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Economic Liberalization and External Shocks. The Hypothesis of Convergence for the Mexican States, 1994-2015

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Abstract: We study the convergence hypothesis for Mexican states during the period 1994-2015 considering the impact not only of NAFTA but also of other external shocks, such as China's entry into the World Trade Organization (WTO) in 2001 and the global financial crisis of 2008. Using econometric panel data models, with no fixed effects to avoid small sample bias, and following the methodology developed by Barro (2012), the main results indicate: i) presence of absolute divergence, consistent with a sigma divergence process, particularly in the period after the outbreak of the global crisis of 2008; and ii) a process weakening in conditional convergence across the sub-periods analyzed.
Keywords: Regional Economic Growth, Convergence, Panel Data.
JEL Classification: R11, C23

Resumen: Se analiza la hipótesis de convergencia para las entidades federativas en México durante el periodo 1994-2015 considerando el impacto no solo del TLCAN sino también de otros efectos externos, como la entrada de China a la Organización Mundial del Comercio (OMC) en 2001 y la crisis financiera global de 2008. Empleando modelos econométricos de datos panel, sin el uso de efectos fijos para evitar el sesgo por tamaño de muestra pequeña, y siguiendo la metodología desarrollada por Barro (2012), los principales resultados indican: i) presencia de divergencia absoluta, consistente con el proceso de sigma divergencia, particularmente para el periodo posterior al inicio de la crisis global de 2008; y ii) un debilitamiento en el proceso de convergencia condicional a través de los sub-periodos analizados.
Palabras Clave: Crecimiento Económico Regional, Convergencia, Datos Panel

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1. Introduction

Mexico's trade liberalization process, which began in the middle 1980s and strengthened after the signing of the North American Free Trade Agreement (NAFTA) led to significant changes in the growth patterns of the Mexican economy. In particular, the degree of integration across regions with the global value chains has been far from homogeneous, which has been reflected in changes in the levels of industrial location and regional specialization and, consequently, in the economic performance of the different regions of the country. In fact, the greater opportunities offered by international trade seems to have been absorbed, to a greater extent, by the States located at the northern border (see Hanson 1998 and Chiquiar 2005, for example), as well as some in the central regions.

This paper analyzes the convergence of GDP per capita between the Mexican States during the period 1994 - 2015, considering the impact not only of NAFTA but also of other external shocks, such as China's entry into the World Trade Organization (WTO) in 2001 and the outbreak of the global financial crisis of 2008.

By applying panel data models without fixed effects to avoid small sample bias, and following Barro (2012), the main results indicate: i) presence of absolute divergence, consistent with a sigma divergence process, particularly in the period after the outbreak of the global crisis of 2008; and ii) a process of weakening conditional convergence across the sub-periods analyzed. Moreover, traditional determinants of economic growth, such as human capital, infrastructure, crime and FDI have the expected effects; however, we find evidence of a club convergence of Bajio States[1] since this region shows a rate of economic growth above the national average. Furthermore, this weakening in the rate of convergence (even when specific characteristics of the states are taken into account, i.e., conditional convergence) warns about the widening of the income gaps between regions, particularly between the north and the south, since the latter continue to show low absorption capacities (Borensztein et. al., 1998) to successfully insert themselves into the global value chains that have allowed the states of the center and the north increase their income levels.

[1] States located in central region of Mexico: Aguascalientes, Guanajuato, Querétaro, and San Luis Potosí.

At the international level, there is a wide literature that has analyzed the convergence across the Mexican states. According to the available empirical evidence, two are the main findings in the literature: (i) for the period before the commercial opening, which in some cases had been identified in 1985 with the signing of the GATT or in 1994 with the entry of Mexico into NAFTA, there was a process of convergence, in other words, states with lower income levels grew at a higher rate than the richer states; (ii) on the other hand, the aforementioned evidence also indicates that after trade liberalization, the convergence process was reversed, thus widening the income gap between regions. As we shall see later, it is worth mentioning that, in general terms, these characteristics are present regardless of the type of econometric methodology employed (cross section, time series or panel data).

In relation to point (i), Esquivel (1999) found that during the period 1940-1960 there was a relatively rapid process of convergence, which was stalled or even reversed in the period 1960-1995. Using more recent data, Sánchez-Reaza and Rodríguez-Pose (2002), Chiquiar (2005) and Rodríguez-Oreggia (2005) agree that during the period 1970-1985 a process of convergence was observed, both absolute and conditional, which was supported, among other factors, by the favorable performance of the southern oil states, the federal public investment, and state public spending. Indeed, this process of convergence was present at the industrial level in the period prior to the economic liberalization (Mallick and Carayannis, 1994).

As regards point (ii), the evidence of Sánchez-Reaza and Rodríguez-Pose (2002) and Chiquiar (2005) indicates that for the period after 1985 the process of convergence, both absolute and conditional, broke down since the states with higher levels of physical and human capital, located mainly in the north and center of the country, were able to take advantage of the trade openness and international trade. Moreover, Rodríguez-Oreggia (2005) found absolute divergence for the period posterior to 1985, although conditional convergence for the same time span. According with some authors, this process of divergence could be explained at a spatial level, implied by the sustained underperformance of the southern states (mainly concentrated in primary activities) and to a lesser extent for the superior performance of an emerging convergence club in the north-center of the country (Aroca, Maloney and Bosch, 2005). Furthermore, Aguayo (2006) finds that the rise in the education premium contributed to widening the income differences between the poor states located in the south and the richer states of the north

From a methodological point of view, it should be noted that the studies referred use econometric techniques for cross-sectional data with ordinary least squares. Subsequently, due to the contributions of Islam (1995) and Casselli, Esquivel and Lefort (1996) some studies have carried out estimates with panel data. Cermeño (2001) in his analysis for the 1970-1995 period using dynamic panel models without exogenous regressors finds favorable evidence for the conditional convergence hypothesis. In another study using panel data by means of Bayesian methods, Calderón and Tykhonenko (2007) find absolute and conditional convergence for the period 1994-2002. In another study considering a broader period, Carrion-i-Silvestre and Germán-Soto (2009) used panel methods to analyze stochastic convergence and beta-convergence after 1940, finding favorable evidence for both hypotheses, although at a different intensity (slower) from the period after trade reform in the mid-eighties.[2] In another study, González-Rivas (2007) finds that trade openness increased income inequality in the Mexican regions in his analysis for 1940-2000 period using panel data models with fixed effects. However, since the author does not include the log of the income in the initial period as a control variable, the convergence issue was not analyzed.

Sakikawa (2012) analyzed the convergence between Mexican states for the period 1970-2005 using static panels with fixed effects, finding conditional convergence even for the period after the trade liberalization, albeit at a lower rate than the period prior to 1985. Cabral and Varella-Mollick (2012), focus on the period after the commercial opening exclusively (1996-2006) and finds evidence of absolute and conditional convergence using the well-known dynamic panel methodology proposed by Arellano and Bond (1991). It is worth to mention that these two last studies have in common the fact that their estimated convergence rates found are well above the so-called "iron law" of convergence (2%), obtaining values even higher than 10% for both absolute and conditional convergence; this imply going from 35 year of half-life[3] to only 7, something far from reality. Indeed, several studies that used panel fixed-effects in order to measure convergence rates fall into the Barro-Hurwicz-Nickel[4] bias.

[2] With a similar data base, Gómez and Ventosa-Santaulariá (2009) obtain similar finding with a time series analysis to test deterministic and stochastic convergence for the period 1940-2006.

[3] The number of years required in order to cut in half the differences between regions.

[4] Following Hurwicz (1950), Nickel (1981) and Barro (2014). More on this in section 3.

To avoid this, we follow Barro (2014) and Cermeño (2001) suggestions and calculate a rate of convergence more in line with the “iron law”.

More recently, Baylis, Garduño and Piras (2012), Garduño (2014) and Díaz, Fernández, Garduño and Rubiera (2017) analyzed convergence using Mexican municipalities as a unit of analysis rather than states. With this level of disaggregation, these studies have found conditional convergence for the period 1980-2009. Moreover, when they split the sample (before and after trade openness) the rate of conditional convergence slows down. In addition, and similar to Chiquiar (2005), the previous studies have found that NAFTA favored the municipalities with the closest proximity to the United States, thus widening the income gap across regions. Indeed, theoretical models such as that of Krugman and Livas (1996) point out that the commercial reform reversed the process of industrial concentration around Mexico City, which was replaced by the United States as the relevant market for the manufacturing industry (Chiquiar, 2005). It should be mentioned that this pattern of relocation of manufacturing production has, as one of its side effects, the increase in the correlation of business cycles (particularly in the manufacturing sector) between Mexico and the United States (Torres and Vela 2003, Chiquiar and Ramos-Francia, 2005, Mejía and Campos 2011).

On the other hand, China’s entry to the WTO in 2001 supposed a change of era in the patterns of the global trade, known like the China Shock (Autor, Dorn and Hanson, 2016). In the case of the Mexican economy, this meant greater competition from Chinese products against Mexican exports to the United States. In fact, the greater commercial integration due to NAFTA favored the income levels in the states bordering the United States, while the Chinese shock had the opposite effect (Chiquiar, Covarrubias and Salcedo, 2017). However, it is worth mentioning that this represented a weaker relationship between Mexico's and United States’ manufacturing sector, which turned out to be temporary since the Mexican economy reassigned resources to sectors where it remained competitive (Chiquiar and Ramos Francia 2008). Finally, the crisis of 2008-2009 represented a common shock to all Mexican States, although those located in the north and center of the country were more exposed due to their connection with the business cycle of the United States.

The document is organized as follows: besides from this introduction, section two shows a descriptive evolution of the regional per capita GDP across the period analyzed; section three contains econometric analysis and section four concludes.

2. Evolution of the Regional Growth in Mexico

Table 1 presents per capita GDP of the Mexican states at four different points in time, including the initial and the final year of analysis. The data shows that on average the highest levels of this indicator are at the northern states, followed by the states located in the central and central-north region. In contrast, the lowest levels of per capita GDP corresponds to the states situated in the southern region. Analyzing by state, it is possible to observe that Ciudad de Mexico has the highest level of this economic indicator, followed by Nuevo Leon, Queretaro and Coahuila. On the other hand, the states of Oaxaca, Guerrero and Tlaxcala presents the lowest levels of per capita GDP.

[Insert Table 1 here]

The last three columns in Table 1 contains the annual average growth rates of per capita GDP for the periods: i) 1994-2001 (the first years after the beginning of NAFTA); ii) 2002-2008, which corresponds to the period after the entrance of China to the World Trade Organization (WTC); and iii) 2008-2015, the time after the global financial crisis. The data shows heterogeneity in the economic performance across time, regions and within regions. For instance, the highest average growth rates were registered between 2002 and 2008 while the lowest growth in GDP per capita was recorded in the period posterior to the global financial crisis. Analyzing by regions, the central part of the country showed the highest growth rates closely followed by the north, whereas the south registered the lowest progress in per capita GDP. Examining by state, the heterogeneity is even higher: on one side there are states that recorded average annual growth rates above 2 percent during the whole period of analysis such as Zacatecas, Aguascalientes, Queretaro and Guanajuato; on the other side, there are states like Quintana Roo, Baja California, Guerrero and Oaxaca with very poor growth rates.

Following Chiquiar (2005) the states of Campeche and Tabasco were excluded from the analysis, in this and the next section, since great part of their GDP is generated by the oil industry and hardly will measure the standard of living of their population. In addition, the

GDP of these states is very volatile because of the changes in the price of the commodity and the fall in the production of oil registered during the last years.

The Figure 1 show the relationship between economic growth and the initial level of per capita GDP for the whole period of time and the tree sub-periods of interest. These type of graphs are usually used as a visual tool to identify possible patters of convergence or divergence across states (Sala-i-Martin, 2000). The graph located in the top left suggest the existence of a possible process of divergence across states in Mexico for the entire period of analysis. The visual tool also suggests that this process appear to be driven by the states located in the north and some of the states situated in the central part that registered both high levels of initial per capita GDP and elevated growth rates.

[Insert Figure 1 here]

The graph in the top right shows no evidence of neither convergence nor divergence. However, the two graphs situated at the bottom indicates some possible patterns of divergence for the two sub-periods posterior to 2001. The divergence seems to be induced by some states located in the north and the central north for the period 2001-2008, while the process appears to be driven by some states situated in the regions north, central and central north for the last period.

In Figure 2, we present the effect of adding controls on the "absolute convergence" with partial-regression plots. Panel A shows the relationship between annual growth rate and the log of initial GDP per capita for all available years (1994 to 2015). Panel B shows the effect of adding control variables (conditional convergence) leading to a more concise relationship between the variables.

[Insert Figure 2 here]

In order to see in more detail the regional characteristics of GDP per capita among states, we show at Figure 3 and 4 the relative per capita GDP by state in 1994 and 2015 respectively with respect to national per capita GDP level, so values above one (in blue) shows a GDP level greater than national average, and values below one (in red) shows states with GDP levels that are smaller than national average.

[Insert Figure 3 and 4 – map relative GDP 1994 and 2015]

In 1994 there was a high dispersion (measured by the standard deviation) in relative GDP among states, which diminished by 2015 (2.01 vs 0.95, respectively). In order to analyze the change in the ranking of the Mexican states, we calculated the growth rate of the relative GDP between 1994 and 2015. According to these estimations a total of 17 states, such as Zacatecas, Querétaro, Aguascalientes and Guanajuato, improve their relative per capita GDP position against the national average, scoring an accumulated growth of 32.6, 31.7, 31.5 and 27.4 per cent, respectively, between 1994 and 2015.

[Insert Figure 5 – map of growth of relative GDP 1994-2015]

Is worth to mention that these (except Zacatecas) states have in common the fact of having a high level of transport equipment manufacturing (Mosqueda and Gómez, 2016). In contrast, the rest of the states got diminished of their relative per capita GDP, with Campeche, Chiapas, Baja California and Quintana Roo among those with a higher reduction.

Given the heterogeneity of states' growth rates and according to the concept of convergence, where the gap between low and high per capita GDP reduces over time, we report the states that contributed to the reduction of this gap, and those who contributed to increase the existing gap (divergence). Among the first group, we define that a state shows "positive convergence" when it started with a per capita GDP below average and its growth rate exceeds the national growth rate (catching up); "negative convergence" means when a state that started with a per capita GDP above average and grows below the national rate (in this case, the state "contributes" to reduce the gap, but in a negative fashion). The states which contributes to divergence are those with per capita GDP above national average, and a growth rate also above average, thus increasing the gap, showing "positive divergence"; and "negative divergence" means a state with a per capita GDP below average and a growth rate lower than the national average, increasing the gap.

The states that contributed to convergence are depicted in blue in Figure 6, and those who contributed to divergence are in red. A total of 12 states contributed "positively" to convergence, 5 did so in a "negative" fashion. In contrast, 5 states above average increased the gap, with growth rates above average, as Nuevo León, Sonora, Coahuila and Ciudad de México, whereas 8 states (mainly at the south) lag further behind, increasing the gap.

[Insert figure 6]

3. Econometric Analysis

Absolute convergence

Given the law of diminishing returns and the assumption of same technology across regions[5], countries with low physical capital per worker will experience a faster growth than rich regions, with high physical capital. This grow differential will reduce the per capita income gaps between regions. In the cross-section/panel approach, there have been two ways to test this gap reduction, σ and β convergence.

σ-convergence

A way to test the reduction of income gaps between regions has been initially addressed by measure the cross-sectional dispersion of per capita incomes. According to Barro and Sala-i-Martin (1992) and Sala-i-Martin (1996), σ-convergence measure the degree on which regions are converging through the variance of the log of per capita income. A reduction in the variance of the income implies convergence in the levels of per capita income across regions.

For the Mexican case, between 1994 and 2015, the variance of the log of per capita income has increased over time (suggesting that the regions are diverging), only with small periods of reduction that coincides with recessions: Tequila Crisis, 1995; Asian Financial Crisis 1998, China entry to OMC / Early 2000s Recession 2001-2003; and the global financial crisis of 2009-2010 (see figure 6).

[Insert Figure 6 here]

<u>β-convergence</u>

In order to test the convergence of per capita income between regions, the literature follow the next equation,

$$\frac{1}{T}(\ln(y_{it}) - \ln(y_{it-1})) = \alpha + \beta \ln(y_{it-1}) + \varepsilon_{it} \qquad (1)$$

Where $\frac{1}{T}(\ln(y_{it}) - \ln(y_{it-1}))$ is the annual growth rate of per capita income, $\ln(y_{it-1})$ measures the initial income per capita for region i and β measures the partial correlation

[5] Based on the Solow (1956) model.

between growth in income over time and its initial level. Here, the literature convention says that negative beta supports the hypothesis of convergence, given that low growth levels are associated with a higher initial level of income.

In order to test the speed of convergence, we need to test the following equation[6]

$$\frac{1}{T}(\ln(y_{it}) - \ln(y_{it-1})) = \alpha - \frac{1-e^{-\lambda T}}{T}\ln(y_{it-1}) + \varepsilon_{it} \quad (2)$$

Where λ is the speed of convergence, and it is common in the literature to find the "iron law of 2%" of this parameter.

The relationship between sigma and beta-convergence, as shown by Young, et al. (2008), is that beta convergence is a necessary but not sufficient condition for sigma-convergence, in other words, it is possible to obtain beta convergence conclusion and sigma divergence.

Conditional convergence and panel

The previous models suggest that each region share the same production function, saving rates and technological progress, allowing the regions only to differ in the initial level of capital (Sala-i-Martin, 1995). However, if we suspect that a low capital region has different access to technology or a different production function, they can reach a different level of per capita income in their steady state, failing to converge to a high capital region. In the literature, Sala-i-Martin, 1995 argues that "if different economies have different parameters, then they will have different steady states" and as a consequence, different patterns of growth are associated with specific characteristics of that region; this is known in the literature as conditional convergence.

In order to test the hypothesis of conditional convergence, we have to include a set of variables that may govern the steady state of each region, as it is shown in the following equation:

$$\frac{1}{T}(\ln(y_{it}) - \ln(y_{it-1})) = \alpha + \beta\ln(y_{it-1}) + \gamma X_{it} + \delta_t + \varepsilon_{it} \quad (3)$$

[6] Following Sala-i-Martin (1995) equation 3.

Where X_{it} is a vector of characteristics such as human capital, crime, physical capital or foreign investment that may influence the growth of state *i* at time *t*. Also, we include time dummies variables in order to capture national shocks that affect all the regions in the panel.

The issue of fixed effects in convergence panels analysis.

During the 1990s it was very popular to study convergence by using microeconometric panel data models such as fixed effects or first differences. Indeed, Caselli, et al. (1996) and Islam (1995) raises the concern of an inconsistency in studies with “incorrect treatment of country-specific effects representing differences in technology”, in other words, failing to capture an omitted variable (like technology, according to Caselli and Islam) may bias the coefficients estimates, including the convergence rate; so, it is logical to approximate this issue with panel fixed effects or least squares with dummy variable (as is the case in Islam, 1995). However more recently, Barro (2012) criticizes these studies that employ country/region fixed effects in panel data in order to capture unobserved characteristics that may explain a persistent growth scheme. According to Barro (2012), the source of the error is in the Hurwicz (1950) type bias, basically, regarding the dynamic property of the growth equation. Moreover, this kind of bias cannot be avoided increasing the time frequency of the data, only with increments of the total period. Barro shows (using Nickel (1981) formula) that the size of the bias can be as large as 0.056 if one assumes a true convergence rate of 0.02 per year if T=50[7].

In our case, T=21 and our data frequency are yearly, so the size of the bias according to Barro-Hurwicz-Nickel must be high. Indeed, according to preliminary regression, the regression results using panel data fixed effects increases the size (bias) of the convergence rate.

[Insert Table 3 here]

Indeed, table 3 shows the rate of convergence for several studies across Mexican states. Studies with fixed effects shows a higher rate of convergence, as Barro-Hurwicz-Nickel bias suggested. Indeed, Shioji (1997) started the discussion saying that data must be large enough in order to capture the 2 per cent “iron law”, later Cermeño (2001) mentioned that there will

[7] As Arbeu et al. (2005) suggest: “…the use of the fixed effects estimator also leads to higher estimates of the rate of convergence, by 4.4 percentage points, whereas the use of the random effects estimator does not have a significant effect.” (p. 27).

be bias in within (fixed effects) when the temporal dimension T is small, and proposed the use of pooled regression, obtaining convergence rates close to two per cent (2.4%-3.6%). Also, Calderón and Tykhonenko (2007) found convergence rates around 2 per cent using Bayesian Methods.

4. Results

The results obtained for absolute convergence tests according to equation (3), without considering the vector of control variables (X_{it}) but including the fixed temporal effects, are presented in Table 4. This estimate is known as absolute convergence since it does not take into account specific states' characteristics that can influence economic growth. Also, the fixed effects are excluded by states because their inclusion could generate considerable bias in the convergence rates (Barro, 2012), according to what was indicated in the previous section.

[Insert Table 4 here]

Regressions were estimated using the panel generalized least squares (GLS) method, correcting for the presence of contemporaneous correlation between states. The following table shows the results of equation (1), which are presented for the full period and for the sub-periods after NAFTA (1994-2001), China's entry into the WTO (2002-2008) and to the period after the global financial crisis (2009 - 2015). According to the analysis of the previous section, the results indicate that the gap between the levels of income across the states was extended to a rate of 0.44 percent per year for the whole period, thus showing a pattern of absolute divergence. Also, when considering the different sub-periods, it can be seen that this rate of divergence increased over time, although for the first two periods the respective coefficient is not statistically significant. In the case of the period after the beginning of the global financial crisis, the coefficient becomes statistically significant.

It is worth to mention that former results should be viewed with caution, since it is possible that regional differences in variables such as economic structure, human capital endowment, level and quality of infrastructure and degree of institutional development, may influence economic growth and patterns of convergence and/or divergence. Therefore, the next section seeks to incorporate these elements using a conditional convergence approach.

Conditional convergence

In this section, we include control variables (X_{it}) as in equation (3) to capture the heterogeneity of the states (conditional convergence). The following are the variables considered as controls, usually used in this type of studies:

- Average years of schooling among the population of 15 years or older as a measurement of human capital.
- Crime, measured as intentional homicides per 10,000 inhabitants.
- Infrastructure, measured by the length of the road network expressed in hundreds of squared kilometers.
- Foreign direct investment (FDI) as a percentage of state GDP.

Moreover, except for crime, we expect a positive direct impact on the rest of variables on growth, the dependent variable. Regarding the source of the variables, INEGI is the source of most of them[8]. Only FDI figures were obtained from the Mexican Ministry of Economy (*Secretaría de Economía*).

As in the case of absolute convergence, estimates were made for both the full period and the three sub-periods referred above. These results indicate that once controlled by the different socioeconomic characteristics of the States, they converge to their steady state at an annual rate of 1.24 percent (Table 7). Furthermore, it is important to mention that when fixed effects are included are included in the estimations, the aforementioned bias is important, since the convergence rates are around 10%, which implies a half-life indicator of around 6.5 years (!).

[Insert Table 7 here]

The control variables have the expected sign and are statistically significant. As expected, estimates show that states with greater human and physical capital, and with a lower level of crime, have a higher rate of per capita GDP growth (Barro and Sala-i-Martin, 2003). Moreover, FDI has a positive impact on the economic growth rates of the states, since it

[8] INEGI, Instituto Nacional de Estadística y Geografía, the Mexican official statistics agency, in its publication “Statistical and Geographical Yearbook by State”, Anuario Estadístico y Geográfico por Entidad Federativa. Table 5 contains descriptive statistics for this variables for the whole period and the three sub periods considered. Likewise, table 6 show the variation of control variables for selected years.

stimulates labor productivity and is linked to technological innovation (see Borenztein, De Gregorio and Lee, 1998). On the other hand, the control variable for the Bajío area[9] indicates that these entities grow more than the national average.

Finally, it is possible to observe that taking into account the sub-periods analyzed, conditional convergence is decreasing over time, with no statistical significance in the post-financial crisis period (2009-2015), in line with the results of the absolute convergence (divergence) obtained in Table 4. The previous results (absolute and increasing divergence as well as the fading of conditional convergence) imply, in the best of cases, a half-life of almost 56 years to halve the disparities in income levels between regions. Therefore, it is necessary to warn about the persistent weakening of the conditional convergence process. Thus, as Rodríguez-Pose (2018) has pointed out, we need not only more policies but also *better* policies to maximize the growth potential of the backward areas (located mainly in the south of the country).

5. Conclusions

The results obtained point to the existence of conditional convergence in the per capita GDP between the states of Mexico for the period 1994 - 2015. By decomposing the coefficient of convergence into sub-periods, it can be inferred that this process has been losing strength, mainly in the period after the global financial crisis. Indeed, during this period the process of conditional convergence was interrupted.

By comparing the initial levels of per capita GDP and its growth rate we were able to identify that 12 states contributed "positively" to convergence, 5 did so in a "negative" fashion. In contrast, 5 states above average increased the gap, with growth rates above average, as Nuevo León, Sonora, Coahuila and Ciudad de México, whereas 8 states (Sinaloa. Nayarit, Hidalgo, Estado de México, Guerrero, Oaxaca and Chiapas) lag further behind, increasing the gap. Most of the states that registered rates of growth above the average are generally more integrated to the global value chains compared with those left behind, fact that it is also reflected in their FDI flows, in the strengthening of its exporting vocation, and in productivity

[9] Given the analysis of the data shown in section 2, and the previous work of Mosqueda and Gómez (2016), we include a dummy variable that covers the states of Aguascalientes, Zacatecas, San Luis Potosí, Guanajuato and Querétaro. Those states show a high level of specialization in transportation equipment.

gains. Therefore, regional development policy of the states with lower levels of per capita GDP (mainly located in the south of Mexico) must incentive the integration of these economies to the global value chains (GVC). A successful example can be found in the states that have been able to develop the transport equipment manufacturing sector, which is very integrated to the GVC and the exports.

Even more, the direct evidence presented in our econometric analysis indicates that human capital, infrastructure, FDI, and lowering crime rates, among other factors, are fundamental to the economic growth of the states. Therefore, it is necessary to continue promoting public policies focused on encouraging the attractiveness of the regions as a destination for FDI. In addition, the formation of human capital, which directly affects labor productivity, and the formation and improvement of local infrastructure must be incentivized by policymakers in order to reach higher growth rates. Finally, the results indicates that when the government enable favorable conditions of security and the enforcement of law local economies are able to grow faster.

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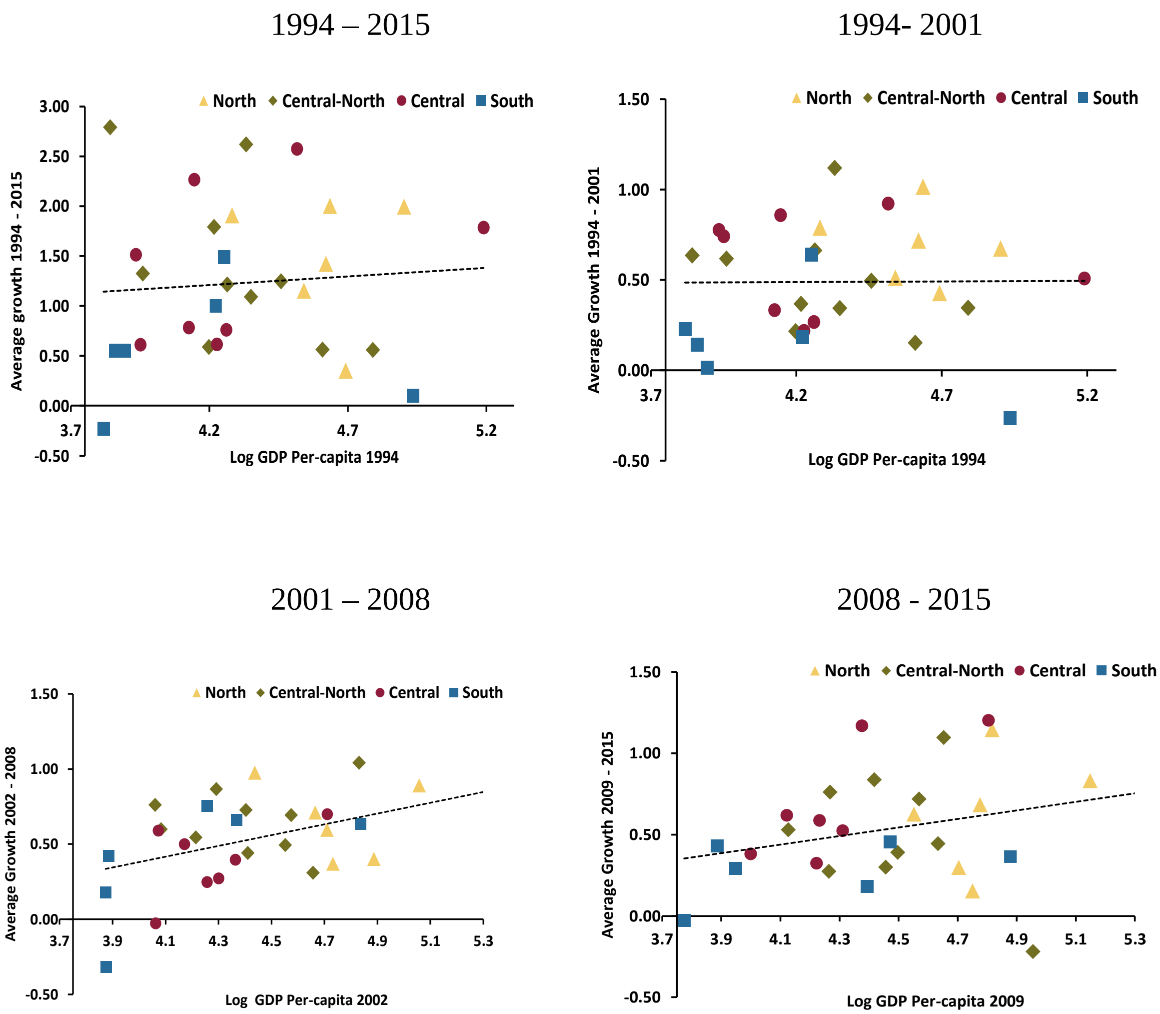
7. Tables and figures.

Table 1. Per-capita GDP by State
(Thousands of pesos and percentages)

	Per-capita GDP				Average growth rate		
	1994	2001	2008	2015	1994-2001	2001-2008	2008-2015
North	**102.4**	**118.3**	**134.9**	**140.6**	**2.08**	**1.89**	**0.60**
Baja California	109.1	119.3	122.7	117.5	1.29	0.40	-0.62
Coahuila	103.1	127.5	144.3	157.0	3.09	1.78	1.21
Chihuahua	72.4	85.4	103.8	108.1	2.40	2.83	0.57
Nuevo Leon	134.6	155.1	189.5	204.8	2.04	2.91	1.12
Sonora	101.5	118.1	125.7	136.8	2.18	0.91	1.22
Tamaulipas	93.8	104.4	123.2	119.4	1.55	2.39	-0.44
Central-North	**76.5**	**84.6**	**97.0**	**100.9**	**1.44**	**1.98**	**0.56**
Aguascalientes	76.1	96.3	112.2	131.9	3.42	2.22	2.34
Baja California Sur	120.3	129.4	155.9	135.4	1.04	2.70	-2.00
Colima	100.3	103.6	112.4	112.9	0.45	1.18	0.06
Durango	71.1	81.7	90.3	91.7	2.01	1.43	0.23
Jalisco	86.3	95.8	105.2	112.2	1.50	1.35	0.92
Michoacan	52.4	59.7	67.3	69.3	1.87	1.72	0.42
Nayarit	66.5	69.6	75.8	75.3	0.65	1.23	-0.10
San Luis Potosi	67.8	73.2	87.7	98.8	1.11	2.61	1.71
Sinaloa	77.4	83.2	95.2	97.4	1.04	1.94	0.32
Zacatecas	46.6	53.2	68.1	83.7	1.92	3.58	3.00
Central	**79.8**	**90.0**	**99.2**	**110.4**	**1.74**	**1.39**	**1.54**
Ciudad de Mexico	179.5	199.7	230.6	261.2	1.53	2.08	1.79
Guanajuato	63.1	75.6	85.3	101.7	2.61	1.74	2.53
Hidalgo	68.5	71.7	74.4	77.9	0.65	0.53	0.67
Mexico	61.9	66.4	72.0	72.9	1.00	1.17	0.19
Morelos	70.9	75.0	78.1	83.2	0.80	0.59	0.90
Puebla	51.1	60.2	66.5	70.2	2.35	1.43	0.79
Queretaro	91.5	111.0	128.8	157.1	2.80	2.14	2.88
Tlaxcala	52.0	60.7	57.8	59.1	2.25	-0.70	0.32
South	**46.8**	**49.5**	**53.6**	**55.3**	**0.82**	**1.14**	**0.46**
Chiapas	45.5	47.7	45.2	43.3	0.69	-0.78	-0.59
Guerrero	49.1	49.2	53.2	55.1	0.04	1.10	0.53
Oaxaca	47.5	48.9	50.0	53.3	0.43	0.31	0.92
Quintana Roo	139.0	131.5	144.1	141.9	-0.79	1.32	-0.22
Veracruz	68.2	70.9	82.7	84.1	0.55	2.23	0.25
Yucatan	70.3	80.4	90.6	96.1	1.94	1.72	0.85
Bajio	**74.6**	**89.0**	**103.5**	**122.4**	**2.55**	**2.18**	**2.42**

Souce: Own calculations with data from INEGI. Campeche and Tabasco are excluded from the analysis.

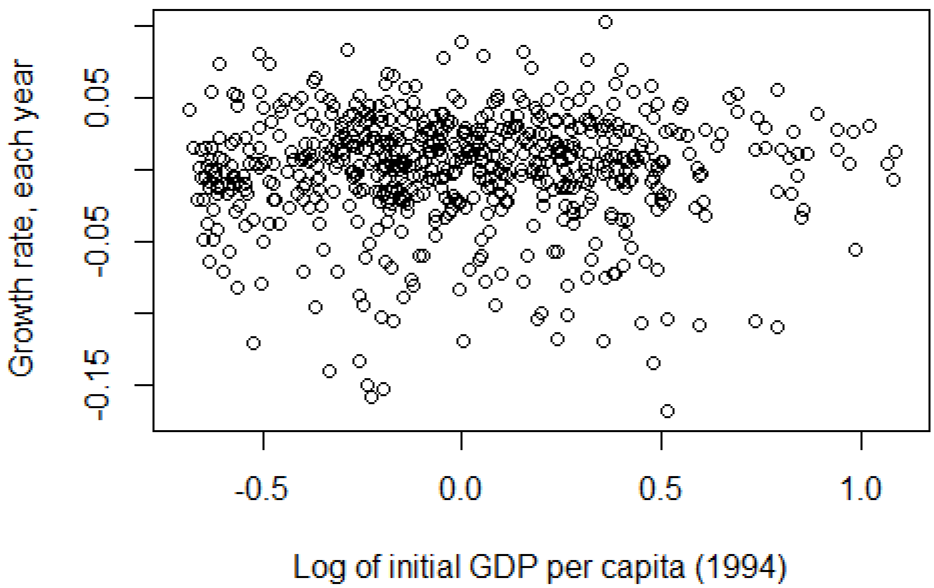
Figure 1



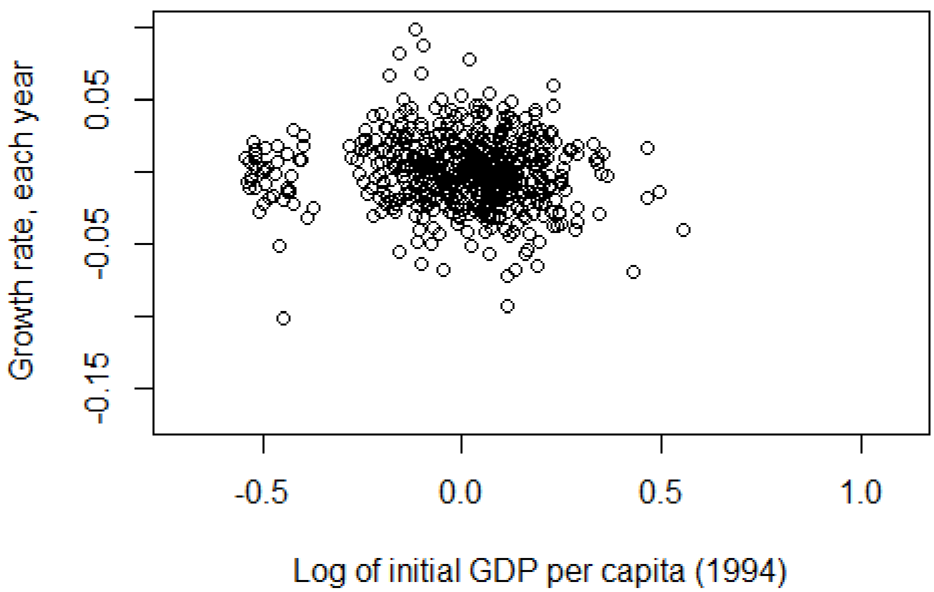
Source: Own calculations with data from INEGI and CONAPO

Figure 2

A. Unconditional, all years (demeaning variables).



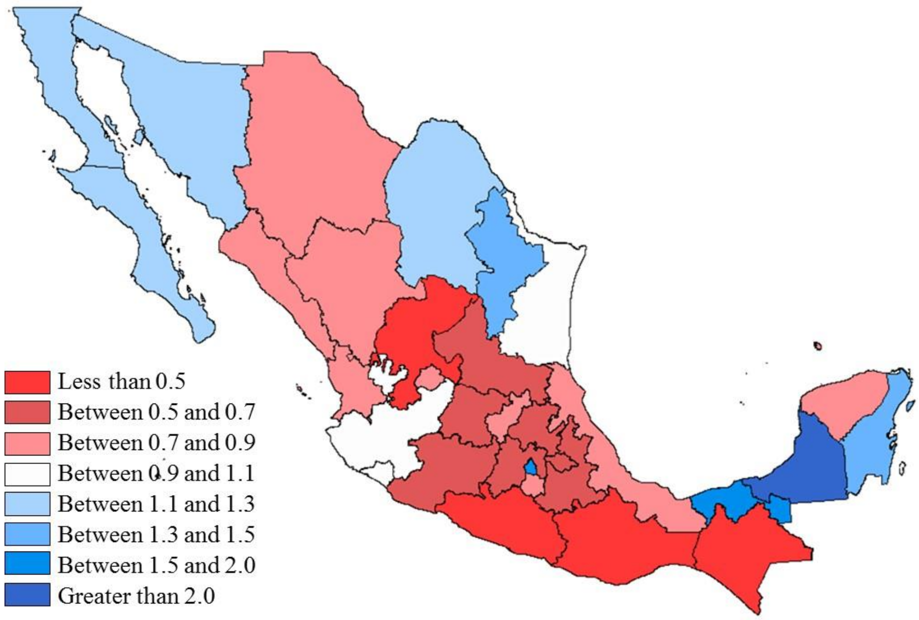
B. Conditional to X_{it} variables, all years (demeaning variables).



Source: Own calculations with data from INEGI and CONAPO.
Note: X_{it} is a vector of characteristics such as human capital, crime, physical capital and foreign investment that may influence the growth of state i at time t.

Figure 3: Relative per capita GDP, 1994

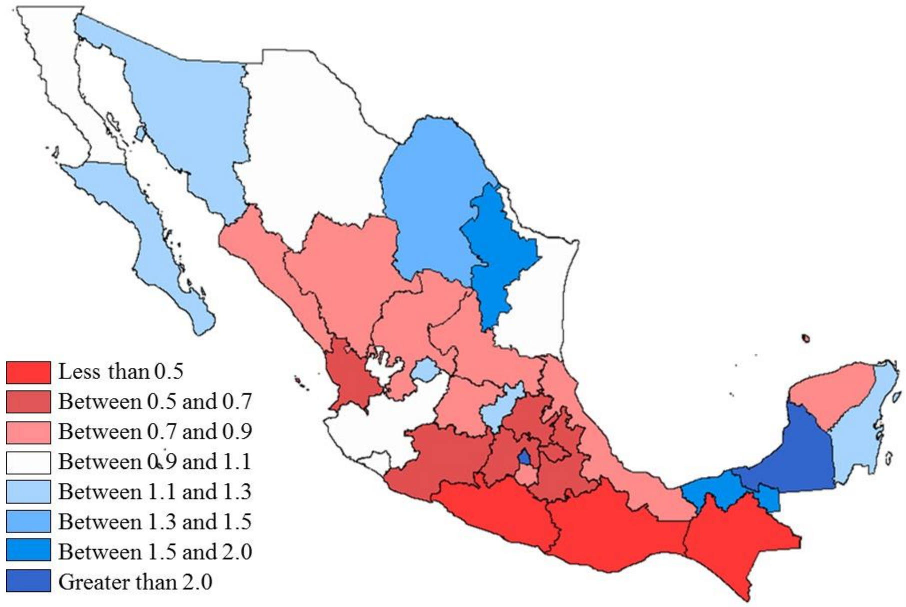
National per capita average = 1



Source: Own calculations with data from INEGI and CONAPO

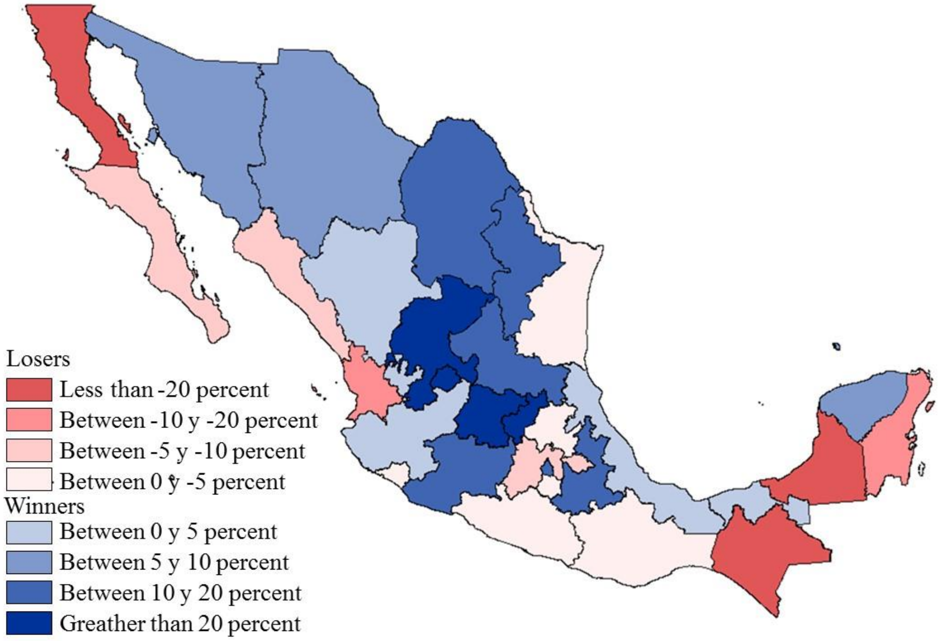
Figure 4: Relative per capita GDP, 2015

National per capita average = 1



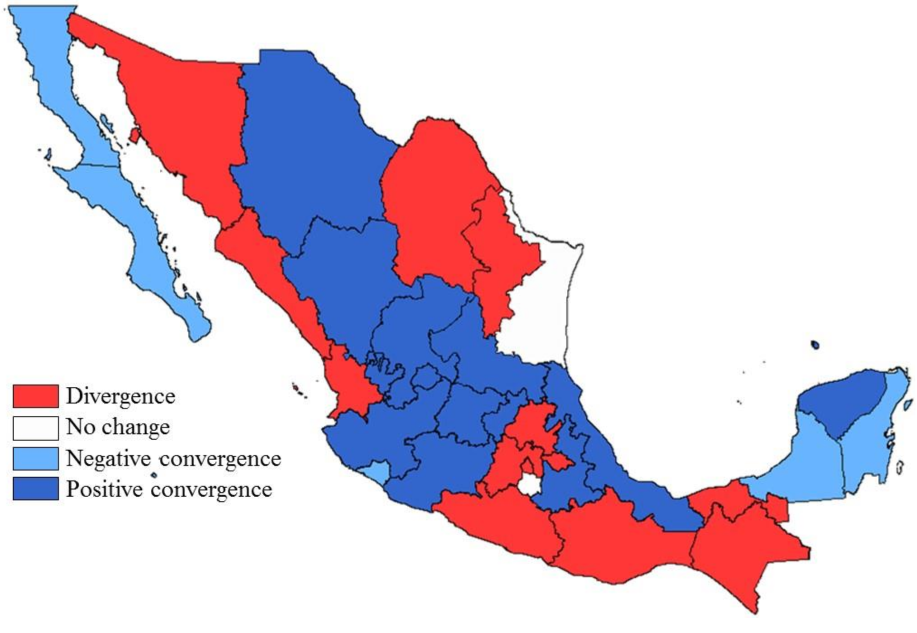
Source: Own calculations with data from INEGI and CONAPO

Figure 5: Relative per capita GDP, 1994-2015
Change in percentage points.



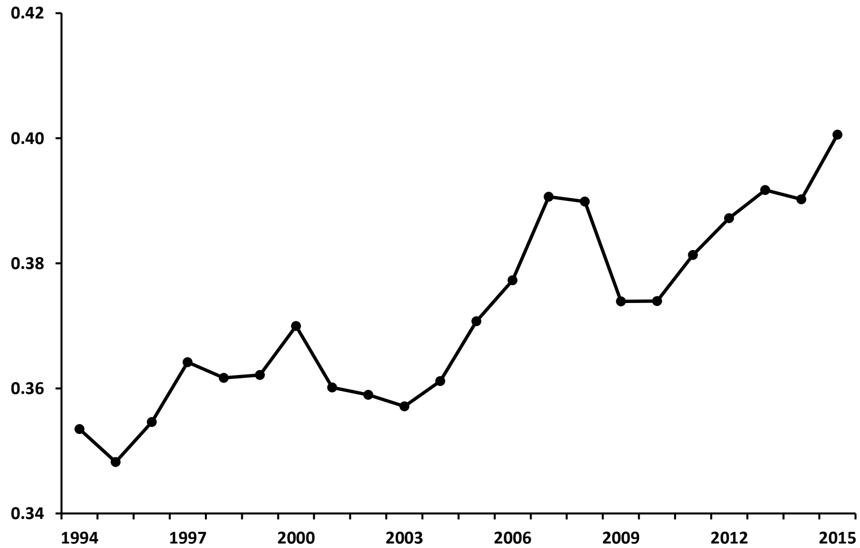
Source: Own calculations with data from INEGI and CONAPO

Figure 6: Mexican states' contribution to convergence
1994-2015



Source: Own calculations with data from INEGI and CONAPO

Figure 7. Sigma Divergence



Source: Own calculations with data from INEGI.

Table 2. Relative Per Capita GDP, Descriptive Statistic: 1994 and 2014

Statistic	1994	2014
Average	1.23	1.09
Std. Deviation	2.01	0.95
Avg. Deviation	0.77	0.49
Coef. of Variation (%)	163.70	87.67

Source: Own calculations with data from INEGI.

Table 3 Evidence for Mexico using panel data

Study	Type of Panel Data Methodology	Rate of Convergence
Cermeño (2001) 1970-1995, quinquennial	Dynamic panel models *without* exogenous regressors	2.4 - 3.6 %
Calderón and Tykhonenko (2007) 1994 - 2002, yearly	Panel data Bayesian methods	2 - 3 %
Sakikawa (2012) 1970-2005, quinquennial	Panel data with fixed effects	13.5 - 16.5 %
Cabral and Varela-Mollick (2012) 1993 - 2006, yearly	Panel data, both static and dynamic	7 - 13 %

Source: Own elaboration.

Table 4. β – Absolute Convergence[1/]

Period	Coefficient	Half-life (Years)	Coefficient	Half-life (Years)
1994 - 2015	0.44	----	-9.64	7.54
	(0.21)		(1.77)	
1994 - 2001	0.00	----	-11.56	6.34
	(0.24)		(1.33)	
2002 - 2008	0.17	----	-10.77	6.78
	(0.25)		(1.26)	
2009 - 2015	0.67	----	-9.69	7.50
	(0.26)		(1.15)	
Fixed Effects	No		Yes	

1/ Coefficients are expressed as percentage points.
Notes: Own calculations with information from INEGI; standard errors in parenthesis.

Table 5 Control Variables: Descriptive Statistics

Variable/Period	1994-2015	1994-2001	2002-2008	2009-2015
Human Capital				
Mean	7.95	7.16	8.06	8.76
Std. Deviation	1.13	0.97	0.92	0.86
Infrastructure				
Mean	38.40	32.34	37.91	45.81
Std. Deviation	19.23	15.72	18.00	21.50
Crime				
Mean	1.45	1.31	0.97	2.10
Std. Deviation	1.50	0.84	0.75	2.24
FDI (% GDP)				
Mean	2.55	1.95	3.09	2.68
Std. Deviation	2.58	2.29	2.50	2.84

Source: Own elaboration.

Table 6a. Control Variables by State

	Human Capital				Infrastructure			
	1994	**2001**	**2008**	**2015**	**1994**	**2001**	**2008**	**2015**
North	**7.8**	**8.4**	**9.1**	**9.6**	**41.0**	**43.7**	**47.9**	**51.7**
Baja California	7.9	8.3	9.1	9.5	26.9	28.5	25.7	28.9
Coahuila	7.8	8.6	9.3	9.7	38.1	38.6	45.6	51.2
Chihuahua	7.3	7.9	8.6	9.1	46.8	52.6	57.5	54.8
Nuevo Leon	8.4	9.0	9.7	10.0	41.1	42.3	45.6	49.7
Sonora	7.8	8.3	9.2	9.7	56.1	59.4	67.7	72.4
Tamaulipas	7.5	8.2	9.0	9.4	37.2	40.8	45.6	53.3
Central-North	**6.8**	**7.5**	**8.4**	**9.0**	**25.1**	**30.4**	**37.5**	**45.2**
Aguascalientes	7.3	8.1	9.0	9.5	9.4	11.1	12.1	13.7
Baja California Sur	7.9	8.5	9.2	9.7	15.4	16.8	19.2	22.7
Colima	7.1	7.8	8.7	9.3	8.7	9.1	11.1	14.5
Durango	6.8	7.5	8.3	8.9	29.0	37.7	45.5	45.9
Jalisco	7.0	7.7	8.6	9.1	46.5	59.4	60.0	76.6
Michoacan	5.8	6.5	7.2	7.7	46.6	53.8	60.1	70.4
Nayarit	6.7	7.4	8.4	9.0	13.4	14.5	29.2	34.4
San Luis Potosi	6.4	7.1	8.0	8.6	27.9	36.8	49.1	57.6
Sinaloa	7.1	7.8	8.9	9.4	28.8	33.2	44.1	53.3
Zacatecas	5.9	6.7	7.6	8.3	25.7	31.8	44.8	62.7
Central	**7.0**	**7.8**	**8.5**	**9.1**	**22.4**	**26.0**	**31.7**	**37.1**
Ciudad de Mexico	9.2	9.8	10.4	10.8	1.5	1.5	1.5	0.9
Guanajuato	5.8	6.6	7.5	8.1	28.5	41.4	58.9	67.5
Hidalgo	6.0	6.8	7.8	8.5	25.9	31.2	37.2	45.1
Mexico	7.6	8.3	8.9	9.3	51.3	52.8	56.8	71.8
Morelos	7.3	7.9	8.7	9.2	14.5	15.5	16.3	17.7
Puebla	6.2	7.0	7.7	8.3	32.8	39.2	50.5	56.9
Queretaro	6.8	7.9	8.7	9.3	12.8	13.9	17.9	19.6
Tlaxcala	7.1	7.8	8.6	9.1	12.2	12.6	14.2	17.5
South	**5.8**	**6.6**	**7.4**	**8.0**	**38.5**	**43.8**	**52.5**	**68.0**
Chiapas	4.8	5.7	6.4	7.0	36.3	46.3	56.4	71.7
Guerrero	5.6	6.5	7.1	7.6	38.1	38.2	45.3	65.1
Oaxaca	5.1	6.0	6.7	7.3	37.9	41.1	58.8	73.5
Quintana Roo	7.1	8.1	8.9	9.5	17.7	19.7	26.2	33.0
Veracruz	6.0	6.7	7.5	8.0	52.8	58.4	66.6	102.0
Yucatan	6.3	7.0	8.0	8.6	48.4	59.5	61.5	62.7

Source: Own elaboration.
Note: Human Capital are average years of schooling among the population of 15 years or older; Infraestructure is measured by the length of the road network expressed in hundreds of squared kilometers.

Table 6b Control Variables by State

	Crime				FDI (% GDP)			
	1994	**2001**	**2008**	**2015**	**1994**	**2001**	**2008**	**2015**
North	**1.3**	**1.1**	**2.5**	**1.5**	**1.9**	**5.3**	**4.1**	**3.2**
Baja California	1.7	1.6	3.4	1.9	1.7	6.1	4.3	2.8
Coahuila	1.0	0.7	0.7	0.8	0.8	5.4	1.7	2.6
Chihuahua	2.1	2.0	7.8	2.7	2.5	5.8	8.4	6.5
Nuevo Leon	0.4	0.2	0.5	0.8	3.3	7.2	2.2	3.1
Sonora	1.2	1.1	1.7	1.6	0.8	2.8	5.4	1.5
Tamaulipas	1.4	0.7	0.8	1.3	2.5	4.7	2.5	2.5
Central-North	**1.7**	**1.0**	**1.3**	**1.4**	**0.6**	**3.1**	**4.6**	**2.6**
Aguascalientes	0.3	0.2	0.5	0.3	0.7	3.9	2.9	3.7
Baja California Sur	0.8	0.5	0.7	2.1	0.3	5.9	8.2	3.9
Colima	1.6	1.0	0.9	2.3	3.5	2.4	3.0	2.0
Durango	2.5	1.1	2.7	0.9	0.3	3.4	3.8	1.3
Jalisco	1.2	0.8	0.8	1.1	0.2	4.0	1.4	3.4
Michoacan	3.3	1.6	1.6	1.4	0.1	1.9	0.7	1.1
Nayarit	3.0	1.2	1.5	0.9	0.2	2.5	2.0	1.2
San Luis Potosi	1.1	1.0	0.8	0.7	0.2	3.6	2.3	7.2
Sinaloa	2.5	1.9	3.0	2.5	0.4	2.6	0.8	1.7
Zacatecas	0.9	0.7	0.7	1.7	0.4	1.2	20.8	0.6
Central	**1.4**	**0.9**	**0.7**	**1.0**	**1.5**	**4.3**	**2.5**	**2.4**
Ciudad de Mexico	1.4	1.1	1.1	1.0	8.1	8.4	4.2	2.6
Guanajuato	0.8	0.5	0.6	1.3	0.2	3.4	1.8	2.8
Hidalgo	0.8	0.5	0.3	0.6	0.0	2.9	0.7	1.7
Mexico	2.8	1.5	1.1	1.3	0.8	3.8	2.4	2.7
Morelos	3.3	1.3	1.3	1.9	0.3	3.0	2.4	2.4
Puebla	1.1	0.8	0.6	0.8	0.2	3.6	1.1	1.6
Queretaro	0.8	0.7	0.4	0.6	2.1	7.4	5.3	4.0
Tlaxcala	0.5	0.5	0.5	0.5	0.7	2.0	2.1	1.7
South	**2.2**	**1.0**	**1.2**	**1.4**	**0.3**	**2.4**	**1.5**	**1.3**
Chiapas	1.8	0.4	0.6	0.7	0.0	1.5	0.3	0.7
Guerrero	4.2	2.1	3.1	4.0	0.1	2.0	3.6	0.9
Oaxaca	3.7	1.9	1.7	1.6	0.0	1.2	1.2	1.0
Quintana Roo	2.4	1.1	1.2	0.7	0.7	4.8	1.8	1.6
Veracruz	1.1	0.5	0.5	1.0	0.0	2.3	1.1	2.7
Yucatan	0.3	0.2	0.3	0.2	0.7	2.4	0.9	0.9

Source: Own elaboration.
Note: Crime is measured as intentional homicides per 10,000 inhabitants. Foreign Direct Investment (FDI) is a percentage of state GDP.

Table 7. β – Conditional Convergence[1/]

Period and Variables	(1)				(2)			
	Coefficient	Half-life (Years)	Coefficient	Half-life (Years)	Coefficient	Half-life (Years)	Coefficient	Half-life (Years)
Convergence (1994 - 2015)	-1.24 (0.35)	55.6	-9.08 (1.07)	7.98	------	------	------	------
Convergence (1994 - 2001)	------	------	------	------	-1.75 (0.26)	39.3	-11.32 (1.19)	6.47
Convergence (2002 - 2008)	------	------	------	------	-1.04 (0.30)	66.3	-11.01 (1.21)	6.64
Convergence (2009 - 2015)	------	------	------	------	-0.05 (0.36)	1385.9	-9.47 (1.11)	7.67
Human Capital	0.59 (0.14)	------	0.08 (0.62)	------	0.58 (0.08)	------	-0.21 (0.71)	------
Infrastructure	0.01 (0.00)	------	-0.02 (0.00)	------	0.01 (0.00)	------	0.00 (0.01)	------
Crime	-0.22 (0.04)	------	-0.27 (0.08)	------	-0.29 (0.05)	------	-0.26 (0.06)	------
FDI (% of GDP)	0.12 (0.01)	------	0.13 (0.01)	------	0.12 (0.01)	------	0.16 (0.01)	------
Bajio	1.25 (0.16)	------	3.35 (1.33)	------	1.28 (0.16)	------	5.41 (1.46)	------
Observations	630	-----	630	-----	630	-----	630	-----
N	30	-----	30	-----	30	-----	30	-----
Fixed Effects	No	-----	Yes	-----	No	-----	Yes	-----

1/ Coefficients are expressed as percentage points.
Notes: Own calculations with information from INEGI; standard errors in parenthesis.