	5
				(-5.491)		(3.605)		(-3.930)				
Nuevo León	AAn	1950	1960	0.047		0.029		-0.023			-5.959[a]	5
				(5.075)		(6.133)		(-6.789)				
Oaxaca	AAn	1950	1960	-0.038		-0.067		0.056			-5.153[c]	1
				(-2.320)		(-6.715)		(7.640)				
Puebla	AAn	1952	1963	-0.159		-0.050		0.099			-5.699[b]	0
				(-4.855)		(-3.928)		(5.780)				
Querétaro	AAn	1960	1980	-0.090		0.080		0.025			-6.419[a]	1
				(-6.580)		(6.093)		(2.818)				
Quintana Roo	CC	1950	1953	0.851	-0.062	-0.492	0.310	-0.542	-0.242		-7.272[b]	6
				(2.734)	(-1.909)	(-3.876)	(5.036)	(-6.832)	(-4.580)			
San Luis Potosí	AA	1950	1963	-0.164	0.003	-0.059		-0.051			-6.780[b]	5
				(-5.905)	(6.017)	(-4.641)		(-3.357)				
Sonora	AA	1972	1994	0.239	-0.002	-0.043		0.049			-5.955[c]	7
				(5.620)	(-4.168)	(-3.706)		(4.403)				
Tabasco	C	1975		-0.105	0.003	0.152	-0.013				-6.192[b]	2
				(-5.124)	(3.807)	(4.627)	(-5.508)					
Tamaulipas	CC	1958	1983	0.388	-0.018	-0.024	0.018	-0.027	0.003		-6.697[c]	8
				(6.436)	(-6.625)	(-2.627)	(6.535)	(-4.083)	(4.849)			
Veracruz	CC	1956	1993	-0.006	0.001	0.048	-0.006	0.077	-0.009		-6.682[c]	7
				(-0.260)	(0.469)	(4.654)	(-2.537)	(6.594)	(-4.853)			
Zacatecas	CC	1968	1994	-0.605	-0.006	0.033	0.014	0.114	-0.030		-7.926[a]	7
				(-8.027)	(-4.981)	(2.351)	(6.462)	(4.512)	(-5.190)			

$T_{b,1}$* and $T_{b,2}$* denote the estimated break points, *t*-values in parentheses. Supscripts a, b and c stand for rejection of the null hypothesis of unit root at the 1, 5 and 10% level of significance, respectively.

Table 3. Cointegration tests with regime shifts models
(States for which the null hypothesis of non-cointegration was rejected)

State	Model	ADF (T_b*)	Z_t (T_b*)
Baja California	S	-4.77[b] (1964)	-5.01[b] (1964)
Campeche	S	-4.79[c] (1981)	-4.88[c] (1982)
Colima	S	-5.11[b] (1963)	-5.01[b] (1963)
Chiapas	T	-4.90[c] (1977)	-5.26[b] (1978)
Chihuahua	T	-5.33[b] (1983)	-5.38[b] (1983)
Distrito Federal	T	-5.22[b] (1993)	
Guerrero	S	-4.93[c] (1983)	
Hidalgo	L		-4.43[c] (1953)
Nayarit	T	-5.35[b] (1969)	
Oaxaca	L	-4.52[c] (1974)	
Puebla	S		-4.69[c] (1965)
Querétaro	S	-5.23[b] (1955)	
Quintana Roo	L	-5.19[a] (1955)	-5.27[a] (1955)
Sinaloa	S	-4.96[b] (1969)	
Sonora	T	-5.46[a] (1976)	-5.49[a] (1976)
Tabasco	T	-4.87[c] (1977)	-5.06[b] (1978)
Veracruz	T		-4.97[c] (1949)
Zacatecas	L	-4.63[b] (1977)	

Note: *ADF** and Z_t* denote the Gregory-Hansen cointegration statistics. Estimated break point in parentheses. Supscripts a, b and c stand for rejection of the null hypothesis of non-cointegration at the 1, 5 and 10% level of significance, respectively.

Notes

[1] AZZONI, 2001; CÁRDENAS and PONTÓN, 1995; and PERSSON, 1997; for Brazil, Colombia and Sweden, respectively.

[2] See, for instance, JUAN-RAMON and RIVERA-BATIZ, 1996; ESQUIVEL, 1999; MESSMACHER, 2000, and CERMEÑO, 2001.

[3] Some reforms that suppose structural changes are the admission of Mexico to the General Agreement of Tariffs and Trade (GATT) in 1986, the North American Free Trade Agreement (NAFTA) started operating in 1994; moreover economic crises in 1976, 1982 and 1994-95 could have affect the trajectory of the product series.

[4]The specification for non-trending variables is denoted as Model An, while the three specifications for trending variables are known as Models A, B and C, depending on whether the break affects the level, the slope or both, respectively.

[5]The specification for non-trending variables that allows for two level shifts is denoted as Model AAn, while for trending variables the Models AA, AC-CA and CC, account for two structural breaks that only affect the level (Model AA), two level shifts but just one slope shift (Model AC-CA), and two shifts both the level and the slope (Model CC).

[6] In Figure 3 the exceptions are Campeche, Tabasco and Quintana Roo. A very large, although very volatile share of these states' income is generated from oil extraction activities, while tourism sector strongly affect Quintana Roo's GDP. Thus, their per capita income figures are not representative of their welfare levels.