

NEIGHBORHOOD EFFECTS, CONVERGENCE AND GROWTH  
IN OPEN ECONOMIES OF U.S. AND MEXICO

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In partial Fulfillment  
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Doctor of Philosophy

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by  
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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

NEIGHBORHOOD EFFECTS, CONVERGENCE, AND GROWTH  
IN OPEN ECONOMIES OF U.S. AND MEXICO

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a candidate for the degree of doctor of philosophy,

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*A mis padres, hermanos y abuelos:*

*Getulio, Roma, Berus, Car, Reyna, Lupita y Carlos*

*con cariño.*

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## ABSTRACT

This dissertation consists of three papers. “Optional sales tax holidays: Which jurisdictions participate? Logit and a spatial analyses,” I reviewed the literature regarding strategic interaction among jurisdictions and border effects due to tax differentials. I used a logit model to estimate whether or not Missouri cities will participate or not in the 2004 sales tax holiday. I found that cities consider their own characteristics and their neighbor’s characteristics when making the decision to participate in the tax holiday. I did not find evidence of spatial autocorrelation, perhaps because other variables already contain some spatial information.

“Convergence of Mexican states, 1993-2004” examines the convergence implications of the Solow (1956) neoclassical economic growth model for Mexico. There is no evidence of unconditional  $\beta$  convergence. There is evidence of conditional  $\beta$  convergence and its value is 2.37 percent. There were mixed results for  $\sigma$  convergence among Mexican states.

“Disparities in Productivity Growth in Mexico, 1993-2004” examines the behavior of productivity among Mexican states for 1993-2004. Investments in physical capital are negatively related to productivity, states attracting labor force have higher productivity, human capital increases productivity. States with a higher percentage of indigenous population have lower productivity than the rest of the country.

# **Chapter 1 . Optional sales tax holidays: Which jurisdictions participate? Logit and a spatial analyses.**

## ***1.1. Introduction***

Tax rates are a reflection of the choices made by local governments in response to the demand for local public services and the available tax base, but they are also a reflection of competing jurisdictions. The strategic interaction among jurisdictions plays a role in making fiscal policy decisions. Among these interactions are *border effects* that tax differentials can generate because of tax holidays.

Missouri held its first state sales tax holiday from 12:01 a.m. Friday, August 13 until midnight Sunday, August 15 in 2004. The exemption included clothing under \$100, school supplies not to exceed \$50 per purchase, computer software with a taxable value of \$200 or less per purchase; and personal computers and computer peripheral devices that did not exceed \$2,000. Missouri has local-option sales taxes and local jurisdictions could vote not to participate in the holiday. If the jurisdiction opted out, then the state sales tax was still exempted and only the local tax was collected (Missouri Department of Revenue, 2004). Cities and counties made concurrent decisions to participate or not.

In August 2005 the second sales tax holiday was held. Because of timing of the signing of the law jurisdictions could not change their decision from 2004. After 2006 they are be able to make that decision annually. What considerations were taken into account by local governments to make the decision to participate or not in the holiday in 2004? How does the decision made by one affect neighbors? This study tries to provide answers to these questions, by reviewing literature relevant to the topic and analyzing the data from the 2004 sales tax holiday in Missouri.

I use a logit model to estimate whether or not a city will participate in a sales tax holiday. I use city and county data from the 2004 sales tax holiday in Missouri. The own city characteristics and the county's decision to participate or not in the sales tax holiday are the variables that most affect the decision of local governments to participate in the holiday. I also estimate a spatial regression model to study the proportion of cities in each county participating in the sales tax holiday using the same explanatory variables but at county level.

In the next two sections I review the literature findings regarding strategic interaction among jurisdictions and the literature regarding border effects due to tax differentials. The fourth section develops the logit and the spatial models that we estimate and the hypotheses. Then the data used in this study are described, followed by the results of

the estimations of the empirical models. Finally I present the conclusions driven by this study.

## ***1.2. Strategic interaction among governments***

When a government makes sales tax decisions it has to consider other local governments' decisions because consumers can be mobile in shopping. In particular when a local government decides whether or not participate in a tax holiday it might consider what other local governments might do, and the conditions of the neighboring communities. This kind of interaction among governments has been discussed in the literature under policy strategic interaction or under tax competition among governmental units. In the following section I review some of this literature and describe how this paper contributes to literature in making tax decisions.

Case et al. (1993) presented a study of strategic interaction among governmental units and investigated interdependence in the determination of spending by state governments in the United States, using a spatial lag framework. In their model, a weighted average of spending levels in neighboring states, computed by applying a predetermined weight matrix to the data, appears as a right-hand side variable in the

regression. The estimation shows that a given state's spending responds positively to higher spending in "competing" states.

Brueckner (1998) uses Case et al.'s (1993) methodology for local governments. He argues that strategic interaction among governments occurs because "the market environment in which local policy decisions are made is affected by the actions of other local governments" (Brueckner, 1988 p. 438). This interaction must be considered when characterizing the public sector equilibrium.

Brueckner focuses on the adoption of growth control measures by cities in California and looks for evidence of policy interdependence. Under the spatial lag specification, the growth control index depends on city characteristics and on a variable measuring the stringency of controls in competing cities. He argues that if the coefficients associated with the competing controls are nonzero, then growth control choices are interdependent across cities, strategic interaction occurs and reaction functions among cities can be drawn.

Brueckner's main goal is to estimate the slope of city reaction functions. He develops a model using variables including distance, population, rent per unit of land, renter income, renter welfare weight, and amenities in the localities. He used data from a survey of California growth control practices of 1988 and computes an index of the

stringency of growth controls in each of the 173 cities included in the study, which serves as the dependent variable for the study.

Brueckner's empirical model is:

$$z_i = \phi \sum_{j \neq i} w_{ij} z_j + S_i \theta + \varepsilon_i \quad (1)$$

Where  $z_i$  denotes the index of the stringency of growth controls in the  $i^{\text{th}}$  city,  $S_i$  denotes the vector of  $i$ 's city characteristics,  $w_{ij}$  represents a set of weights that aggregate the growth control choices of competing cities into a single "competing controls" variable which has a scalar coefficient  $\phi$ . This coefficient represents the slope of the reaction function. The vector  $\theta$  contains city characteristics coefficients, and  $\varepsilon_i$  is the error term. The model parameters are estimated by applying maximum likelihood techniques.

The city characteristics considered in the study include the city's population and density; racial mix; age structure; education, skill levels, and unemployment; household crowding; and income. Additional variables measure the extent of commercial activity, as well as the city's tax burden, its total expenditures, capital expenditures, and debt level (all of these variables are expressed on a per capita basis). Other measures include the percentage of Democratic votes in the 1988 presidential election, the city's percentage of owner-occupied housing, and the median house value in 1980. Additional variables include the net 1980-1986 migration into the county containing the city,



expressed as a percentage of 1980 county population; the 1992 daily vehicle-hours of congestion delay on freeways in the county containing the city, expressed on a per capita basis and finally a dummy variable indicating that the city borders the Pacific Ocean.

Brueckner uses four different weighting schemes same weight for every city ( $w_{ij} = 1$ ), distance based weights ( $w_{ij} = 1/d_{ij}$ ), population based weights ( $w_{ij} = P_j$ ), and a combination of population and distance weights ( $w_{ij} = P_j/d_{ij}$ ) to define his weights matrix  $W$ <sup>1</sup>.

The estimations for the population-weighted schemes show that the coefficients on  $W$  rank between 0.205 and 0.402; for the population-unweighted schemes the coefficients range is 0.129 – 0.236 and both are statistically significant at the 5%. The diagnostic tests indicate that the population-weighted schemes' results are more robust. Then it can be said that these results provide evidence of strategic interaction among California cities in the choice of growth controls. They are playing a *growth controls game*. "A large population, high education and skill levels, a liberal political stance, and high house prices increase a city's preference for controls. Conversely, dense, high-income cities

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<sup>1</sup> Where  $d_{ij}$  denote the distance from city  $i$  to city  $j$ ,  $P_j$  denote city  $j$ 's population, and  $d^*$  denotes the critical distance beyond which weights are set equal to zero. Then,  $w_{ij}$  is set equal to zero if  $d_{ij} > d^*$ , and  $W$ 's diagonal elements are also set equal to zero. For off-diagonal elements where  $d_{ij} \leq d^*$ ,  $w_{ij}$  is given by one of the 2 to 5 Equations.

that contain many one-person households have a weaker preference for controls. A noteworthy aspect of the results is the poor performance of variables explicitly intended to measure population pressure, which may partly reflect imperfect measurement” (Brueckner, 1988 p. 462-463).

It can be said that while the results provide evidence of interaction, they do not prove that the source of it can be identified; “cities could be naive followers of localized policy fads in a setting of generalized hostility toward growth” (Brueckner, 1988 p. 465).

In 2000 Brueckner analyzed the strategic interaction among states in the determination of welfare benefits, which arises when the welfare benefit level in a given state depends on benefits in nearby states. When there are different welfare benefit levels in nearby states potential welfare migration can affect policy decisions. Then he states that strategic interaction would suggest that states behave in a way that leads to a race to the bottom, indicating a need for policy intervention to raise benefit levels.

Brueckner (2000) evaluated the evidence for a race to the bottom after U.S. welfare reform in 1996, which gave the states much more freedom in deciding how welfare funds will be spent. In general the federal government was trying to reduce total welfare expenditures. Bruckner reviewed 8 welfare migration studies<sup>2</sup> finding mixed

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<sup>2</sup> Southwick (1981), Gramlich and Laren (1984), Blank (1988), Levine and Zimmerman (1995), Walker (1994), Enchautegui (1997), Borjas (1997), and Meyer (1998).

empirical findings for welfare migration. He also reviewed 4 strategic interaction studies<sup>3</sup> finding evidence of strategic interaction among states.

Based on his literature review, Brueckner concluded that “instead of switching from matching to block grants, welfare reform should have left the matching-grant structure in place while relying on other changes in the law to restrict eligibility and to broaden the scope of the cost-sharing rules encouraging innovation” (Brueckner, 2000 p. 507).

In his study Brueckner represents the equilibrium with welfare migration through reaction functions of two states. State 1’s reaction function gives the best value of benefit level ( $T_1$ ) conditional on the benefit level in state 2 ( $T_2$ ), and vice versa for state 2. Equilibrium requires that the states’ choices are mutually consistent. The state 1 reaction function is given by:

$$T_1 = \Phi + \frac{1 - \beta\delta M}{2 + \beta\delta M} T_2 \quad (2)$$

---

<sup>3</sup> Brueckner (2000) reviews the principal studies on evidence of strategic interaction among states. These are: Figlio, Kolpin, and Reid (1999), Peterson, Rom and Scheve (1997), Smith (1997), and Saavedra (2000). Saavedra’s (2000) findings suggest the existence of strategic interaction among the states in the choice of welfare benefits. Her findings show that reaction functions are upward sloping. Figlio, Kolpin, and Reid (1999) used instrumental variables and estimated a first-difference model with dependent variable equal to  $T_{i,t} - T_{i,t-1}$ . Their findings are similar to Saavedra’s. Peterson et al. (1997) included a lagged own-benefit level  $T_{i,t-1}$  along with contemporaneous benefit levels in other states, getting similar results to the Saavedra’s and Figlio et al. Smith (1997) assumed that the benefit choice of a given state is affected by the lagged benefit levels in other states  $T_{j,t-1}$ . He found some evidence of strategic interaction but his results were not as conclusive as the Saavedra (2000), Peterson et al. (1997), and Figlio et al. (1999) studies.

Where  $M$  are the non-poor consumers in state 1;  $\beta > 0$  is the slope of the marginal productivity (unskilled wage) of poor people in both states;  $\delta > 0$  is the slope of the utility function of the rich people in both states; and  $\Phi$  is a constant. State 2's reaction function is obtained by interchanging  $T_1$  and  $T_2$ . "The intersection of these two reaction functions yields the common equilibrium value of  $T_1$  and  $T_2$ , which is ... too low from society's point of view.... A way of testing strategic interaction would be to estimate a regression equation relating state welfare benefits to benefit levels in nearby states, as well as other explanatory variables" (Brueckner, 2000 p. 513). Then he proposed the following regression equation to test for strategic interaction:

$$T_i = \phi \sum_{j \neq i} w_{ij} T_j + Z_i \gamma + \varepsilon_i \quad (3)$$

Where  $T_i$  is the benefit level in state  $i$ .  $T_j$  represents benefit levels in other states  $j$ ,  $j \neq i$ ,  $Z_i$  is a vector of economic and demographic characteristics for state  $i$ ,  $\gamma$  is the associated coefficient vector, and  $\varepsilon_i$  is an error term. The  $w_{ij}$  terms in Equation 3 are weights that indicate the importance attached by state  $i$  to benefits in the various other states. He mentions that the simplest weighting scheme is a "contiguity" scheme, which assigns a weight of  $1/n_i$  to each of the  $n_j$  states that shares a border with state  $i$ , while assigning a weight of zero to each noncontiguous state.

As can be noticed, Equations 1 and 3 are very similar and they can be applied when one government's decisions affect the decisions of other jurisdictions. Different weighting systems can also be used as described by Brueckner (1988).

Based on his model, Brueckner (2000) concluded that benefit levels in nearby states affect a given state's benefit choice. "Although evidence on welfare migration is mixed, the direct behavioral evidence of strategic interaction is compelling. It suggests that states are indeed playing a welfare game, which is more likely motivated by a concern about welfare migration, and that a race to the bottom may emerge" (Brueckner, 2000 p. 523).

Following Brueckner and Case et. al., Brett and Pinkse (2000) state that useful insights into the nature of local taxation can be gained by modeling the decision of independent tax authorities in a game-theoretic framework. "It is common to consider local taxes rates are the outcome of Nash competition in taxes among jurisdictions" (Brett and Pinkse, 2000 p. 696). In this framework they cited two studies<sup>4</sup> that provide models of tax competition between two jurisdictions of unequal population. Each concludes that tax rates are higher in more populous regions. The intuition is that the losses associated with the erosion of the tax base are lower in more populous regions, since population provides an advantage in the battle to attract and retain businesses.

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<sup>4</sup> The cited studies are Bucovetsky (1991) and Kanbur and Keen (1993).

Brett and Pinkse (2000) present a methodology to assess empirically the extent to which municipal governments are influenced by strategic considerations when tax rates are decided, with an application to municipal business tax rates in the province of British Columbia, Canada. They developed a two equation model. In the first equation the municipal tax base is a function of local characteristics and a weighted average of the tax rates of neighboring jurisdictions; in the second equation they model the choice of tax rate, with the size of the base being among its determinants.

They assume that municipal governments have an objective that combines the utility that local residents gain from the provision of public services and rents accruing to private activities. The level of public services is financed by municipal taxes. They also assume that the capital tax base is at least partly mobile but a municipality has a set of characteristics that make it more or less attractive for business investment. This mobility implies that the business capital stock in a particular location depends on tax rates elsewhere, as well as on characteristics of other jurisdictions.

The reduced form of the Brett and Pinkse's (2000) model can be understood as the product of two components: the impact of neighbors' taxes on the tax base and the influence of own base on the tax rate. The model they estimate is a simultaneous equation model of the form:

$$\begin{aligned} \ln c_i &= X_{1i}^T \theta + \alpha(y_i + b_i) + \gamma w_i^T (y + b) + w_i^T S \delta + u_i \\ y_i &= \eta \ln c_i + \zeta b_i + X_{2i}^T \beta + v_i \end{aligned} \quad (4)$$

Where  $c_i$  denotes the tax base of municipality;  $X_{1i}^T$  is a vector of characteristics of  $i^{\text{th}}$  municipality; The vector  $\theta$  contains a list of jurisdiction-independent parameters;  $y_i$  is its tax rate;  $b_i$  denotes the total rate levied by tax authorities at other levels;  $w_i^T$  are spatial weights with  $w_{ij} = d_{ij} / n_i$ ;  $n_i$  denotes the total number of neighbors of jurisdiction  $i$ , and  $d_{ij} = 1$  when  $i$  and  $j$  are neighbors and zero otherwise;  $S$  is a matrix of the characteristics of other potentially competing municipalities.

They considered four different distance measures. First they define *neighborliness* to reflect *economic closeness*. By this they mean that “the jurisdictions are situated so that some individuals would view them as substitute locations to do business in. One such measure is the notion of a road neighbor. ...municipalities  $i$  and  $j$  are road neighbors if the shortest driving route between them does not pass through the core of any other jurisdiction” (Brett and Pinkse, 2000 p. 699).

A second notion of neighborliness is the *boundary neighbors*. “Two municipalities are called neighbors if their nearest-point sets are contiguous” (Brett and Pinkse, 2000 p. 699). This concept fails to take into account topography; business is less likely to move across mountains.

Another distance measure involves the *Euclidean notion* “jurisdictions [are] neighbors if and only if they are separated by a sufficiently small number of kilometers” (Brett and Pinkse, 2000 p. 699). Using a too small radius will leave some jurisdictions without neighbors, and a large radius will result in many neighbors. They define a *four nearest neighbor* concept under which “municipality  $j$  is a neighbor of  $i$  if it is one of the four closest jurisdictions to  $i$ ”

They constructed a final type of neighbor: a *population neighbor*. “Jurisdiction  $i$  is a population neighbor of  $j$  if it has one of the four closest population sizes to  $i$ . It may be that some enterprises view alternative locations of similar size as alternative places to do business even if they must jump over several communities of dissimilar size” (Brett and Pinkse’s, 2000 p. 700).

Brett and Pinkse (2000) used basic municipal property tax rates for 1991 and 1987 as the choice variables of the municipalities. The variables explaining the tax base are: median family income, meters of road per capita, the percentage of the workforce employed in primary industries, and the hectares of parks per capita. Median family income is included as a measure of the attractiveness of a locale for commercial development. Meters of road per capita is a measure of public infrastructure. The hectares of parks per capita measure the availability of land and the amenity value of an area. The workforce variable is included to take account of location-specific factors that



may impart market power to some communities. The percentage of seniors is included in the tax equation as a proxy for the demand for public services.

Brett and Pinkse (2000) estimate their model using random and fixed effects, and they also considered the four neighborliness measures described above. “The random-effects estimates of the tax base equation fail to reveal any significant influence of own or neighboring tax rates on the assessed value of commercial property. Contrary to what was found in the fixed-effects model, the reduced form estimates also indicate that neighbors’ tax rates have no significant effect on taxes.... On balance, there is no strong evidence for the existence of cutthroat tax competition among British Columbia municipalities” (Brett and Pinkse, 2000 p. 711).

According to Revelli (2001) these inconclusive results could be due to the fact that geographical neighbors are more likely to experience similar shocks, such as tax base and business-cycle shocks; thus implying that it will be very difficult to separately identify the spatial correlation in local taxes, which is attributable to substantive spatial dependence, from the one that is simply due to the effect of common shocks.

Revelli (2001) argues that shocks to local taxes are “expected to produce a correlation in tax rates between the lower and upper level of government, particularly if the two tiers of government rely on the same tax base” (Revelli, 2001 p. 1101). But at the same time, tax spatial dependence is not expected to occur between different levels of

government, especially if different levels of governments are in charge of the provision of different public good and services.

Revelli (2001) states that “if spatial correlation in local tax rates between governments of the same level is simply attributable to the presence of spatially correlated shocks and has no behavioral relevance, then the tax rates of the lower tier of government will also be expected to be correlated with the tax rates of the upper tier of government. On the other hand, if tax mimicking is driving the spatial dependence in local tax rates, no vertical correlation in tax rates between districts [higher tier] and counties will be expected” (Revelli, 2001 p. 1102).

In order to test for the presence of tax mimicry, Revelli (2001) estimates a dynamic tax equation that allows for horizontal and vertical spatial interactions, as follows:

$$r_{it} = \rho r_{it-1} + \tau M_i r_t + \theta W_i R_{kt} + z_{it}' \beta + d_i + q_t + v_{it} \quad (5)$$

Where  $r_{it}$  represents the property tax rate set by district  $i$  in the period  $t$ ;  $R_{kt}$  represents the property tax rate set by county  $k$  in period  $t$ ;  $z_{it}$  is a vector of explanatory variables specific to district  $i$ ;  $d_i$  is a fixed effect that is an unobservable characteristic of the districts that influences the local tax rate and is constant over time;  $q_t$  is a time effect intended to control for systematic influences common to all districts in a given year (e.g. business cycle effects). Parameters  $\tau$  and  $\theta$  measure the

horizontal interactions between districts, and the vertical interactions between districts and counties respectively.  $M_i$  denotes the  $i^{\text{th}}$  row of a spatial weights matrix  $W$ . Matrix  $M$  attributes neighbors to each district<sup>5</sup> 1 if they are neighbors and zero otherwise. On the other hand, matrix  $W$  assigns a county to each district. The element  $w_{ik}$  is equal to one if district  $i$  is located within county  $k$ , and equal to zero otherwise. Finally  $v_{it}$  is an error term.

Revelli (2001) uses a panel data set of the English non-metropolitan districts from 1983 to 1990 to estimate Equation 5 using a generalized method of moments with instrumental variables approach. His estimation included as a dependent variable the local tax rate set by the United Kingdom shire districts every year. The regressors included the per capita *rateable* value (a measure of the tax base available to the local authority); the Block Grant per capita (the equalization transfer made by central government to municipalities) and the proportion of domestic local tax base. The equation also includes the unemployment rate as an indicator of socio-economic conditions (and as a proxy for income), and a political control variable to allow for systematic differences in tax setting behavior between parties. The political control variable is a dummy variable that equals one if the local council is controlled by the Labour Party.

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<sup>5</sup> Revelli (2001) considers that two districts are neighbors if they share a border.

The results confirm the presence of large and significant spatial interactions among districts. A 10% increase in the local property tax rate of a district's neighbors leads to an increase of 4–5% in its own property tax rate. However the absence of correlation in tax rates between district authorities and county authorities suggests that the spatial pattern in district tax rates is not simply driven by spatially auto-correlated shocks, but instead is compatible with tax mimicking at the local level.

As these reviewed studies suggest some of the interactions in fiscal planning among jurisdictions could be due to the possibility of tax base movements (capital, consumers, etc). In the case of sales tax rates it can be expected that people will prefer to buy where sales taxes are lower. Thus, interactions among jurisdictions in planning sales taxes might be observed. A sales tax holiday is a sudden drop in this tax, and shoppers may travel to those jurisdictions with more favorable rates. For this reason cities and counties might take into consideration what other governments might do when they make their tax decisions. In this paper I investigate possible interactions among cities during a sales tax holiday, in which all decisions were made nearly concurrently.

### ***1.3. Border effects and tax holidays***

This section presents a brief summary of the literature on border effects due to tax differentials and the empirical evidence from several states that have held sales tax holidays. If during a tax holiday each local government has the option to participate in the holiday or opt out, it is possible to study tax differentials within the state. In a previous study (Patron and Stallman, 2005) we reviewed the literature regarding tax differentials.

1980 p. 185). Transportation costs suggest that the sales tax differential will not be equally important for all commodities; the differential will affect sales of homogeneous commodities that are purchased in large quantity per trip or that have high value.

Walsh and Jones (1988) analyzed the border city problem to assess the sensitivity of per capita grocery store sales in 46 counties of West Virginia during the period 1979-1984. To test the hypothesis that the sales tax differential exerts a significant effect on sales in border counties, but does not lead to changes in sales in interior counties the data were divided into two sub-samples: those counties that border one or more of the five neighboring states; and those that do not share a border with another state. The results indicate that West Virginia consumers living in border counties had been shopping

Table 1-1 summarizes the main findings of that literature review. There is evidence that consumers will shift purchases to lower sales tax jurisdictions and the bigger the tax differential, the more consumers can be expected to shift.

Mikesell (1970) analyzes per capita city sales to estimate the impact of a sales tax rate differential on retail sales in 173 central cities of SMSA'S for 1963. His control variables include: relative population of cities, geographic region [variables representing the Office of Business Economics geographic regions], per capita income, and geographic area [square miles]. His results indicate that "the loss of per capita city sales from a one percent change in the sales tax variable will be between 1.69 and 10.97 percent" (Mikesell, 1970 p. 213). He concludes that central cities facing an adverse sales tax rate differential have lower retail sales per capita.

Fisher (1980) states that prices between two jurisdictions are not just due to tax rate differences. He performed a study relaxing the assumption of constant cost industries and perfectly competitive markets for the District of Columbia and the surrounding Maryland and Virginia suburbs for 1962-1976 using data for the general sales tax base, for food consumed at home, and for apparel. (Sales tax rates in D.C. have been higher than those in Maryland and Virginia.) He suggested that the tax-induced price differences can persist if information or transportation costs are considered. He concludes that "while there is evidence that the tax rate difference on food does cause a

revenue loss to the District, there is no strong evidence that tax rate differences on other commodities cause consumers to change the location of their purchases” (Fisher, 1980 p. 185). Transportation costs suggest that the sales tax differential will not be equally important for all commodities; the differential will affect sales of homogeneous commodities that are purchased in large quantity per trip or that have high value.

Walsh and Jones (1988) analyzed the border city problem to assess the sensitivity of per capita grocery store sales in 46 counties of West Virginia during the period 1979-1984. To test the hypothesis that the sales tax differential exerts a significant effect on sales in border counties, but does not lead to changes in sales in interior counties the data were divided into two sub-samples: those counties that border one or more of the five neighboring states; and those that do not share a border with another state. The results indicate that West Virginia consumers living in border counties had been shopping outside of West Virginia to avoid the tax on food, but stopped shopping elsewhere as the tax was phased out<sup>6</sup>.

These tax base movements can be compared to Brueckner’s (2000) approach to welfare migration, but in this case shoppers “migrate” to lower sales tax rate jurisdictions. Thus, we can expect that jurisdictions will take into consideration what other city and county governments would do.

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<sup>6</sup> During 1980-1982 the West Virginia sales tax rate was cut from 3% by 1 percentage point per year.

**Table 1-1 Studies of Local Sales Tax Rate Differentials**

Study	Dependent Variable(s)	Data Base	Tax Variable	Results
Harmovitch (1966)	Taxable Receipts	N.Y. City 1948 - 1964	N.Y. City sales tax rate	One percent point increase in tax rate causes a 3.5%-8.6% decrease in taxable sales
Levin (1966)	Total sales receipts, apparel an house furnishing	N.Y. City 1929-1963	N.Y. City sales tax rate	One percentage point increase in tax rate associated with a 10% decrease in total sales. After correction for non-tax location factors, a reduction in total sales of 6.1%
Mikesell (1970)	Per capita city sales	173 central cities in SMSA's 1963	$\frac{1+t_c}{1+t_s}$ Where $t^c$ = city tax rate; $t_s$ = suburb tax rate	Elasticity of sales with respect to the tax variable range from 1.7% to 11.0%
Fisher (1980)	General sales tax base, food consumed at home, and apparel	District of Columbia and the surrounding Maryland and Virginia suburbs 1962 - 1976	$T = \frac{1}{2} \left[ \frac{1+t_c}{1+t_m} + \frac{1+t_c}{1+t_v} \right]$ Where $t_c$ =DC tax rate; $t_m$ = Maryland suburb tax rate; and $t_v$ = Virginia suburb tax rate	Changes in the general sales tax rate and in apparel do not cause consumers to change the location of purchases. Elasticity of food sales tax revenue with respect to the tax variable is about 7%.
Walsh and Jones (1988)	Per capita grocery store sales	46 counties of West Virginia 1979 - 1984	$P_{it} = \frac{p_{it}(1+T_{it})}{p_{at}(1+T_{at})}$ Where $P_{it}$ =relative after-tax price; $T_{it}$ =the "home" state sales tax rate applied to grocery food in the county $i$ at time $t$ ; $T_{at}$ = the sales tax rate applied to grocery food in the nearest county of an adjacent state; $p_{it}$ , $p_{at}$ = home and adjacent state pre-tax prices.	For border counties each 1% drop in the sales tax rate implies a 1% decrease in the after-tax price, which increases the grocery store sales by 5.9%.

Taken from (Patron and Stallmann, 2005).



A sales tax holiday seeks to provide relief to taxpayers by instituting a temporary tax exemption on certain items for a specific period of time. New York instituted a sales tax holiday on January 18-24, 1997 for items of clothing selling for less than \$500. The New York State Department of Taxation and Finance (1997) pointed out that the clothing purchases during the exemption week could be one of three types:

“Purchases that consumers would have made during that week even without the exemption...; purchases that consumers simply shifted from prior or later weeks by delaying or accelerating their purchases to take advantage of the exemption...; [and] purchases made by residents or non-residents because the after tax price of clothing was lower...” (New York State Department of Taxation and Finance, 1997 p. 1).

Sales of stores that sell most of the clothing purchased in New York State were only slightly higher in the quarter in which the exemption took place. The sales were no higher than one would expect based on economic growth for the period. Therefore, it seemed that most of the increase in sales of clothing and general merchandise retailers was part of the larger national trend and was not attributable to the temporary exemption.

In 2000 clothing and footwear items priced under \$110 were exempted from New York State sales tax year-round, with a local option for the local portion of the sales tax. Border localities were more likely to opt into the holiday, but at the same time, the New York State Department of Taxation and Finance (2003) reported that “fewer localities participated in the clothing exemption than in an earlier temporary exemption” (New York State Department of Taxation and Finance, 2003 p. 2). This suggests jurisdictions

are not willing to forego the revenue loss and/or that consumers are less likely to change shopping patterns for an entire year than they are for a week. Finally, data regarding the reported dollar value of clothing sold and the corresponding state and local tax reduction for the exemption indicated that the savings to taxpayers were less than predicted by the New York State Department of Taxation and Finance.

Iowa held its first sales tax holiday on August 4 and 5, 2000. It was limited to items of clothing and footwear costing less than \$100 an item. It was difficult for the Iowa's Department of Revenue and Finance (2001) to determine if the tax exemption granted during this period resulted in additional sales for retailers, because the tax exemption attracted substantial numbers of customers from border states, and it was not possible to determine the extent to which the sales experience of stores in border communities differed from those located elsewhere in Iowa. Gross sales fell from 1999 to 2000 during the July- to September quarter.

The second sales tax holiday in Iowa was on August 3 and 4, 2001. A survey of 10 department and discount store chains and 10 other multiple-location clothing and footwear retailers by the Department of Revenue and Finance (2004) indicates that the state sales tax collections were about the same as 2000. Tax exempt sales fell from 2000-2001 during the July to September quarter (Iowa's Department of Revenue and Finance, 2001). Because they also fell from 1999 to 2000, sales were lower in 2001 than in 1999. This may be due to economic conditions.

A further question is whether retailers offer more or fewer markdowns during the sales tax holiday, which would also affect families' savings. A Florida study (Harper, et al, 2003) compared Pensacola city in Florida during a tax holiday with a comparison city without a tax holiday. "Basic theory suggests that taxes will be shared between producers and consumers. Logic would suggest that savings from a sales tax holiday would also be shared between producers and consumers" (Harper, et al. 2003 p. 110). The study found that there were fewer price markdowns during the tax holiday than before and after. The most generous markdowns were after the holiday. As a result consumers received about 80 percent of the tax-savings and retailers captured 20 percent of the tax savings.

"If markdowns are less generous, total exempt purchases can overstate the revenue loss. In other words, an exempt purchase of \$25 may actually represent a revenue loss of the tax rate on a \$20 purchase later in the year" (Harper, et al. 2003 p. 109).

Because this is a one-year study it was not possible to determine if the pattern of fewer markdowns in the holiday week and more markdowns in the previous and following week is a normal retail pattern for those three weeks or if it was influenced by the holiday.

These studies provide mixed evidence on whether tax differentials that are long standing influence consumers to shift purchases across jurisdictions to avoid taxes. The “New York study also suggests that consumers shift purchases to the tax holiday. This shifting does save money for consumers.... The decreases in retail sales in Iowa during the tax holidays of 2002 and 2001 and the small increases in New York (smaller than economic growth) indicate that retail sales are most responsive to general economic conditions with a small response to the tax holiday” (Stallmann and Patron, 2005 p. 12).

These consumers’ movements might be the source for strategic interactions among jurisdictions because each jurisdiction wants to attract as many consumers as possible to benefit its economy and their sellers. But to participate in the holiday they will give up some revenues. Thus the local governments might also consider the expected revenues that will be lost due to the sales tax holiday.

#### **1.4. Model**

Given the literature presented in the previous two sections in this section we develop two models to analyze whether a city government would choose to participate or opt out of a sales tax holiday when the option is given.

### **1.4.1. Logit model**

While previous studies have estimated the sales tax rate of a jurisdiction, I want to analyze whether or not a city would participate in a tax holiday. My dependent variable is a dummy variable that takes value one if the city participated in the tax holiday and zero if the city opted out.

In making the decision to participate in the sales tax holiday a city would be expected to consider its own characteristics. This would suggest including a matrix of variables summarizing the socioeconomic characteristics of the city that describe the tax base. The literature on border effects and tax holidays suggests that the cities located in border counties would be more willing to participate in the sales tax holiday, because they would attract consumers from the surrounding states, these can also be considered as part of the socioeconomic characteristics of the city. But tax revenues also depend on the sales tax rate, so it is also important to consider the size of the tax rate and the revenues that the city would give up if decides to participate.

As suggested by Brueckner, jurisdictions are influenced by actions of neighboring jurisdictions. In this case, all decisions were made in a short time period so there is very little information about the actions of other jurisdictions, thus jurisdictions may substitute the neighbors' characteristics for their unknown actions when choosing to

participate or not. As mentioned by Brueckner (1998 and 2000), there could be different weight systems for the neighboring jurisdictions, in this study I am differentiating cities within the county, and cities in surrounding counties.

As mentioned above, Revelli (2001) takes into consideration not just horizontal but vertical spatial interactions among jurisdictions. It might be the case that the county decision can affect the city's decision (vertical interaction). Then theory would suggest that the county's decision to participate or not in the tax holiday might have an effect on the city's decision, thus we include this in the equation.

Then based on Revelli (2001) but with just one observation in time, the proposed model is:

$$p_i = c + \alpha X_i + \beta W_j Z_j + \chi R_i + \delta V_k + \varepsilon_i \quad (6)$$

Where:

$p_i$  is the dummy dependent variable that takes the value one when the  $i^{\text{th}}$  city participates in the sales tax holiday and zero if does not.

$c$  is a constant

$X_i$  is a matrix summarizing the socioeconomic characteristics of the  $i^{\text{th}}$  city.

$W_j$  is a weight matrix for neighboring cities in the county.

$Z_j$  is a matrix summarizing the socioeconomic characteristics of the surrounding counties.

$R_i$  is the sales tax rate in the  $i^{\text{th}}$  city.

$V_k$  represents the decision to participate in the sales tax holiday by the county in which the city is located. This variable takes the value of one if the county participated and zero if it did not.

And  $\varepsilon_i$  is an error term.

For the purposes of this study we consider in  $X_i$  the city's population and its growth rate; its localization, either if it is on the border of the state or not; its sales tax rate; and its income per capita in 2003. We expect that the coefficient associated with population would be negative, meaning that larger cities are less willing to participate in the tax holiday, given that they have less competition because of the amount of retail they have to offer. Population growth rate is also considered within this matrix, and its coefficient would be either a positive or negative sign. It can be the case that cities decreasing its population might be willing to participate in the holiday in order to bring more consumers into their area and generate more economic activity, but it could also be the case that they are not willing to participate because they have to give up to part of their sales revenue when they have already experienced declining base. In this case it is important to note that there is a tradeoff between potential revenues and participating in the sales tax holiday.

Given a sales tax rate, the more consumers, the more revenue; but with the holiday there is a negative effect on revenue because of the reduction in the sales tax rate. If cities decide not to participate, then they keep their revenue, but do not bring new consumers into their areas and may lose some regular consumers who decide to shop elsewhere. If they participate they can stimulate the economic activity of the city because of border effects, and because regular consumers are encouraged to spend but they have to give up some sales tax revenue. A city will stay in the tax holiday if they expect to attract so many people during the holiday such that the substitution effect exceeds the income effect<sup>7</sup>.

Another important characteristic is whether or not the city is located on the border of the state or not. As mentioned above, the literature suggests that when there is a tax rate differential consumers will try to save money shopping in areas with lower tax rates. A sales tax holiday is a scenario where the sales tax rate could drop to zero in some jurisdictions. Then if the surrounding states and local governments are not having a sales tax holiday on the same dates, we would expect that border cities will try to bring consumers from neighboring states into their areas.

According to the economic closeness concept of Brett and Pinkse (2000), people would prefer to travel short distances, but if they are not going to find what they are looking

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<sup>7</sup> *Income effect*: the revenue that the local government is giving up because of the reduction in the tax rate.

*Substitution effect*: the revenue that the local government is gaining because of the increase in "other" sales. Increase in economic activity.



for they would rather travel longer distances and go to the big cities with lower taxes. Then the decision of opting out of the tax holiday for a big city can be more important than for small cities. This could be interesting to test, but for the purposes of this paper we will leave it out.

Given the relationship between the sales tax rate and sales tax revenue, the sign associated with the coefficient of the sales tax rate might be positive or negative. If positive it can be understood as an indicator of competitiveness; that means that the substitution effect is larger than the income effect. If negative it can be understood as proxy for dependence on sales taxes; that is the income effect is higher than the substitution effect.

The characteristics of neighboring jurisdictions are included in the  $z_j$  matrix. In this matrix we include the number of cities in the same county and the number of cities in the surrounding counties. I expect that when there is more competition--more surrounding cities--the jurisdiction will try to attract more customers or not lose its own by participating in the holiday. But again if the expected income effects are larger than the substitutions', then the jurisdiction opts out. Given this trade off this interaction can also be thought of as the prisoner dilemma game. This is a simultaneous game, nobody knows what the other is going to do. The strategy is to participate or not in a sales tax holiday. There must be some reaction functions and some kind of relationship across jurisdictions.

The same idea can be applied to test for vertical interaction among county governments and local governments. For that purpose I include a variable indicating if the city's county participated or not in the sales tax holiday. I might expect that both move together (positive relationship). Since counties and cities made a concurrent decision it would be interesting to specify an equation similar to 10, but for counties; and estimate them simultaneously. But for the purposes of these paper I will assume that local governments used some informal networks to figure out if the county would participate or not in the tax holiday.

#### **1.4.2. Spatial model**

As mentioned in previous sections some authors (Brueckner, 1988; Case et al., 1993, Smith, 1997; and Revelli, 2001) have used spatial model specifications to analyze strategic interactions among jurisdictions and border effects. To test for spatial autocorrelation a spatial probit model specification would be appropriate. We are using GeoDa to perform our spatial estimations and this software does not support binary dependent variables yet. So instead, we specify a spatial model to analyze the percentage of cities in a given county participating in the Missouri sales tax holiday (which is a continuous variable). In order to do that we estimate the following equation:

$$q_j = c + \alpha X_j + \beta W_j + \gamma Z_j + \chi R_j + \eta_j \quad (7)$$

Where:

$q_j$  is the county percentage of cities participating in the 2004 Missouri sales tax holiday.

$c$  is a constant

$X_j$  is a matrix summarizing the socioeconomic characteristics of the  $j^{\text{th}}$  county.

$W_j$  is a weight matrix for neighboring counties.

$Z_j$  is a matrix summarizing the socioeconomic characteristics of the surrounding counties.

$R_j$  is the sum of the county and the state sales tax rate in the  $j^{\text{th}}$  county.

And  $\eta_j$  is an error term.

As in the logit model,  $X_j$  contains information about the county's population, its growth rate, the proportion of population living in urban areas; its localization (border of the state or not); and if the county participated or not in the holiday (dummy variable: one if county participated, zero if not). I expect that the coefficient associated with county's population would be positive, meaning that a higher percentage of cities will be willing to participate in the sales tax holiday, given that they have more competition within the county. The sign associated with the county's population growth rate could be either positive or negative as in the logit model. The sign associated with the proportion of population living in urban areas is undetermined. If the county's

urban population is from many smaller cities, the percentage willing to participate may increase as the cities compete with each other. If the county's urban population is concentrated in a single city that may not be willing to give up to the revenues that they know they will get "anyway" because they do not have many retail competitors. I expect a positive sign associated with the location of the county (border effects). I expect a positive sign associated with the dummy variable if the county participated or not in the holiday.

The  $W_j$  matrix is defined as rook contiguity that only considers counties with common boundaries to define neighbors (Anselin, 2003).  $Z_j$  matrix contain the same variables as in the logit specification for the neighboring counties.

The county's sales tax rate  $R_j$  is a variable that the city cannot control and after controlling for the county participation I expect a positive sign, a high county rate would cause the city to participate.

### **1.5. Data**

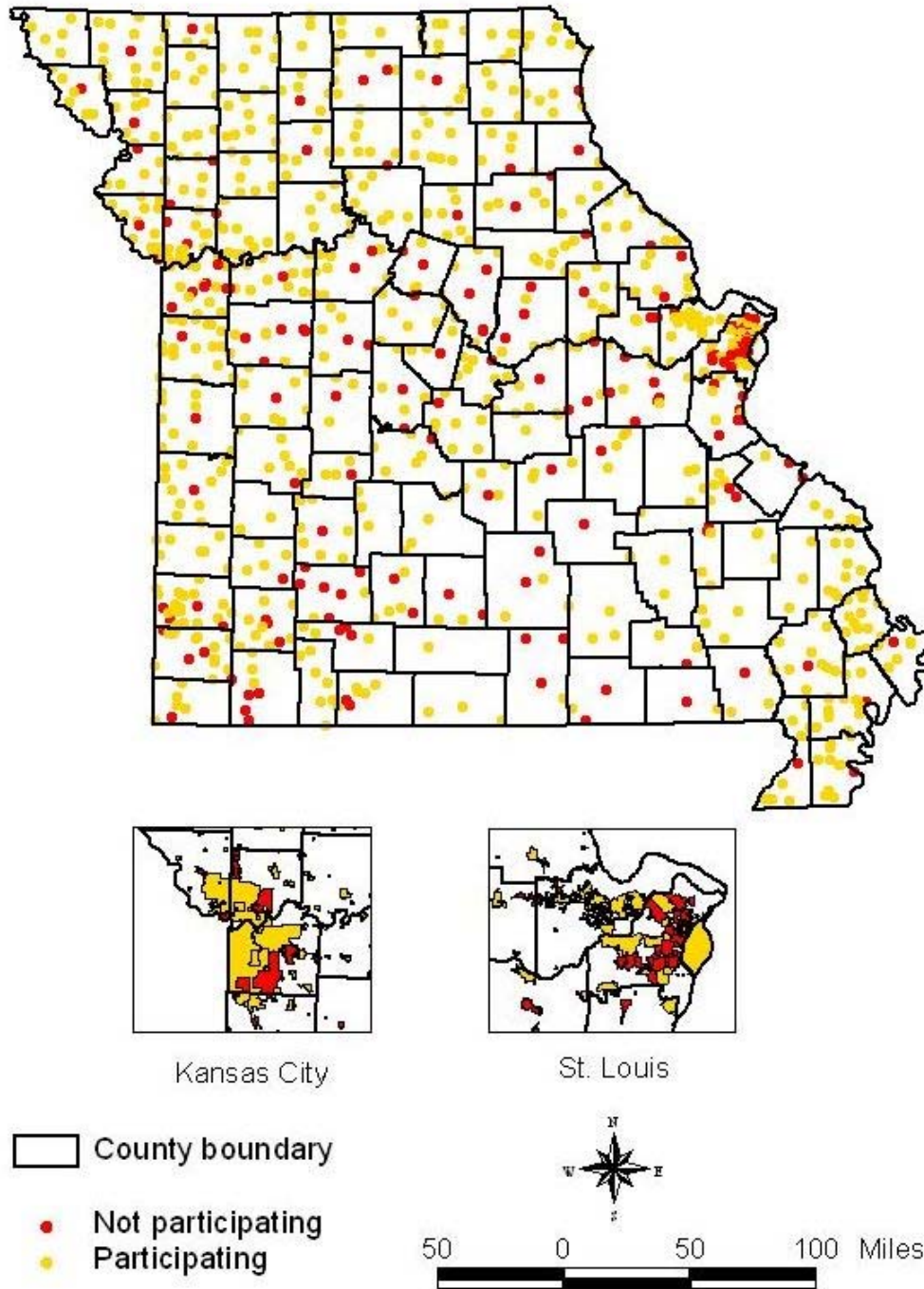
In this section I describe the data used in this study. I also present the sources for these data and a map of the distribution of the cities participating in the 2004 Missouri Sales Tax Holiday (Figure 1-1). As mentioned before I define our logit dependent variable as 1 if the city stays in the tax holiday and 0 if the city opted out of the tax holiday. The data regarding this variable were obtained from the List of Sales Tax Holiday of the Missouri's Department of Revenue (Missouri Department of Revenue, 2005a). This list provides information about 179 cities that had notified the Department of Revenue that they would not participate in the August 2004 sales tax holiday.

A similar list is provided for 66 counties that had notified the Department of Revenue that they would not participate in the August 2004 sales tax holiday (Missouri Department of Revenue, 2005b).

The total number of cities after merging different databases used in this study is: 912. From these 733 participate in the 2004 sales tax holiday, and 179 did not.

The data for population were taken from the Census Bureau 2000, and the growth rate was calculated based on the cities' population from 1990 and 2000. The proportion of population living in urban areas was calculated with the 2000 data.

Figure 1-1. Cities participating in the Missouri Sales Tax Holiday, 2004.



The sales tax rates correspond to the July–September 2004 period provided by the Missouri’s Department of Revenue (Missouri Department of Revenue, 2004a).

The border dummy variable is defined as: 1 if the city is on a county that is on the state border, and 0 if the city is on a county that is not on the state border.

The number of cities in the county was taken from the Census Bureau on Government Organization (2002). In the same way the number of cities in surrounding counties was obtained by adding the number of cities in each of the contiguous counties.

It is important to mention that the cities that are in more than two counties were listed separately in each county in the databases. Then the cities in more than one county were placed in the county where the largest proportion of city population lives.

## 1.6. Results

### 1.6.1. Logit model

As mentioned above, the dependent variable in this model is a dichotomous variable that takes a value one if the city participated in the 2004 sales tax holiday in Missouri and zero if opted out. Given this characteristic, the ordinary least squares (OLS) method cannot be used in this study<sup>8</sup>, instead I use a maximum likelihood binary logit estimation method. In this section I present the results for estimations of Equation 6 with the variables specified in the data section.

Table 1-2. Logit estimation results

VARIABLE	1	2
Intercept	10.5917 ***	10.9622 ***
Log(Population)	-0.6674 ***	-0.6616 ***
Population growth rate 1990-2000	0.1211	
Sales tax rate	-0.7764 ***	-0.7788 ***
City in border county	0.4590 **	0.4694 **
County participated in holiday	0.6669 ***	0.6580 ***
# of cities in the county	-0.0122 ***	-0.0124 ***
# of cities in surrounding counties	0.0000004	0.0002
S.E. of regression	0.3425	0.3425
Sum squared resid	106.0308	106.1555

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01

<sup>8</sup> Using OLS would yield unbiased but inefficient estimators, because the error terms will be heteroscedastic (Gujarati, 1997).



The estimations of two functional forms of Equation 6 are shown on Table 1-2. Looking at the regression and prediction indicators it can be said that the estimations in columns one and two are very similar.

Table 1-3 is a transformation of Table 1-2 to provide a better interpretation of the coefficients shown in Table 1-2, using this formula  $[\text{EXP}(\text{regressor})-1]*100$ . It expresses the probability of the city participating with respect to not participating.

**Table 1-3. Percentage change on  $\left(\frac{\hat{P}}{1 - \hat{P}}\right)$  for a regressors' unit increase.**

VARIABLE	1	2
	(%)	(%)
Log(Population)	-48.70 ***	-48.40 ***
Population growth rate 1990-2000	12.87	
Sales tax rate	-53.99 ***	-54.10 ***
City in border county	58.25 **	59.90 **
County participated in holiday	94.83 ***	93.08 ***
# of cities in the county	-1.21 ***	-1.24 ***
# of cities in surrounding counties	0.00005	0.02

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01.

The negative coefficient associated with population indicates, as expected, that larger cities are less likely to participate, they have less competition because of the amount of retail they have to offer. This result is similar to the results presented by Brett and Pinkse (2002). In the estimation that included the population growth rate variable I observe that it has a positive sign. That means that cities that are growing faster are more likely to participate in the holiday than the ones with lower population growth rates, but this coefficient is not significant.

The sales tax rate also shows a negative and significant sign. Taking the antilog of the coefficient and subtracting one shows that a one percentage point increase in the rate will induce a reduction in the probability of participating in the sales tax holiday with respect to the probability of not participating by -54 percent (see Table 1-3).

When I was describing the data we mentioned that if the sales tax rate shows a positive sign it can be an indicator of competitiveness, but in this case, because the sign is negative I would say that it indicates revenue dependence on sales taxes. That is, cities with higher sales tax rates rely more on sales taxes than the ones with lower rates, and are less willing to participate in the sales tax holiday. They do not want to give up these revenues.

I test for state border effects by including a variable that indicates if the city is in a border county or not. I find evidence that cities in border counties are more willing to participate in sales tax holidays than interior cities. Being at a state border increases the possibility of cross border shoppers coming across and also buying things that are not on holiday. If the city is located in a border county its likelihood of participating in the tax holiday will increase around 58 percent (Table 1-3).

As I expected, the decision made by a city's county also affects the city's decision. As noted in previous sections, I know that these decisions were made approximately

concurrently, but we assume that the local governments talked to each other and have a good idea how the decision will go. In particular, if the county participates the probability of the city participating with respect to not participating will increase 94 percent. This result supports the idea that vertical tiers could be reacting to the same competitive situation as Revelli (2001) suggests (geographical neighbors are more likely to experience similar shocks).

The number of cities in the county shows a negative and significant sign indicating that the more cities in the county, the less the city will be willing to participate in the sales tax holiday. This result is counter intuitive because I expected that the city will compete with its neighbors to bring in more buyers. The results for this variable indicate that if the number of cities within the county increases by one, the probability that the given city will participate in the holiday will decrease by one percent with respect to not participating. This may be because St. Louis' county has a large number of cities (approximately 90 that represent 10% of our observations) and there is a sales tax revenue-sharing agreement among the cities and between cities and the county.

In the case of the number of cities in the surrounding counties I observe a positive sign indicating that more competing cities increases the probability that a city will participate in the tax holiday. However the coefficient associated with this variable is not significant.

In general terms it can be said that there are some factors that might be influencing local governments' decisions more than others. The own-city characteristics (population and sales tax rate) and the county's decision to participate or not in the sales tax holiday seem to be the variables that most affect the decision of local governments to participate in the holiday.

As noted in the literature review there are other ways to approach this kind of analysis, in particular, if I want to consider spatial autocorrelation among jurisdictions I need to specify a spatial model. In the next section I present the results for our spatial specified model.

### **1.6.2. Spatial Model**

In order to know if we need to estimate a spatial lag or a spatial error model first I need to estimate an ordinary least squares (OLS) model and then analyze its diagnostic spatial dependence measures. The dependent variable of this model is the percentage of cities in a given county participating in the holiday. Thus, this model uses county data rather than city-level data.

Table 1-4 shows the results for a usual OLS regression method. The coefficient associated with population is, as expected, positive indicating that if the county has a

large population a higher percentage of cities will participate in the sales tax holiday, this can be considered a competitiveness indicator. The coefficient associated with the county's population growth rate is positive, however, this coefficient is not significant. The proportion of population living in urban areas has a negative and significant coefficient, indicating that in more urban counties, cities are less willing to participate in the sales tax holiday.

The county sales tax rate is a variable that is not under the control of the city's government, it shows a negative sign indicating that in counties with lower sales tax rates the proportion of the cities participating was larger. However, it is not significant, suggesting that the cities take this as a given and it does not affect their decision.

Contrary to what the logit estimation shows, the location of the county on the border of the state shows a negative and significant sign. Missouri is a state with a lower state sales tax rate than its neighboring states; once the state sales tax is taken off the local-option sales taxes will be lower than the sales tax rate in the surrounding states. Thus, there is no incentive to lower the city's sales tax to attract out-state consumers.

As in the logit estimation, county participation is positively related to the percentage of cities participating in the holiday, suggesting that vertical government tiers move together.

Finally the county per capita income, the number of cities in the county, and the number of the cities in surrounding counties show negative but not significant coefficients.

**Table 1-4. OLS results**  
**Dependent variable: proportion of cities in the county participating in the sales tax holiday**

<b>VARIABLE</b>	<b>OLS</b>	<b>Standard Errors</b>
Intercept	0.1928	0.3095
Log(Population)	0.0731 **	0.0286
Population growth rate 1990-2000	-0.0014	0.0017
Proportion of population living in urban areas	-0.2023 *	0.1182
Sales tax rate	-0.0852	3.5049
County in state border	-0.1101 ***	0.0389
County participated in holiday	0.0981 ***	0.0361
Income	-0.000003	0.000007
# of cities in the county	-0.0013	0.0027
# of cities in surrounding counties	-0.000007	0.0010
R-squared	0.1429	

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01.

The diagnostics on the OLS regression (Table 1-5) suggest that we do not need to estimate a spatial lag nor spatial error models. The coefficients associated with spatial autocorrelation variables are not significant. If both of the Lagrange Multipliers for a spatial lag or a spatial error are statistically significant, then the corresponding spatial model should be estimated (Anselin, 2007). However I present these estimations in Appendix B. In these models the coefficients on the spatial lag and the spatial error are not statistically significant, confirming that the spatial models are not needed.

These results could be because I have already included variables that contain spatial information, like the state border dummy, number of cities in the county and in

surrounding counties. The non significance of the spatial tests in the OLS model provides greater confidence in the results of the logit model.

**Table 1-5. Diagnostics for spatial dependence. OLS estimation**

<b>Test</b>	<b>MI/DF</b>	<b>Value</b>	<b>Prob</b>
Moran's I (error)	0.0192	0.8153	0.4149
Lagrange Multiplier (lag)	1	0.3875	0.5336
Robust Lagrange Multiplier (lag)	1	0.1013	0.3117
Lagrange Multiplier (error)	1	0.7373	0.7502
Robust Lagrange Multiplier (error)	1	1.1248	0.3905

### **1.7. Conclusions**

In this paper I reviewed the literature regarding strategic interaction among jurisdictions and border effects due to tax differentials. Tax rates are a reflection of the choices made by local governments in response to the demand for local public services and the available tax base, but they are also a reflection of competing jurisdictions. The strategic interaction among jurisdictions plays a role in making fiscal policy decisions. Among these interactions are *border effects* that tax differentials can generate because of tax holidays.

In August 2004 Missouri held its first sales tax holiday. Local governments had the option to participate or not in the holiday. Counties and cities had to make an

approximately concurrent decision about their participation. In this paper I used a logit method to estimate whether or not cities will participate or not in a sales tax holiday. I found that local governments consider their own characteristics and their neighbor's characteristics when making the decision to participate in the tax holiday. I also found evidence that the decision made by other cities in the county affects the decision of the city to participate. The county's decision to participate in the sales tax holiday increased the participation of cities.

Strategic interactions among government suggest the use of a spatial interactions model. I used GeoDa to perform our analysis, but this software does not support binary dependent variables, so instead I used a spatial model to analyze the percentage of cities in a given county (a continuous variable) participating in the sales tax holiday.

In order to know if I need to estimate a spatial lag or a spatial error model first I estimated an OLS model. After analyzing its diagnostic spatial dependence measures I concluded that there was no need to estimate a spatial model. The OLS results suggested that in counties with larger population a higher percentage of cities will participate in the sales tax holiday, competing for costumers. Contrary to what I found in the logit analysis, counties located in the border of the state there are less cities willing to participate. The county decision to participate in the tax holiday also increases the percentage of cities participating. Whereas cities in more urban counties are less willing to participate in the holiday.



At the time of this research, I did not have access to spatial logit or probit software. As this software becomes more readily available it opens up avenues for future research. The logit and spatial models' dependent variables are not comparable, and the explanatory variables are measured at different levels (at city level for the logit, and at county level for the spatial model). At the same time, the insignificance of the spatial tests in the OLS model gives us greater confidence in the results of the logit model.

## Chapter 2 . Convergence of Mexican states, 1993-2004

### 2.1. Introduction

Neoclassical economic growth models have predicted that if economies are similar with respect to preferences and technology, poorer ones will grow faster than richer ones (Solow, 1956), generating *economic convergence* among them. Barro and Sala-i-Martin (1991; 1992) have studied the convergence question, developing econometric models to analyze the broadly used  $\beta$  and  $\sigma$  convergence indicators. “ $\beta$  *convergence* relates to poor economies growing faster than rich ones and  $\sigma$  *convergence* involves a decline over time in the cross-sectional dispersion of per capita income or product” (Barro and Sala-i-Martin, 1991, pp. 112).

Since Barro and Sala-i-Martin’s publications (1991; 1992) a large literature has developed testing convergence. Most of these contributions focused on the analysis of income per capita as an indicator of economic convergence. However, in the last few years the United Nations, the OECD, and some other organizations, have stressed the importance of other development variables, as indicators of economic development. In

this paper I test for output per unit of labor convergence across Mexican states for the 1993-2004 period.

I summarize the literature related to convergence analysis and the main empirical findings since Barro and Sala-i-Martin (1991; 1992) studies. Then I summarize empirical convergence studies for Mexico that show mixed results and indicate that rather than convergence, since increasing the Mexican economy's openness (signing trade agreements like the General Agreement on Tariffs and Trade GATT and the North America Free Trade Agreement NAFTA), Mexican states are diverging.

I specify a convergence model to analyze Gross State Output (GSP) per working age population. Using panel data with state level observations for 1993-2004, I control for physical capital investments, net migration rate, indigenous population, and marginalization levels.

Next I describe the data used in this study, present the estimations results, and derive conclusions from this study.

## **2.2. Convergence Literature**

The neoclassical model developed by Solow (1956) is based on a function where output depends on capital and labor, and an exogenous technology level. In the long-run, capital formation generates economic growth using aggregate savings to finance additions to the national capital stock. An economy with an initially low capital-labor ratio will have a high marginal product of capital. Then, if a constant fraction of the income generated by a new piece of equipment is saved, the gross investment in new capital goods may exceed the amount needed to offset depreciation and to equip new members of the workforce. Over time, capital per worker will rise, which (with constant returns to scale and fixed technology) will generate a decline in the marginal output of capital. As the marginal output of capital continues to fall, the savings generated by the income accruing to new capital also will fall, and eventually will be only just sufficient to replace worn-out machines and equip new workers. At this point the economy enters a *steady state* with an unchanging standard of living. As pointed out previously, Solow (1956) predicted that economies can converge to a *steady state*, and also predicted convergence of economies to a common level because poorer economies will grow more rapidly than richer economies.

The concept of *economic convergence* had been broadly studied and empirically tested since the Barro and Sala-i-Martin publications in 1991 and 1992. Barro and Sala-i-Martin

(1991; 1992) investigate whether Solow's (1956) conclusion on convergence to a steady state in the standard neoclassical growth model with exogenous technological progress and a closed economy holds for the U.S. states, European countries, 98 countries, and the 20 original OECD members.

To analyze the convergence behavior of U.S. states Barro and Sala-i-Martin (1991) used the following equation:

$$(1/T) \cdot \log(y_{it} / y_{i,t-T}) = x_i^* + \log(\hat{y}_i^* / \hat{y}_{i,t-T}) \cdot (1 - e^{-\beta T}) / T + u_{it} \quad (1)$$

Where  $i$  indexes the economy,

$t$  indexes time,

$T$  is the length of the observation interval,

$y_i$  is per capita output, income per person, or income per worker,

$x_i^*$  is the steady-state per capita growth rate corresponding to exogenous, labor-augmenting technological progress in Solow's model,

$\hat{y}_i^*$  is the steady-state level of output per effective worker (the number of workers adjusted for the effect of technological progress),

$\hat{y}_i$  is output per effective worker,

the  $\beta$  coefficient is the rate of convergence, and

$u_{it}$  is an error term.

Thus the convergence coefficient  $\beta$  indicates the rate at which  $\hat{y}_i$  approaches  $\hat{y}_i^*$ , and it depends on the productivity of capital and the willingness to save in the neoclassical growth model (Barro and Sala-i-Martin, 1991).

According to Barro and Sala-i-Martin (1991) closed-economy models cannot be applied literally to different economies (states, regions or countries). If technologies are the same, then convergence in per capita outputs and capital stocks occurs more rapidly in open economies; and the rate of convergence tends to be higher if the flow of technological advances from rich to poor economies is allowed. On the other hand it is also true that human and physical capital may move from poor to rich economies creating a force toward divergence (Barro and Sala-i-Martin, 1991).

Barro and Sala-i-Martin also identify  $\sigma$  convergence. There is  $\sigma$  convergence when there is a decline over time in the cross-sectional dispersion of per capita product (income) i.e. the dependent variable in Equation 1.  $\sigma$  convergence is achieved when the dispersion (variance) of the natural logarithm of state product (or income) per capita decreases over time. According to Martin and Sunley (1998), the concept of  $\sigma$  convergence is closely related to that of  $\beta$  convergence. The existence of  $\beta$  convergence will tend to generate a decline in per capita product (income), that is, it will generate  $\sigma$  convergence. However, the latter also depends on the variance of the error term or 'shocks' in Equation 1, and the long-term (steady-state) dispersion could be increasing

because of these shocks. Thus the existence of  $\beta$  convergence is a necessary but not sufficient condition for  $\sigma$  convergence.

The distinction between  $\beta$  and  $\sigma$  convergence can be understood with two different kinds of questions. First, suppose that I want to know how fast and to what extent the per capita income of a particular economy is likely to catch up to the average of per capita incomes across economies. Then  $\beta$  convergence is the concept that matters. On the other hand, if I want to know how the dispersion of per capita income across economies has behaved in the past or is likely to behave in the future, then  $\sigma$  convergence is the relevant concept (Barro and Sala-i-Martin, 1991).

Barro and Sala-i-Martin(1992) found the existence of  $\beta$  convergence in the sense that economies tend to grow faster in per capita terms when they are further below the steady-state position of personal income and gross state product. They found  $\beta$  convergence for the U.S. states over various periods from 1880 to 1988. They found that poor states tend to grow faster in per capita terms than rich states, and that the speed of convergence appears to be roughly the same (2% per year) regardless of the time period or whether they considered personal income or GSP.

Barro and Sala-i-Martin (1992) also found evidence of  $\beta$  convergence for a sample of 20 OECD countries from 1960 to 1985 in a *conditional* sense, that is, only if they hold constant variables such as initial school enrollment rates and the ratio of government

consumption to GDP. They interpreted these variables as proxies for the steady-state value of output per effective worker and the rate of technological progress. When they hold constant these additional variables, the estimated rates of convergence were only slightly smaller than those found for the U.S. states.

The standard neoclassical growth model with exogenous technological progress and a closed economy predicts  $\beta$  convergence. If technologies are the same, then the introduction of a global capital market tends to speed up the  $\beta$  convergence for output but to slow down the  $\beta$  convergence for income. The empirical results for the U.S. states from Barro and Sala-i-Martin (1992) indicate that the speed of  $\beta$  convergence for output is only slightly faster than for income. At this point, they were able to reconcile this finding with the theory only if they include elements of capital market imperfections, such as a limited ability to borrow to finance accumulations of human capital.

The endogenous economic growth models developed by Lucas (1988) and Romer (1986; 1990) allowed the analysis of the human capital variables, incorporating them as part of the technological change that years before Solow (1956) took as exogenous. Rebelo (1991) used Lucas's and Romer's ideas to build a model of endogenous economic growth in an open economy that assumes constant returns to a broad concept of capital that includes human capital. Rebelo (1991) also points out that some elements of an open economy--the mobility of labor and technology--tend to speed up the predicted



rate of  $\beta$  convergence as in Barro and Sala-i-Martin (1991). Furthermore Barro and Sala-i-Martin (1992) found that in open-economy versions of the neoclassical growth model, it is possible to find  $\beta$  convergence effects associated with technological diffusion even if the returns to physical capital are constant. This is possible because technological diffusion can create increasing returns to investments in human capital, thus increasing  $\beta$  convergence rate.

The concept of conditional convergence has been also related with the notion of *club convergence*. Baumol (1986), Quah (1996) and Durlauf and Quah (1999) have tested for club convergence among economies. In particular, Quah (1996) critically reviewed Barro and Sala-i-Martin's (1991; 1992) key findings, clarified their implications, and related them to empirical results. Quah (1996) paid particular attention to  $\beta$  convergence empirics' interpretations. One of his main critiques is that the uniform 2 percent rate of  $\beta$  convergence could arise for reasons unrelated to the dynamics of economic growth, like to an uninteresting statistical uniformity (0.02 unit root in time series). He also pointed out that usual empirical analyses--cross-section (conditional) convergence regressions, time-series modeling, panel data analysis--can be misleading for understanding convergence because economic structures vary in many ways across environments, and "thus cannot be the source for the 2% uniformity" (Quah, 1996 p. 1355). Quah (1996) proposes a model that makes predictions on cross-section dynamics by linking three observations: "(i) countries endogenously select themselves into groups, and thus do not act in isolation; (ii) specialization in production allows exploiting

economies of scale; and (iii) ideas are an important engine of growth” (Quah, 1996 p. 1368).

Quah (1996) found that cross-sections, or countries, have incentives to form coalitions of *like partners*<sup>9</sup>, and that there exist incentives to fragment within the overall set of countries. This result indicates that income distribution can stratify and the gap between rich and poor increase. Thus, convergence will only take place within relatively homogeneous convergence clubs. Groups of economies (countries, states, regions) that share some common characteristics tend to converge: the poor getting relatively poorer, and the rich richer, with the middle class vanishing. Quah’s suggestions for club formation would be to group countries within the context of their most important trading partners and/or their geographic location. The idea of club formation seems analogous to the idea of neighborhood effects used in the paper on participation in a sales tax holiday included in this dissertation.

Besides addressing the econometric issues in convergence analysis pointed out by Quah (1996), Carlino and Mills (1996) also reviewed Barro and Sala-i-Martin (1991; 1992) studies and found that, as mentioned previously, economic shocks could be an important source for divergence. Carlino and Mills (1996) found that that after decades of apparent convergence, state and regional per capita earnings in the U.S. start

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<sup>9</sup> Barro and Sala-i-Martin (1992) suggest that more homogeneous economic groups will converge to a similar U.S.  $\beta$  convergence of 2%, while when considering more heterogeneous groups (98 OECD countries) this  $\beta$  convergence decreases.

diverging between 1978 and 1988 as a result of economic shocks. They point out that “two conditions are required for convergence<sup>10</sup>: shocks to relative [to the nation] regional per capita earnings should be temporary, and regions having per capita earnings initially above their compensating differential should exhibit slower growth than those regions having per capita earnings initially below their compensating differential” (Carlino and Mills, 1996 p. 598). The purpose of their paper was to examine the convergence characteristics of the U.S. states and regions using time-series techniques. Their hypothesis was that “if convergence holds anywhere, it should hold for the U.S. states and regions where factors of production can freely migrate across states and regions. Convergence resulting from factor migration suggests that the appropriate variable of analysis should be based on earnings and not income” (Carlino and Mills, 1996 pp. 598) which includes interest, dividends, and transfer payments.

A simple time series model of a state economy is developed by Carlino and Mills (1996) to illustrate the determinants of state per capita earnings, and to show why per capita earnings need not to be equalized across states in long-run equilibrium. They found that for the 1929-1978 period “although per capita earnings are not equalized across states, per capita earnings have converged in the conditional sense in that differences in per capita earnings across states appear to be compensatory in nature” (Carlino and Mills, 1996 p. 613-615). Twelve U.S. states were found to be converging from above

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<sup>10</sup> Carlino and Mills (1996) call cross-sectional convergence the situation when regions having per capita earnings initially above their steady state exhibit slower growth than those regions having per capita earnings initially below their steady state. This can be understood as Barro and Sala-i-Martin’s (1991)  $\beta$  convergence concept.

(negative rate of change in relative regional per capita earnings) and 25 U.S. states were converging from below (positive rate of change in relative regional per capita earnings). Furthermore, their findings suggest that “convergence had been achieved by the end of World War II and that the divergence episodes of the late 1970s to late 1980s were temporary” (Carlino and Mills, 1996 pp. 615).

But not only external shocks have caused *temporary divergence periods* as Carlino and Mills (1996) suggest; Pritchett (1997) states that divergence in relative productivity levels and living standards is the dominant feature of modern economic history across countries. According to Pritchett’s (1997) calculations and supporting Quah’s (1996) arguments, in the last century, incomes in the less-developed countries have fallen far behind those in the developed countries (European countries and their offshoots<sup>11</sup> plus Japan), both proportionately and absolutely. Pritchett (1997) estimates that from 1870 to 1990 the ratio of per capita incomes between the richest and the poorest countries increased by roughly a factor of five and that the difference in income between the richest country and all others has increased by an order of magnitude. It can be said that Pritchett (1997) implies the concept of convergence clubs developed by Quah (1996). Pritchett argues that this divergence across countries is the result of different patterns in the long-run economic performance of two sets of countries--two convergence clubs.

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<sup>11</sup> The European countries include: Great Britain, Belgium, Netherlands, Switzerland, Denmark, Germany, Austria, France Sweden, Italy, Norway, and Finland. The offshoots: Australia, New Zealand, U.S., and Canada.

In the group of currently developed countries<sup>12</sup>--European countries and their offshoots and Japan--Pritchett found that since 1870, the long-run growth rates of these countries have been rapid, their growth rates have been similar, and the poorer members of the group grew sufficiently faster to produce considerable convergence in absolute income levels. But in the set of developing countries the growth rates have been, on average, slower than the richer countries, producing divergence in relative incomes between the two sets. Also among this last set of countries there have been different patterns of growth across countries, with some converging rapidly on the leaders while others stagnate; there has been a mixed record of takeoffs, delays and fall downs, suggesting several clubs.

Pritchett (1997) points out that there are countries that are rich now and were rich historically, in which case they all have had the same growth rate (Europe) or countries that are rich now and were poor historically (Japan). But there are another set of countries that grew much more slowly and went from relative riches to poverty (Argentina) or countries that were poor and grew slowly as to become relatively poorer (India). Pritchett also point out that there are forces that can create the potential for explosive growth in poor countries, such as those in some countries in East Asia; but

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<sup>12</sup> Pritchett (1997) present data for seventeen *presently* high-income industrialized countries, "which Maddison (1995) defines as the "advanced capitalist" countries" p. 4. These include: Australia, Great Britain, New Zeland, Belgium, Netherlands, USA, Switzerland, Denmark, Germany, Austria, France, Sweden, Canada, Italy, Norway, Finland and Japan. It's important to mention that not everybody would agree with this classification, and it could be argued that data should be taken from the seventeen 1870's high-income countries.

there are in addition strong forces for stagnation: he found that a quarter of the 60 countries with initial per capita GDP of less than \$1,000 in 1960 have had growth rates less than zero, and a third have had growth rates less than .05 percent. Very low income or output seems to carry severe disadvantages, and some of these countries could fall in poverty traps, i.e. low education, less job opportunities, less income and market access, resulting in less education opportunities for younger generations, falling in a vicious circle.

Pritchett's (1997) findings about poor countries suggest that there could be a role for public policy in order to help poor countries out of their poverty traps. In this sense, Button (2000) reviewed the main conclusions of endogenous economic growth models and human capital investments (Romer 1986, 1990 and Lucas, 1988), as well as the theoretical framework developed by Barro and Sala-i-Martin (1991;1992) to analyze convergence among economies and incorporated Aschauer's (1989) ideas about the importance of investing in infrastructure to promote economic growth. Then infrastructure investments could be considered as a policy tool to encourage economic growth.

Button (2000) looks at the linkages between the developments in spatial economics that have changed the way that convergence is viewed. He indicates that "the recent work on the role of infrastructure becomes relevant because if neoclassical convergence mechanisms are not strong enough to bring about the necessary factor return

adjustments, then some intervention strategy is required” (Button, 2000 p. 481). The notion that infrastructure investments can be a supplement and a complement to private capital in a region and so enhance its economic performance, as Aschauer (1989) suggests, can be seen as a mechanism to stimulate a self-sustaining growth process in an otherwise economically backward region. The work of Aschauer (1989; 1998; and 2000) has provided some evidence that the quality of infrastructure can matter in terms of productivity. And Button (2000) stresses that “evidence that public infrastructure generates a significantly higher rate of return than private capital may be seen as a stimulus for policy reformation at a time [of] government withdrawal in many countries” (Button, 2000 p. 488-489).

But not just infrastructure and human capital roles have been analyzed in convergence analysis; little by little more *development indicators* have been analyzed in the convergence theoretical framework. McCoskey (2002) uses a panel data study to investigate the convergence properties of six indicators of well being in Sub-Saharan Africa countries (capital per worker, openness of the economy, real GDP per capita, standard of living, and real GDP per worker). She uses unit roots and cointegration analysis to test convergence among those indicators. Overall she finds little evidence for claims of convergence across Africa, although in some cases, smaller convergence clubs within Africa may be found (openness of the economy and standard of living). McCoskey (2002) uses Quah’s (1996) concept of convergence clubs and indicates that

the use of panel data tests<sup>13</sup> to investigate convergence properties offers several advantages (unit roots and cointegration tests) over the strict time series case for the testing and establishing of coherent convergence clubs.

Panel data approaches also show some advantages over cross-section techniques. The work of Islam (2003) points out how cross-section approaches rely on the assumption of identical technologies across economies; but “allowing for technological differences have a significant impact on the estimated values of the convergence parameters” (Islam, 2003 p. 326). Islam (2003) indicates that in the absence of technological shifts, diminishing returns set in rather quickly; and that there is not much evidence of an externality associated with physical capital. “The panel results also indicate that the way human capital influences output is perhaps different from the way physical capital does” (Islam, 2003 p. 326). Islam (2003) suggests that externalities associated with human capital may be larger than those associated with physical capital.

Within the theoretical framework of the new endogenous growth theories, Duranton and Monastiriotis (2002) analyze earnings behavior for U.K. regions over 1982–1997. They found evidence of rapid convergence across regions regarding the determinants of individual wages (i.e., regional fixed-effects, gender gaps, and returns to education and

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<sup>13</sup> McCoskey (2002) uses the IPS panel data test of the null hypothesis of nonstationarity (the null hypothesis is that all series in the panel contain a unit root, against the alternative that none of them contain a unit root); the McCoskey-Kao test of the null hypothesis of cointegration (this panel test allows for a heterogeneous cross-sections, and for individual estimation of a potential cointegrating vector); and the test of the null hypothesis of no-cointegration.



experience). In contrast, data on average regional earnings point to a worsening of U.K. regional inequalities and a rise in the North-South gap.

To explain these seemingly contradictory findings Duranton and Monastiriotis (2002) proposed these questions: Do *similar* individuals have the same wage across U.K. regions? How have the differences evolved in the last 20 years? Duranton and Monastiriotis (2002) proceed in two steps, first regress individual wages for full-time employees on individual characteristics (sex, education, experience, and its squares). Each regression is run using a full set of regional dummy variables. As far as the estimated coefficients are concerned, this is equivalent to running separate regressions for each region. Individuals cannot be identified and followed over time, so a separate cross section is run for each available year of observation. This allows for each coefficient to vary across regions and across time. Thus for each region-year they obtain a constant (hereafter the regional fixed effect), a gender gap, returns to education and experience, and a depreciation of experience.

Duranton and Monastiriotis (2002) found that there has been “a movement of wage equalization across U.K. regions between 1982 and 1997 in both regional fixed-effects and in the returns to key labor market characteristics such as experience, education, and sex. By contrast, the cross-region distribution of education is increasingly uneven. In conjunction with the national trend of rising and converging returns to education, this has generated an increase in aggregate regional inequalities over 1982-1997” (Duranton

and Monastiriotis, 2002 p. 247). This phenomenon can provide an explanation for migration from poorer economies to rich ones.

Education accounts for most of the discrepancy between aggregate divergence and disaggregated convergence. First, London gained because its workforce became relatively more educated over the period. Second, returns to education increased nationwide, which favored the most educated regions (i.e., London). Third, returns to education were initially lower in London but they (partially) caught up with the rest of the country. If the returns to education and their distribution across U.K. regions had remained stable over the period, then the U.K. North-South divide would have decreased. Thus Duranton and Monastiriotis (2002) suggest that regional policy should direct more of its attention to education and its determinants at a regional level. Infrastructure and human capital investments could contribute to decreasing the divergence patterns identified in the U.K.

Lim and McAleer (2004) apply Barro and Sala-i-Martin (1991; 1992)  $\beta$  and  $\sigma$  convergence analysis and Quah's (1996) convergence clubs concept to determine if there is a convergence club for ASEAN-5<sup>14</sup>, as well as ASEAN-5 and the USA. Lim and McAleer (2004) indicate that most countries in South-East Asia, particularly the five founding ASEAN member countries (ASEAN-5), have experienced substantial economic growth, with the pace of growth having varied substantially across countries. The

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<sup>14</sup> ASEAN countries include Indonesia, Malaysia, the Philippines, Thailand and Singapore.

catching up hypothesis states that the lagging country, with low initial income and productivity levels, will tend to grow more rapidly by copying the technology of the leader country, without having to bear the associated costs of research and development. This hypothesis is based on the idea that open economies will converge faster than closed ones.

Lim and McAleer (2004) found that the Philippines had the lowest average annual growth rate of 1.2 percent over the period 1965–92. On the other hand, Singapore's average annual growth rate of 7.2 percent and initial level of real GDP per capita were the highest in ASEAN-5. As for the measure of the technological catching up (the log-difference in real GDP per capita between the USA and the ASEAN-5), the Philippines was the only country in ASEAN-5 that did not reduce its GDP per capita over the period 1965–92. Overall Lim and McAleer (2004) find that "using unit root and cointegration techniques, the time series tests for convergence do not support income convergence between pairs of ASEAN-5 countries... similarly, there is no evidence of technological catching up by ASEAN-5 to the technology leader, apart from Singapore, with further support regarding limited convergence with the USA" (Lim and McAleer, 2004 p. 152).

Tortosa-Ausina, et al. (2005) also review the main contributions of Barro and Sala-i-Martin (1991 and 1992) convergence analysis as well as Romer's (1980) knowledge spatial spillovers concept. They apply  $\beta$  and  $\sigma$  convergence analysis to analyze economic

performance in Spanish provinces. Intense capital accumulation since the 1950s played a key role in a considerable improvement in the standard of living of the Spanish population. But provincial inequalities may increase or decrease as a result of this growth pattern. The Tortosa-Ausina, et al. (2005) study analyzes the evolution of the disparities by means of distribution dynamics techniques. It explicitly considers the economic size of each Spanish province and whether spatial spillovers exist from 1965 to 1997.

Tortosa-Ausina's, et al. (2005) results indicate that the convergence process has been especially rapid for labor productivity, total factor productivity, and capital intensity, while for per capita income the patterns of convergence are slower. But when they weight their analysis according to the economic size of each Spanish province, these conclusions do not hold. However, when they take geographic location and the spillover effects into account, they find that the convergence process speeds up in general; particularly it increases per capita income convergence in Spanish provinces. This finding supports Quah's (1996) idea of convergence clubs; in this case neighbors' economies will benefit from technological progress, given that there are trade and commerce relationships among them. This idea is similar to the neighborhood effects that is used in the paper on sales tax holiday included in this dissertation. Endogenous growth models also treat these effects as agglomeration or cluster economies.

Since the work of Barro and Sala-i-Martin (1991; 1992) came onto the stage in economics, income convergence has been a particularly hot area for economic debate. These growth and convergence studies had been limited in the way that they accommodate the time dimension. For the most part, they use cross-section data sets or cross-sections constructed from observations averaged over time. But since Quah's (1996) critique, convergence studies have been including time series analysis, and the concept of convergence clubs. Also, as Button (2000) points, the data availability has become of high importance. The use of panel data integrates both cross-section and time series techniques, in this paper I use a panel data techniques to analyze convergence among Mexican states.

### ***2.3. Convergence Studies for Mexico:***

This section reviews some of the studies that have analyzed the convergence question for Mexico. After a long period of industrialization based on import substitution, Mexico started to open up its economy by joining the General Agreement on Tariffs and Trade (GATT) in 1986. The export-promotion strategy was transformed into one of regional integration with the signing of the North American Free Trade Agreement (NAFTA) in 1994.

Mallick and Carvannis (1994) point out that a key assumption underlying regional convergence is geographical factor mobility, which is expected to diminish regional differences, but as in other empirical studies (Pritchett, 1996), Mexico has shown inconsistent results on tests of economic convergence. Mallick and Carvannis (1994) point out that “while labor mobility [in Mexico] is encouraged by regional economic differentials, it may be impeded by offsetting factors such as residential housing market illiquidities or by quality-of-life, infra-structural, and tax considerations” (Mallick and Carvannis, 1994 p. 326) that are not sufficiently represented in theoretical models. To these considerations it might be important to note that other social factors could also limit the factor mobility in Mexico, for example the indigenous population in some states, with different cultures and languages.

As mentioned before, Aschauer (1989, 1998, 2000) supports the idea that investments in infrastructure will promote economic growth and economic convergence among economies. In this sense, Mallick and Carvannis (1994) support the idea that labor mobility is facilitated by low transportation costs, but convergence in a less-developed economy may be impeded by the absence of a well-developed transportation and communication infrastructure. They chose Mexico as their preferred less-developed economy because of its location and because of the NAFTA trade policies.

Mallick and Carvannis (1994) examined the rate and industrial composition of economic convergence in Mexico, 1970-1985, using the Barro and Sala-i-Martin  $\beta$  convergence

model (1991; 1992), and Mexico was compared with the U.S. They found that “industries that serve a national market, such as manufacturing, have been found to be more mobile than local industries such as services. Industries that are based on natural resource endowments, such as agriculture and mining, or fixed locational amenities, such as tourism, should also be less mobile than manufacturing” (Mallick and Carvannis, 1994 p. 327).

Mallick and Carvannis (1994) find evidence of stronger convergence in GSP per capita in Mexico relative to previous estimates for the U.S. They found a  $\beta$  convergence rate of 4.18 percent for the 1970-1980 period and a divergence rate of 0.06 (non-significant) for the 1980-1985 period. While manufacturing activity has been found to be a primary source of convergence in the U.S., weaker evidence of manufacturing activity convergence in Mexico was found ( $\beta$  convergence = 1.82 percent for 1970-1980). The study shows weak evidence of regional convergence in Mexican manufacturing in the 1970s, and no evidence of manufacturing convergence in the 1980s. On the other hand, industries such as hotels and transportation were found to be significantly influential in regional convergence in the Mexican economy. The empirical result on transportation was expected, since it supports Aschauer’s arguments that infrastructure investments will promote faster convergence rates. Mallick and Carvannis (1994) propose that the results in the hotels and transportation sectors could be reflecting the change in preferences towards less traditional tourist regions, as well as greater dispersion of transportation-related activity.

Juan-Ramon and Rivera-Batiz (1996) examine state and regional growth in Mexico during 1970-93 (omitting the oil-producing states of Campeche and Tabasco). Evidence of both  $\beta$  and  $\sigma$  convergence of real per capita GDP is found during the period of higher average national per capita growth (1970-85), and divergence is found during the period of lower growth (1985-93). The results indicate that  $\sigma$  convergence holds across states and regions, and within regions. As confirmation of the hypothesis of Barro and Sala-i-Martin (1991; 1992) about  $\beta$  convergence, the poorest states grew more than twice as fast as the rest during the period of higher growth, but experienced absolute and relative decline during the period of lower growth. The growth performance of a poor state in relation to that of the group of poor states, support Quah's (1996) idea of convergence clubs, and it was found to be more erratic over time than the growth performance of a richer state in relation to that of its group.

Convergence is reversed when economic growth halts. Juan-Ramon and Rivera-Batiz (1996) estimate an annual rate of  $\beta$  convergence of 2.4 percent (almost half of Mallick and Carvannis, 1994 findings) for the period of positive average real per capita growth (1970-85) and -1.6 percent for the negative average growth period (1985-93).

Messmacher (2000) analyzed the establishment of the NAFTA, and he tests if NAFTA has largely benefited the northern states of Mexico, generating greater inequality between the north and the south of the country, since the northern states were precisely the



ones with higher income per capita during the period 1993-1999. This study found that the rate of growth of the manufacturing sector has increased substantially since 1993 expanding more than any other sector of activity, with the exception of the transport, warehouse and communications sector. Thus the states in which manufacturing represent a high proportion of production have grown faster. According to Messmacher (2000), given that manufacturing in some of the northern states (Sonora and Sinaloa) does not represent a high share of production, and that the production of some center and southern states (Puebla and Tlaxcala) has a large participation of manufacturing, there is no evidence of relative divergence in the period.

Messmacher (2000) based his analysis on Barro and Sala-i-Martin (1991; 1992)  $\beta$  and  $\sigma$  convergence. For the 1970-1975 period the  $\beta$  convergence rate was 1.5 percent; 0.6 percent for 1975-1980; 5.1 percent for 1980-1985; 0.5 percent (not significant) for 1985-1993 (just before the NAFTA was implemented); and of 3.6 percent for 1993-1999. These findings show a low and discontinuous convergence process. He also tested for differences across states and found that the northern states have a better performance than expected given the composition of their production. This finding supports the idea of Mallick and Carvannis (1994) that the labor mobility associated with each economic sector could affect convergence rates, since Mallick and Carvannis note that manufacturing activities are more mobile than other economic activities (agriculture, mining, tourism).

The previous studies using Mexican states as units of analysis, despite exceptions for some time periods, have supported the convergence hypothesis (eg. Mallick and Carvannis, 1994; Juan-Ramon and Rivera-Batiz 1996; and Messmacher, 2000) and stressed the measurement of convergence in the manufacturing sector. Some of these findings could be due to the link between changes in the Mexican economy (as it has increased its economic openness to international markets) and the evolution of regional disparities (especially among the northern and southern states). According to Sanchez-Reaza and Rodriguez-Pose (2002) “recent changes such as trade liberalization, economic integration, the demise of the *petrolization*<sup>15</sup> of the economy, and the greater inflow of foreign direct investment (FDI) are completely transforming the way Mexican economy is managed” (Sanchez-Reaza and Rodriguez-Pose, 2002 p. 73).

Sanchez-Reaza and Rodriguez-Pose (2002) explore the impact of the opening of the economy on regional disparities in Mexico using  $\beta$  convergence analyses (Barro and Sala-i-Martin, 1991; 1992). They employed four different samples to control for the inclusion of oil-producing (*petrolization*) and maquiladora-based states. The results for the entire country (full sample) show that whereas the final stages of the import substitution period (1970-1985) were dominated by convergence trends, trade liberalization (GATT, 1986-1993) and economic integration (NAFTA, 1994-1998) have led to divergence and greater polarization in Mexico. “Border-states have developed

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<sup>15</sup> According to Sanchez-Reaza and Rodriguez-Pose (2002), “the *petrolization* of the economy in the late 1970s and early 1980s, as a result of the discovery of huge oil reserves in the Gulf of Mexico, and its demise since the mid-1980s.” pp. 74.

specialized industrial centers and are becoming less dependent on traditional labor-intensive maquiladora plants and more reliant on capital-intensive firms in which the Mexican input in the production process is increasing. In contrast, a large percentage of the foreign direct investments being channeled to the center and the south of the country is still concentrated in labor-intensive sectors, such as textiles” (Sanchez-Reaza and Rodriguez-Pose, 2002 p. 87).

Chiquiar (2002) also performed a similar analysis to Sanchez-Reaza and Rodriguez-Pose (2002). He analyzed the effects of the reforms that opened Mexico’s economy to international trade and capital flows in the mid 1980s (GATT) and in the mid 1990’s (NAFTA). According to Chiquiar (2002), the effects of these reforms were not homogeneous across Mexican regions and led to a divergent pattern in regional per capita output levels.

“The reforms apparently had three effects with regional implications. First, they induced a change in overall returns across sectors, affecting southern regions concentrated in agricultural production. The reforms also altered the optimal location choice of manufacturing firms, promoting a movement of economic activity towards the border with the United States and the break-up of Mexico City’s manufacturing belt. Finally, they induced an increase in the skilled-unskilled wage gap, especially in the states that have a border with the U.S. Thus, the existing evidence suggests that the initially richer northern states reaped most of the benefits from the reforms, while the central and southern states hardly registered an improvement in their growth performance” (Chiquiar, 2002 p. 2).

Chiquiar’s (2002) based his study on a sample to include Mexico’s regional growth patterns after NAFTA by exploring what kind of factors may account for the loss of convergence across Mexico’s GSP per capita. His results support the previous findings

that, after 1985,  $\beta$  convergence across Mexican states' per capita outputs was lost, and that this divergent pattern was not reversed after NAFTA started. He also presents results that suggest that the winners from the structural change were those states initially endowed with, or able to attract, higher levels of human and industrial capital and better infrastructure (this support the previous findings by Aschauer (1989; 1998; 2000), Lucas (1988), and Romer (1986; 1990). This was especially true for the northern states, which benefited additionally from their proximity to the United States; this finding is very similar to what Sanchez-Reaza and Rodriguez-Pose (2002) found. In contrast, southern states, whose labor force is more concentrated in agricultural activities and that have the greatest lags in human capital and infrastructure, are not benefitting from the policy shift undertaken during the mid-eighties. These findings could suggest the existence of at least two convergence clubs (north and south) among Mexican states. Note that southern states have more indigenous population.

Esquivel and Messmacher (2002) study the main sources of  $\beta$  convergence in Mexico between 1960 and 2000. They show that the behavior of labor productivity was an important source of convergence in GSP per capita during this period. They explore the evolution of GSP per capita decomposing it into demographic, labor market, and productivity components<sup>16</sup>. They found, however, that this trend did not show during the 1960s and 1980s<sup>17</sup> and that the lack of convergence was mostly due to the evolution

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<sup>16</sup>  $\Delta x_{t,t-1} = \alpha + \beta x_{t-1}$  was the model of the estimated equations where  $x$  were the analyzed variables.

<sup>17</sup> This study considers the 1960's period and in the mid eighties previous studies have shown some divergence patterns, especially between the northern and southern states.

of labor market variables (the employment and the participation rates), whereas the divergent process of the 1990s was mostly driven by the divergence observed in labor productivity. The latter result is particularly worrisome since relatively rich states are becoming more productive and richer than the rest of the country which exacerbates the already high degree of regional inequality that has traditionally characterized the Mexican economy, and supports the idea of two very different convergence clubs (Quah, 1996).

Esquivel and Messmacher (2002) found that the change in the regional pattern of productivity is associated with a structural change that took place during the 1990s (NAFTA and Mexico's trade global integration). They found that the structural change increased the importance of education and infrastructure in the determination of output per capita and productivity. This finding can be related to the Aschauer (1989; 1998; 2000) findings about the importance of infrastructure in convergence, and the importance of human capital in endogenous growth models (Romer 1986; 1990), and suggests that the Mexican government could improve the situation of southern (poorer) states with some policy interventions.

The large degree of inequality in Mexico could be less of a concern if it were falling over time, but previous studies (Juan-Ramon and Rivera Batiz, 1996; Messmacher, 2000; and Sanchez-Reaza and Rodriguez-Pose, 2002) have found that after Mexico opened its economy to international markets, the pattern among the northern and the southern

states has been diverging. Esquivel and Messmacher (2002) suggest that the lack of convergence in output per capita might be due to a lack of absolute convergence in post-primary education and to a slow process of migration across states. Recent technological change seems to have been complementary with human capital, effectively leading to an increase in the return to human capital. But as I mentioned above when discussing Mallick and Carvannis (1994), there could be some other social factors that are slowing the process of migration across states, such as indigenous population that do not have access to markets because of language barriers.

Esquivel and Messmacher (2002) found that labor productivity was the main source of regional convergence in output per capita in Mexico for the 1960-1990 period. However, this trend did not show in the 1960s and 1980s because of the evolution of labor market variables, like population of employed people as a proportion of the economically active population, labor participation rate, and proportion of working age population. In sharp contrast with this trend, labor productivity was the main factor behind the divergence pattern in output per capita across Mexican states that was observed during the 1990s.

Aroca, Maloney, and Bosch (2003) agree with Quah (1996) that standard parametric tests of convergence cannot capture whether convergence behavior is due to some econometric issues or to economic factors. They analyzed the increased dispersion among state incomes to determine if it is due to a steep gradient between north and

south, a few hot states randomly distributed, or as an intermediate position, the emergence of convergence clubs. Aroca, Maloney, and Bosch (2003) built on Quah's idea of convergence clubs, to test for spatial dependency in income levels and growth rates before and after the trade liberalization of 1985 and up to 2000. Looking at levels of income per capita per state and using spatial statistics such as the Moran statistics and the Kernel density plots<sup>18</sup>, they found that there is no growth-driving gradient sloping down from the U.S. and losing steam just before Chiapas.

Aroca, Maloney, and Bosch (2003) clearly identify a *south*, but there are no *north* or *center* regions. Beyond the frontline states on the U.S. border, they define an area as poor as the south and incomes in the central zone itself are almost randomly distributed geographically. Growth shows little evidence of spatial dependency, they found that "the South exists, but there is no longer a North and there never was a Center. This conclusion, again, must be tempered by the finding that if [they] define the northern neighborhood to only include the border states, [they] do find stronger evidence of a convergence cluster. But the discrete income cliff after the front line after which a virtually random pattern emerges interrupted only by the group of 3 or 4 Southern states suggests that proximity to the North is not the exclusive or even overriding determinant of high income levels. This is also supported by the findings that growth appears to be essentially randomly distributed with the exception of a potential (low) growth cluster among Chiapas, Veracruz and Oaxaca [center states] that is not shared

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<sup>18</sup> For more details about the Moran statistics and the Kernel density plots, see Appendix 1 and Figure 3 in Aroca, Maloney, and Bosch (2003).

with other states far from the border. These states are being left behind, but exclusion from the benefits of NAFTA due the lack of proximity to the US does not seem to be the cause" (Aroca, Maloney, and Bosch, 2003 p. 13).

Aguayo-Tellez (2006), using microdata from the 1990 and 2000 Mexican Population Census, decomposed the income per capita divergence into components due to economy-wide changes in skill prices (wages, labor earnings and self-employment income) and components due to state-specific changes in the composition of workers (human capital). In this sense, this study could be related to the one performed in the U.K. by Duranton and Monastiriotis (2002) where they found that education accounts for most of the discrepancy between aggregate divergence and disaggregated convergence among U.K. regions. Aguayo-Tellez (2006) found that the rise in the education premium limited the progress of poor states and raised the variance of average state wages and labor earnings. However, educational attainment mostly compensated for this income-widening effect. State level analysis revealed that the initial level of education, size of the agricultural sector, and distance from the U.S. border were important factors, while public infrastructure was not.

According to Aguayo-Tellez (2006) Mexican states appeared to have long-run  $\beta$  convergence over a period of more than four decades. However, coinciding with the adoption of trade liberalization and other domestic reforms, economic convergence across Mexican states broke down starting in the mid-1980's.



The initial stock of human capital may influence the rate of introduction of new technologies and ideas and as the endogenous growth model suggests (Lucas, 1988 and Romer, 1986; 1990) human capital could also be an important determinant of growth rates and convergence behaviors. Aguayo-Tellez (2006) proxy a state's initial level of human capital by two variables, the mean level of education of the adult population in 1990, and the number of elementary schools for every thousand inhabitants in 1990. Similar considerations lead to the inclusion of a measure of the initial level of public infrastructure. The availability of transportation and a developed communications system in a state is expected to facilitate growth and to attract foreign investment. Two measures of state infrastructure availability are included: the number of telephone lines per capita in 1990 and the number of airports for every thousand inhabitants in 1990. The distance from the U.S. border is included to reflect the innate advantage of being closer to Mexico's major trading partner. A second variable related to Mexico's growing economic interdependence with the U.S., which may affect the growth of different states, is Foreign Direct Investment (FDI) per capita in 1994. The initial share of agricultural employment in a state allows for the possibility that states intensive in the production of agricultural commodities will experience slower growth in wages, especially as the NAFTA liberalized trade in agricultural commodities while economic restructuring decreased agriculture subsidies.

Trade and domestic policies implemented in Mexico during the last two decades of the twentieth century increased wages of skilled workers relative to wages of unskilled workers. At the same time, richer states were relatively abundant in skilled workers. Aguayo-Tellez (2006) found that the economy-wide increase in the skill premium and the uneven distribution of skill endowments across states contributed to the divergence in state incomes. However, skill endowments continued to converge across states. Higher rates of educational acquisition in the poorer states counterbalanced the rise in skill prices. While changes in the prices of skills explained almost one half of the increase in state income inequality, changes in quantities of skills accounted for a one third reduction in such income variability across Mexican states. These findings are very similar to those found by Duranton and Monastiriotis (2002) for the U.K. This implies that unobserved changes in skill prices and quantities and other unobservable factors accounted for most of the Mexican economic divergence.

As has been seen most of the previous studies focused on income (production) per capita at state level across Mexico, but in 2003 Esquivel and Velez analyzed the behavior of the Human Development Index (HDI) that the United Nations Development Program (UNDP) calculates in order to evaluate and make comparisons among different countries. Human development could be considered part of the endogenous growth models, since the indicators that are included in the HDI<sup>19</sup> are related to human capital. Esquivel and Velez (2003) calculate HDI at the state level for the 1950-2000 period in

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<sup>19</sup> According to the UNDP, the HDI includes indicators for life expectancy at birth, adult literacy rate, combined gross enrolment ratio for primary, secondary and tertiary schools, and GDP per capita.

Mexico and compare this result with previous studies on GSP and income per capita analyses. In particular they focus on the  $\beta$  and  $\sigma$  convergence analysis, and found that the HDI and its components converge across Mexican states. When comparing the GSP per capita and the HDI behaviors they found that while the HDI  $\beta$  converges at rates of 3.5-4.6, the GSP per capita converges at rates between 1.5-2.6 percent. Thus the time needed for the HDI to converge is significantly less than for GDP per capita. This empirical finding suggests that investments in human capital take time to be reflected in income or production per capita.

Summarizing, it can be said that studies analyzing Mexican convergence have found that for the 1960-1985 (import substitution) period there is evidence of convergence among Mexican states (Mallick and Carayannis, 1994; Juan-Ramon and Rivera-Batiz, 1996; Messmacher, 2000; Sanchez-Reaza and Rodriguez-Pose, 2002; Chiquiar, 2002; and Esquivel and Messmacher, 2002). Once the Mexican economy started to open to international markets, with the GATT in 1985, divergence patterns were identified (Juan-Ramon and Rivera-Batiz, 1996; Messmacher, 2000; Sanchez-Reaza and Rodriguez-Pose, 2002; Chiquiar, 2002; and Esquivel and Messmacher, 2002). In 1994 the participation of Mexico in the NAFTA increased its economic openness and the divergence pattern remains. In addition two main convergence clubs have been found (Sanchez-Reaza and Rodriguez-Pose, 2002; Chiquiar, 2002; and Esquivel and Messmacher, 2002; and Aguayo-Tellez, 2006). These convergence clubs have been identified as the north and the south, where northern states are specialized in

manufacturing activities and have increased their economic growth, while the southern states had not increased as rapidly as the north, diverging from the north. Human capital has influenced this pattern and states with lower human capital levels and larger indigenous population are located in the south of the country.

The endogenous models have pointed to infrastructure and human capital. In that sense Esquivel and Velez (2003) make an important contribution with an analysis of the HDI and its components. In addition to the previous reviewed literature this paper tests for output per unit of labor  $\beta$  and  $\sigma$  convergence among Mexican states controlling for physical capital, net-migration, human capital, indigenous population and marginalized areas in Mexico.

#### **2.4. Model specification**

The theoretical assumptions of the neoclassical models lead to a very particular empirical model specifications. In particular Mankin, Romer, and Weil (1992) used a Cobb-Douglas Production function to specify Solow's model in a neoclassical framework:

$$(2) \quad Y(t) = K(t)^a (A(t)L(t))^{1-a} \quad (0 < a < 1)$$

Where  $Y$  is output;  $K$  refers to physical capital;  $A$  represents the level of technology;  $L$  represents labor;  $AL$  are the effective units of workers, and  $t$  represents time. This function has constant returns to scale and each factor of production shows positive but diminishing marginal productivity. Similar to the standard neoclassical growth model derivation, Mankin, Romer, and Weil define a production function adding human capital ( $H$ ) accumulation to the Solow model<sup>20</sup>

$$(3) \quad Y(t) = K(t)^a H(t)^c (A(t)L(t))^{1-a-c} \quad a + c < 1$$

According to Mankin, Romer, and Weil (1992) neoclassical models actually predict the speed of convergence to steady state. If  $y^*$  is the steady-state level of income per capita, and  $y(t)$  the actual value at time  $t$ , then the speed of convergence around the steady state would be given by:

$$(4) \quad \frac{d \ln(y(t))}{dt} = \lambda [\ln(y^*) - \ln(y(t))]$$

where  $\lambda = (n + g + \delta)(1 - a - c)$ .

Then Mankin, Romer, and Weil (1992) suggest a regression to study the rate of convergence:

$$(5) \quad \ln(y(t)) = (1 - e^{-\lambda t}) \ln(y^*) + e^{-\lambda t} \ln(y(0))$$

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<sup>20</sup> I use  $c$  instead of  $\beta$  to relate Mankin, Romer, Weil (1992) model to Martin and Sunley's (1998).

where  $y(0)$  is income per effective worker at some initial date. Subtracting  $\ln(y(0))$  from both sides of equation (5),

$$(6) \quad \ln(y(t)) - \ln(y(0)) = (1 - e^{-\lambda t}) \ln(y^*) - (1 - e^{-\lambda t}) \ln(y(0))$$

and substituting for  $y^*$  I get:

$$(7) \quad \begin{aligned} \ln(y(t)) - \ln(y(0)) = & (1 - e^{-\lambda t}) \frac{a}{1 - a - c} \ln(s_k) - (1 - e^{-\lambda t}) + (1 - e^{-\lambda t}) \frac{c}{1 - a - c} \ln(s_h) \\ & - (1 - e^{-\lambda t}) \frac{a + c}{1 - a - c} \ln(n + g + \delta) - (1 - e^{-\lambda t}) \ln(y(0)) \end{aligned}$$

Thus, in this neoclassical model the growth of income is a function of the determinants of the ultimate steady state and the initial level of income. Where  $s_k$  is the fraction of income invested in physical capital, and  $s_h$  is the fraction of income invested in human capital.

To test for unconditional convergence I use the following equation:

$$(8) \quad \left[ \ln\left(\frac{Y_t}{L_t}\right) - \ln\left(\frac{Y_{t-i}}{L_{t-i}}\right) \right] / i = \beta_0 + \beta_1 \ln\left(\frac{Y_{t-i}}{L_{t-i}}\right) + \varepsilon$$

Where  $Y/L$  is measured as GSP per working age population. If there is  $\beta$  convergence,

I expect  $\beta_1$  to be negative<sup>21</sup>.

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<sup>21</sup> The value of  $i$  could be determined by some research; however, due to some data availability plays a role and restricts its value. In this study I use  $t = 1995, 2000, \text{ and } 2004$ , and  $i = 2, 5, \text{ and } 3$  respectively.

To test for conditional  $\beta$  convergence I extend equation (8) to include investment in fixed capital per value of GSP  $I/Y$ , and to control for states' net migration I modify Mankin, Romer, and Weil's (1992) empirical equations, to open state economies and to incorporate labor migration into our basic empirical equation, instead of just the working age population growth rate:

$$(9) \quad \left[ \ln\left(\frac{Y_t}{L_t}\right) - \ln\left(\frac{Y_{t-i}}{L_{t-i}}\right) \right] / i = \beta_0 + \beta_1 \ln\left(\frac{Y_{t-i}}{L_{t-i}}\right) + \beta_2 \ln\left(\frac{I_{t-i}}{Y_{t-i}}\right) + \beta_3 \ln\left(\frac{n}{N}\right)_{Avg(t-i,t)} + v$$

$n$  is the average annual working age population growth rate at the state level for the  $t-i$  to the  $t$  period.  $N$  is the average annual working age population growth rate at national level for the  $t-i$  to the  $t$  period. The ratio  $n/N$  is used as a proxy for the net migration rate in each state,  $n/N < 1$  would indicate state net out-migration, and  $n/N > 1$  state net in-migration.

I expect that  $\beta_2$  to be positive because investments in physical capital are positively related to growth in output per unit of labor. The sign of the  $\beta_3$  coefficient is undetermined because working age population growth and migration effects have two opposite effects: Labor is positively related to output  $Y$ , but since the dependent variable is the log difference of the output per unit of labor, increasing labor will reduce the  $Y/L$  ratio.

I also augment equation (9) to include human capital measures as:

$$(10) \left[ \ln\left(\frac{Y_t}{L_t}\right) - \ln\left(\frac{Y_{t-i}}{L_{t-i}}\right) \right] / i = \beta_0 + \beta_1 \ln\left(\frac{Y_{t-i}}{L_{t-i}}\right) + \beta_2 \ln\left(\frac{I_{t-i}}{Y_{t-i}}\right) + \beta_3 \ln\left(\frac{n}{N}\right)_{Avg(t-i,t)} + \beta_4 \ln(HC_{t-i}) + \eta$$

Where  $HC$  stands for human capital variables and I expect that  $\beta_4$  to be positive because investments in human capital are positively related to growth in output per unit of labor. For this study I estimate equations using two different human capital control variables.

The first indicator is the number of students enrolled in higher education as a proportion of the working age population. Higher education levels include: college, graduate, teachers training, and job training. I called this indicator  $HC1$ . The second indicator  $HC2$  is the population 15 or older with higher education divided by the working age population.

To test if regions with larger indigenous population grow more slowly, I include the log of the proportion of population 5 years and older that speaks an indigenous language ( $INDI$ ) lagged five years in equations (8), (9), and (10). In general I expect a negative signs associated the indigenous variable, as differences in culture and language are expected to be obstacles to market participation.



To test if the marginalized areas grow more slowly I include a marginalization dummy variable  $MD$  and interaction terms with the other control variables in equations (8), (9), and (10). I expect negative signs associated with the simple dummy variable and for the interaction terms signs opposite to those predicted above for  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$ , and  $\beta_4$ .

Islam (2003) differentiates among  $\sigma$  convergence in terms of growth rate vs. convergence in terms of income level, or for the purpose of this paper, convergence in terms of output per unit of labor vs. convergence in terms of output per unit of labor growth rate. According to the neoclassical models (Solow, 1956), economies grow at the same rate in the steady state. "This yields the hypothesis of convergence in terms of growth of rate. To this researchers often added the assumption that all countries have identical aggregate production function. This implies that steady state income levels of all [economies] are also identical. This yields convergence in terms of income level" (Islam, 2003 p. 314). To test for  $\sigma$  convergence in terms of level I analyze the standard deviation of the output per unit of labor, and its log transformation; and to analyze  $\sigma$  convergence in terms of growth rate, the standard deviation of the output per unit of labor growth rate for each period.

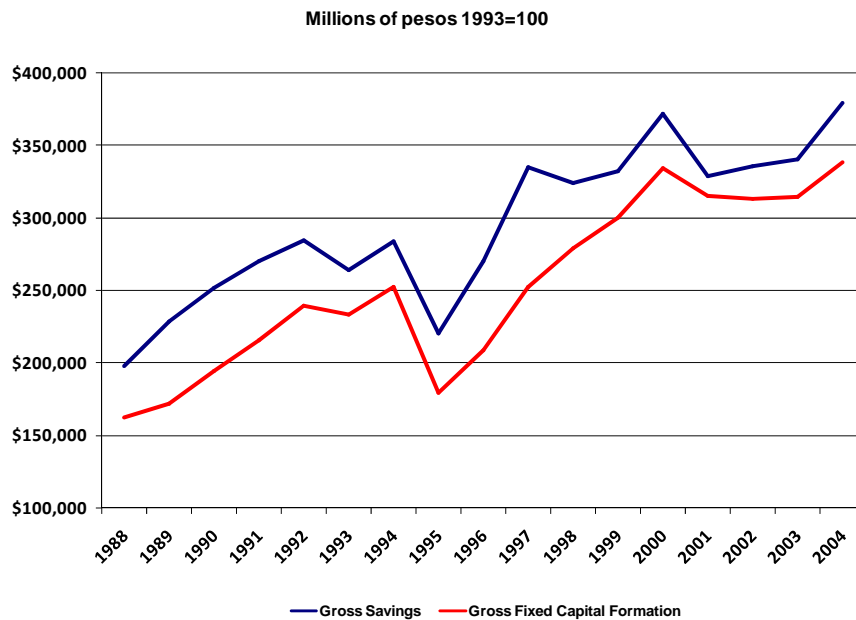
## **2.5. Data**

In this section I present the data used in this study to proxy the variables described in the previous section.

**Gross State Output (GSP)** is used to proxy output  $Y$ . The Statistics, Geography, and Informatics National Institute (INEGI) publishes the GSP for the 1993-2004 period that is measured in millions of constant pesos 1993=100 (INEGI, 2007a).

**Gross fixed capital formation** is plotted against national gross savings (Figure 2-1). They move together and gross fixed capital formation represents on average 85 percent of gross savings. It is important to mention that even when at national level the correlation is high, this might not be true at state level. I used gross fixed capital formation to measure  $I$  because gross savings data is only available at the national level. The INEGI publishes data on each state's percentage contribution to national gross fixed capital formation for the period 1993 to 2003 (INEGI, 2007c) that includes both private and the public investments. I multiply the state's contribution by the national gross fixed capital formation to get the state's gross fixed capital formation.

Figure 2-1. Mexican Capital Account 1988-2004.



I measure  $n$  as the rate of growth of the **working-age population** (WPOP), where working age is defined as people from 15 to 64 years old. The annualized growth rate for a period is calculated as  $[(WPOP_t - WPOP_{t-i}) / WPOP_{t-i}] / i$ . This procedure was used to calculate WPOPG 1993-95, 1995-2000, and 2000-2004. The state data for this variable were taken from publications of the National Council of Population (CONAPO) for the period 1980-2006 (CONAPO, 2006). Variable  $N$  is calculated as  $n$ , but using national data.

**Human capital** measured using two indicators. A flow variable,  $HC1$ , is the number of students enrolled in higher education as a proportion of the working age population.

The number of students enrolled in higher education levels data is published annually by the Mexican Ministry of Education (SEP) for the period 1990-2006 (SEP, 2007).

The second indicator a stock variable,  $HC2$ , is the population 15 or older with higher education divided by the working age population. The population 15 or older with higher education data comes from the National Census of 1990 and 2000, and the National Counts for 1995 and 2005 published by CONAPO. When this variable is used in the equation (10) I used 1990 because it is not available for 1993.

Austin and Schmidt (1998) tested if the presence of Native American populations affects the sensitivity of convergence among the U.S. counties in the Great Plains. Excluding counties with greater than 25 percent of Native American population they found an increase in the rate of convergence. To study the behavior of the Mexican states with higher indigenous population we used the **proportion of population 5 years and older that speaks an indigenous language**,  $INDI$ , for the years 1990, 1995, 2000, and 2005.

There are ten states in which 8 percent or more of the population is indigenous for each one of these periods: Campeche, Chiapas, Guerrero, Hidalgo, Oaxaca, Puebla, Quintana Roo, San Luis Potosí, Veracruz, and Yucatán.

The **marginalization** dummy,  $MD$ , is based on the marginalization index that the CONAPO publishes. In particular, I used the 1990 index at state level (CONAPO, 2001). The marginalization index in México is an exclusion index (CONAPO, 2002. p. 221).

Exclusion on four dimensions that the Census data capture: education, housing, income, and population distribution.

**Education:** Knowledge access is a crucial aspect for people's living projects. The population's education is a key factor to increase labor productivity, to adopt technological innovations, and to strengthen local and regional competitiveness. The most intense social marginalization, derived from the lack of the participation in the education system, is registered among the adult population that does not know how to write or read (illiterate). Low quality or incomplete primary instruction limits the opportunities for access to new technologies; it also isolates the individuals from labor markets and better wages and salaries.

**Housing:** Housing includes a variety of measures of housing quality (Appendix E). These measures not only affect quality of life but also affect development of human capital and economic activity. Housing crowding affects educational achievement of children, and increases health risks and problems. Population living in households without electric power, running water, hard floor, and/or an exclusive sanitary sewer are exposed to more health risks. These obstacles also inhibit economic activity, such as home-based business entrepreneurship, communication, and information with the outside world, etc.

**Income:** In market economies, like México, monetary income plays a very important role because it determines the capacity to acquire goods and services. The lack of income represents one of the most important forms of exclusion, because it prevents the individuals from participating in markets to acquire goods and services. It also limits the ability to acquire assets for economic activity.

**Population Distribution:** the spatial dispersion of population in small communities can result in geographical isolation. Particularly, low population density prevents the creation and the use of economies of scale that urban areas provide, such as services, modern technologies, high productivity, etc. Low population density increases the social investment costs per person that are needed to provide health, education, electric power, drains, and running water services in isolated communities.

Nine indicators measuring these four dimensions had been used to calculate the Marginalization Index at national, state and municipal levels using Census data<sup>22</sup>. For 1990 the Index ranges from -1.69 to 2.36, the 32 Mexican states are classified into four marginalization categories: Very low, low, high, and very high marginalization. This index has been calculated for 1995, 2000, and 2005 (CONAPO, 2001).

The *MD* variable takes a value of one in 14 states with high and very high marginalization levels: Campeche, Chiapas, Guanajuato, Guerrero, Hidalgo, Michoacán,

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<sup>22</sup> For more detail in these nine indicators see Appendix E.

Nayarit, Oaxaca, Puebla, San Luis Potosí, Tabasco, Veracruz, Yucatán, and Zacatecas and zero in the rest of the country.

## **2.6. Results**

The estimation results of Pooled Least Squares of this study are summarized in Tables 2—1, 2—2, 2—3, and 2—4. The column labeled *base* corresponds to the direct estimation of equations (8), (9), and (10). The *indigenous* column corresponds to the estimations including the proportion of indigenous population *INDI* in  $t - 5$  period. Note that I am using  $t - 5$  because the data for indigenous population is only published every 5 years in Mexico. The *marginal* columns correspond to estimations with the marginalization dummy (*Marginal 1*) and its interaction terms (*Marginal 2*). The coefficient associated with  $\ln(Y_{t-i} / L_{t-i})$  is the convergence indicator.

As mentioned before, this study contributes to previous studies because it uses more recent data, and the dependent variable is output per working age population, while previous studies have analyzed GDP (Juan-Ramón and Rivera-Batiz, 1996), GSP per capita (Mallick and Carvannis, 1994; Sanchez-Reaza and Rodriguez-Pose, 2002; Messmacher, 2000; Chiquiar, 2002; Esquivel and Messmacher, 2002; Aroca, Maloney, and Bosch, 2003; and Aguayo-Tellez, 2006), and the human development index

(Esquivel and Velez, 2003). In that sense, this study is not strictly comparable to previous ones.

### **2.6.1. Unconditional $\beta$ Convergence**

Table 2-1 reports the regressions of the annualized change in the log of GSP per working age population over the period 1993-2004 on the log of GSP per working age population in  $t-i$  with and without controlling for indigenous population and marginalization level (Equation 8). Under the *base* column I observe a negative but not significant sign for the unconditional convergence indicator.

Under the indigenous column the coefficient associated with the percentage of indigenous population in the state is negatively contributing to growth. This suggests that indigenous population does not have full access to markets, limiting growth in states with large indigenous populations. Notice that the adjusted  $R^2$  also increases. Overall this equation provides the best fit of the equations presented in the table.

When the marginalization dummy is included (*Marginal 1* and *2*) neither the marginalization dummy nor the interaction terms are significant. The adjusted  $R^2$  is negative, suggesting that the inclusion of these variables is not appropriate, and that they are not related to growth in states with high marginalization levels.



**Table 2-1. Unconditional  $\beta$  convergence**

Dependent variable  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-i}}{L_{t-i}} \right) \right] / i$  for t= 1995, 2000, and 2004.

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
<b>Constant</b>	0.0548	0.0956	0.0297	0.0560
$\ln(Y_{t-i} / L_{t-i})$	-0.0055	-0.0112	-0.0032	-0.0058
$\ln(INDI)_{t-5}$		-0.0043 **		
<b>Marginalization dummy</b>			0.0047	-0.0629
Interaction terms with:				
$\ln(Y_{t-i} / L_{t-i})$				0.0068
$\bar{R}^2$	-0.0050	0.0437	-0.0103	-0.0195
Significance: * 0.10    ** 0.05    *** 0.01				

## 2.6.2. Conditional $\beta$ Convergence

Table 2-2 reports the estimations for Equation (9) testing for  $\beta$  conditional convergence, i.e. including investment in physical capital as a proportion of GSP and net migration with and without controlling for indigenous population and marginalization levels. The convergence indicator is negative but as in Table 2-1 it is not significant, indicating that there is no  $\beta$  conditional convergence among Mexican states for these periods.

Notice also that the coefficients associated with physical capital investments and net migration are not significant, indicating that they do not contribute to growth in GSP per working age population.

**Table 2-2. Conditional  $\beta$  convergence**

Dependent variable  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-i}}{L_{t-i}} \right) \right] / i$  for t= 1995, 2000, and 2004.

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
Constant	0.0303	0.0758	0.0171	0.0790
$\ln(Y_{t-i} / L_{t-i})$	-0.0037	-0.0096	-0.0026	-0.0097
$\ln(I / Y)_{t-i}$	-0.0041	-0.0032	-0.0040	-0.0096
$\ln(n / N)_{Avg(t-i,t)}$	-0.0095	-0.0063	-0.0087	-0.0071
$\ln(INDI)_{t-5}$		-0.0039 **		
<b>Marginalization dummy</b>			0.0028	-0.2037
Interaction terms with:				
$\ln(Y_{t-i} / L_{t-i})$				0.0222
$\ln(I / Y)_{t-i}$				0.0086
$\ln(n / N)_{Avg(t-i,t)}$				-0.0131
$\bar{R}^2$	-0.0029	0.0341	-0.0119	-0.0206
Significance: * 0.10    ** 0.05    *** 0.01				

As in Table 2-1, the coefficient associated with the presence of indigenous population in the state is negative and significant, indicating that states with higher indigenous population are growing slower than the rest of the country.

The results after controlling for marginalization (*Marginal 1* and *2* columns), as in Table 2-1, indicate that the marginalization dummy and its interaction terms should not be included in the analysis because the size of the adjusted  $R^2$  is negative.

In Tables 2—3 and 2—4 I extend the analysis to include human capital indicators. Table 2-3 measures human capital as number of students enrolled in higher education as a proportion of the working age population (HC1); and Table 2-4 measures human capital

as the stock of the population 15 or older with higher education as a proportion of the working age population (HC2).

The *base* results on Table 2-3 indicate that after controlling for physical investment, net migration, and human capital measured as the proportion of students enrolled in higher education (HC1) the convergence indicator is negative and significant under all the columns, indicating that there is evidence of conditional convergence among Mexican states. This coefficient increases in size once I control for indigenous population (*Indigenous* column). In addition, the indigenous coefficient is negative and significant, and the adjusted  $R^2$  increases from 0.0624 to 0.0822. Of the models reported in Table 2-3, this model provides the best fit.

**Table 2-3. Conditional  $\beta$  convergence and human capital 1**  
**Dependent variable**  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-i}}{L_{t-i}} \right) \right] / i$  **for t= 1995, 2000, and 2005.**

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
Constant	0.2696 **	0.2792 **	0.2605 **	0.3001 **
$\ln(Y_{t-i} / L_{t-i})$	-0.0209 **	-0.0237 **	-0.0196 *	-0.0237 *
$\ln(I / Y)_{t-i}$	-0.0074	-0.0063	-0.0077	-0.0121 *
$\ln(n / N)_{Avg(t-i,t)}$	-0.0032	-0.0014	-0.0003	0.0050
$\ln(HC1_{t-i})$	0.0228 ***	0.0202 **	0.0254 ***	0.0274 **
$\ln(INDI)_{t-5}$		-0.0032 *		
<b>Marginalization dummy</b>			0.0078	-0.1676
Interaction terms with:				
$\ln(Y_{t-i} / L_{t-i})$				0.0174
$\ln(I / Y)_{t-i}$				0.0072
$\ln(n / N)_{Avg(t-i,t)}$				-0.0201
$\ln(HC1_{t-i})$				-0.0046
$\bar{R}^2$	0.0624	0.0822	0.0662	0.0456

Significance: \* 0.10 \*\* 0.05 \*\*\* 0.01

Notice also that the coefficients associated with physical capital investments and net migration are negative, and in most of the cases they are not significant (except for physical capital under *Marginal 2*), thus in general they do not affect growth in output per working age population.

On the other hand, human capital measured as the proportion of students enrolled in higher education is positive and significant under all Table 2-3 columns. This coefficient is indicating that increasing the flow of human capital in Mexico increases productivity growth in the future.

Under *Marginal 1* and *2* columns the results are not different from those under *Base* and *Indigenous* columns, and the adjusted  $R^2$  is actually decreasing compared to *Indigenous*; suggesting that in general the equations that include marginalization do not have as much explanatory power as the *Base* and *Indigenous* equations.

Results in Table 2-4 where human capital is measured as the stock of the population 15 or older with higher education as a proportion of the working age population (HC2) are in general not significant. Only in the *Marginal 2* column does the convergence coefficient become significant. As in the previous tables, the indigenous variable is negative and significant.

**Table 2-4 Conditional  $\beta$  convergence and human capital 2**

Dependent variable  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-i}}{L_{t-i}} \right) \right] / i$  for t= 1995, 2000, and 2005.

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>	
Constant	0.1687 *	0.1548	0.1787	0.3726	**
$\ln(Y_{t-i} / L_{t-i})$	-0.0129	-0.0139	-0.0133	-0.0292	**
$\ln(I / Y)_{t-i}$	-0.0044	-0.0036	-0.0045	-0.0095	*
$\ln(n / N)_{Avg(t-i,t)}$	-0.0091	-0.0076	-0.0075	-0.0026	
$\ln(HC2_{t-5})$	0.0178	0.0117	0.0213	0.0411	**
$\ln(INDI)_{t-5}$		-0.0029 **			
<b>Marginalization dummy</b>			0.0038	-0.4052	*
Interaction terms with:					
$\ln(Y_{t-i} / L_{t-i})$				0.0337	*
$\ln(I / Y)_{t-i}$				0.0079	
$\ln(n / N)_{Avg(t-i,t)}$				-0.0117	
$\ln(HC2_{t-5})$				-0.0380	
$\bar{R}^2$	0.0550	0.0927	0.0507	0.0567	

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01

Notice also that the marginalization dummy is negative and significant once the interaction terms are included; and the sign of the interaction term associated with the convergence indicator has the opposite sign of that for the rest of the country as expected. This suggests that marginalized areas are growing faster than the rest of the country and indicates convergence. The HC2 indicator is positive, but it is only significant when the marginalization dummy and the interaction terms are included.

In general terms it can be said that the best estimation is shown on Table 2-3, *Indigenous* column. Indigenous population and human capital measured as number of students enrolled in higher education as a proportion of the working age population (HC1) are important conditions to control for  $\beta$  conditional convergence. Also HC1 is

positively related to growth in output per unit of labor, while states with larger indigenous population experience lower growth rates.

Overall results in Tables 2—1 to 2—4 indicate that the percentage of indigenous population is an important factor determining growth in output per unit of labor. The human capital measure of number of students enrolled in higher education appears to be a better measure of human capital than the population of 15 or older with higher education; and the contributions of a better educated working age population are strong enough to offset the effect of the increase in labor units.

### **2.6.3. $\sigma$ convergence**

Table 2-5 shows the standard deviation for output per working age population and its log transformation. Under the output per working age population ( $Y/L$ ) column, the standard deviation decreases from 1993 to 1995 showing  $\sigma$  convergence for this period, this means the dispersion of  $Y/L$  across states is decreasing. However, from 1995 to 2000 the standard deviation increases to \$11,004.86 implying that the dispersion among Mexican states increased. This standard deviation decreases to \$10,808 in 2004. The change in the standard deviations from 1993 to 2004 was a small increase of about 800 1993 pesos. This same pattern is shown by the standard deviation of the log

transformation  $\ln(Y/L)$ . In general, the standard deviation has increased, indicating that there is no  $\sigma$  convergence.

**Table 2-5. Standard deviations for  $Y/L$  and  $\ln(Y/L)$**

<i>Year</i>	<i>Y/L (\$)</i>	<i>ln(Y/L)</i>
<b>1993</b>	10,008.06	0.3898
<b>1995</b>	9,226.65	0.3848
<b>2000</b>	11,004.86	0.4078
<b>2004</b>	10,807.68	0.4033

Table 2-6 shows the standard deviation for the annualized log difference of output per working age population  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-i}}{L_{t-i}} \right) \right] / i$ . A decrease in the standard deviation of the growth rate for the 1995-2000 period is observed with respect to 1993-1995, indicating some  $\sigma$  convergence pattern. Also in the latest period (2000-2004) this dispersion decreased, suggesting that the growth rates dispersion among Mexican states is  $\sigma$  converging, that is, states tend to grow at the same rate and poorer ones are not catching up with richest ones.

**Table 2-6. Standard deviations for  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-i}}{L_{t-i}} \right) \right] / i$**

<i>Period</i>	<i>Standard Deviation</i>
<b>1993-1995</b>	0.0214
<b>1995-2000</b>	0.0160
<b>2000-2004</b>	0.0137

## **2.7. Conclusions**

In this study I have reviewed the convergence implications of the neoclassical economic growth model. Solow (1956) predicted that if economies are similar with respect to preferences and technology, poorer ones will grow faster than richer ones, generating  $\beta$  and  $\sigma$  convergence. Barro and Sala-i-Martin (1991; 1992) have studied the convergence evidence, developing econometric models to analyze the broadly used  $\beta$  and  $\sigma$  convergence indicators.

Since Barro's and Sala-i-Martin's publications (1991; 1992) a large literature has developed testing convergence. Most of these contributions have focused on the analysis of income per capita as an indicator of economic convergence. In this paper I specify a convergence model to analyze Gross State Output (GSP) per working age population. Using panel data with state level observations for 1993-2004, I control for physical capital investments, working age population growth rate, net migration rate, indigenous population, and marginalization levels.

I did not find evidence of unconditional  $\beta$  convergence. The indigenous model in Table 2-3 shows the highest adjusted  $R^2$ , this model controls for investment in physical capital as a proportion of GSP, state's net migration, indigenous population and human capital measured as number of students enrolled in higher education as a proportion of



the working age population (HC1); the conditional  $\beta$  convergence indicator becomes significant and its value is 2.37 percent.

Based on economic growth and convergence theory I expected that productivity growth in output per unit of labor would be positively related to investments in both physical and human capital. However investments in physical capital are either not significant or negatively related. These results could be due to several factors: 1) a data collection problem, 2) the gross fixed capital formation data is not actually a good proxy for physical investment, or 3) a problem in the lags in the model--physical investments may take more than five years to have an effect on economic growth. We need a more detailed analysis of these data to figure out the appropriate lag.

The net migration variable is never significant, probably because the effects of increasing output and increasing labor are offsetting each other.

The human capital indicators are measured as number of students enrolled in higher education as a proportion of the working age population, and as the stock of the population 15 or older with higher education as a proportion of the working age population. In general I found evidence that these measures are positively related to the growth in output per working age population.

The percentage of indigenous population variable is always negative and significant, indicating that the limitations that the indigenous population faces to participate in the markets are strong enough to slow the growth of states and their convergence to the rest of the economy.

I also analyze  $\sigma$  convergence among Mexican states. I found some mixed results when testing for level of output per working age population  $\sigma$  convergence. In general the dispersion of the output per unit of labor has increased, indicating that there is no  $\sigma$  convergence among Mexican states. But when analyzing the dispersion of the growth rates among states there is evidence of  $\sigma$  convergence, suggesting that states can grow at the similar rates, but poorer economies are not catching up with richer ones.

From this study I can conclude that there is a weak evidence of  $\beta$  conditional convergence, in particular after controlling for indigenous population and the flow of human capital. Also, depending on the variable (output per unit of labor, log of output per unit of labor, or output per unit of labor growth rate) the results for  $\sigma$  convergence are mixed for the 1993-2004 period. It is possible to identify the factors that are positively or negatively related to economic growth and convergence, and then governments can design policies to support poorer or indigenous economies. For example, programs supporting indigenous populations and the enrollment of students in higher education will have a positive impact in reducing the output per labor gaps

among Mexican states. It is also necessary to identify what factors or institutional problems are influencing the physical capital behavior.

## **Chapter 3 . Disparities in Productivity Growth in Mexico: 1993-2004**

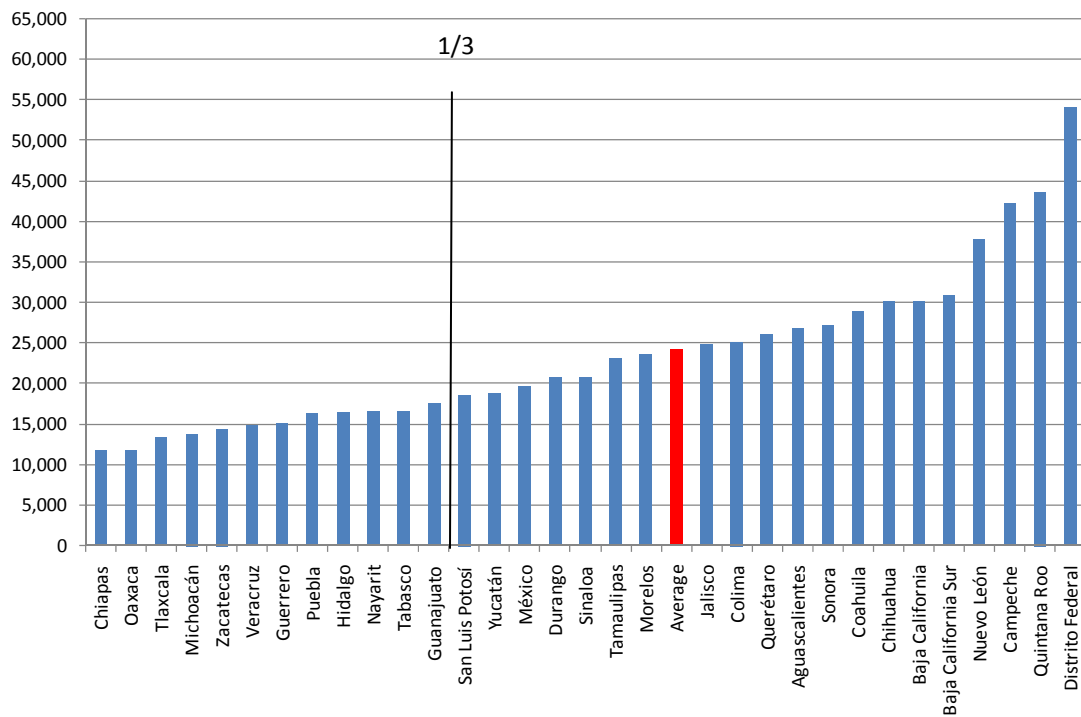
### ***3.1. Introduction***

Economic growth has been one of the most important issues for many economists, not only to analyze how to increase growth, but also to analyze why growth patterns vary across economies. Some studies have focused their attention on output per capita, while others have studied output per unit of labor. In this study we analyze the behavior of output per unit of labor across Mexican states for the period 1993-2004.

Differences in output per unit of labor across Mexican states have been traditionally high and fairly persistent. Many studies focused on testing convergence among Mexican regions and or states, i.e. Mallick and Carvannis, 1994; Juan-Ramón and Rivera-Batiz, 1996; Messmacher, 2000; Sanchez-Reaza and Rodriguez-Pose, 2002; Chiquiar, 2002; Esquivel and Messmacher, 2002; Aroca, Maloney, and Bosch, 2003; and Aguayo-Tellez, 2006. Output per capita in the richest state was 4.6 times that of the lowest in 1993; and 4.86 times, in 2004. In addition, there are indicators suggesting that regional inequalities in Mexico also are increasing. For example, GSP per working age, in

1993 45 percent of the population lived in states with less than one third of that the highest state (12 out of 32 states). By 2004, 34 percent of the population was concentrated in states with less GSP per working age population than one third of the richest (11 out of 32 states) see Figure 3-1 and Figure 3-2.

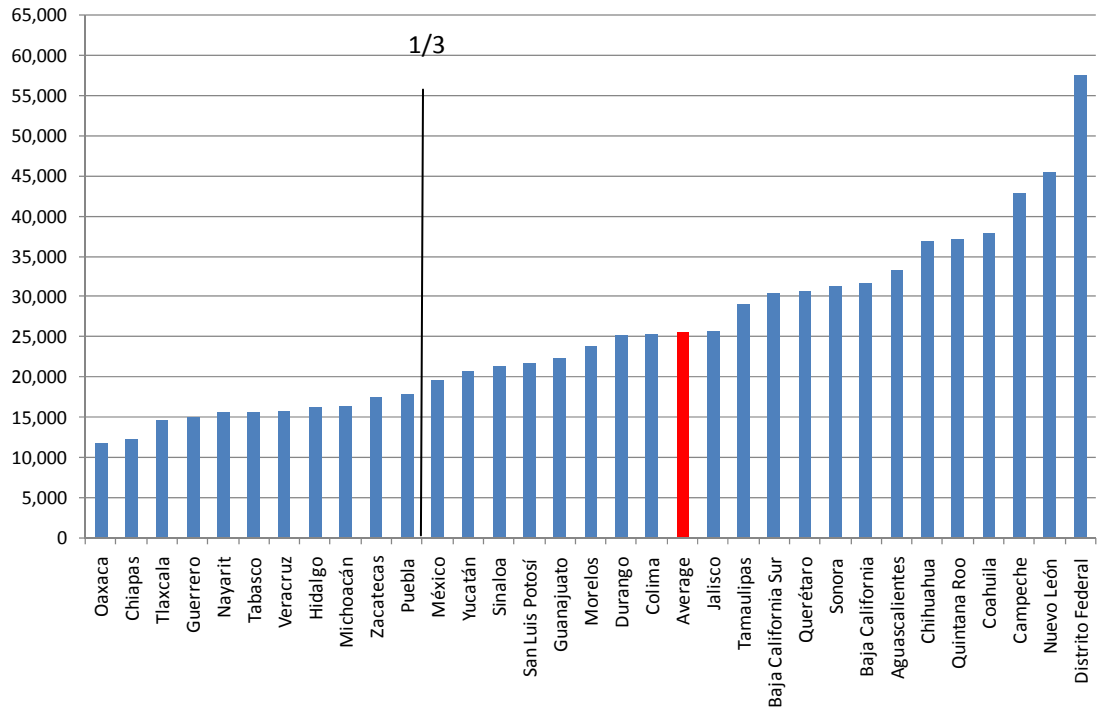
**Figure 3-1. GSP per Working Age Population, 1993**  
 Mexican Pesos 1993=100



Based on economic theory we expect that growth in output per unit of labor would be positively related to investments in both physical and human capital. It is also known that the labor force moves to where there are employment opportunities and we expect that states attracting labor force would experience an increase in their total output, but at the same time there may be an opposite effect on the output per unit of labor.

Figure 3-2. GSP per Working Age Population, 2004

Mexican Pesos 1993=100



Mexico is a country with a large indigenous population. In some states more than 25 percent of the population is indigenous. The indigenous population faces barriers in access to markets: language, discrimination, historical lag of investment, etc. Thus we would expect that states with higher indigenous presence would grow more slowly than the rest of the country.

Similarly, marginalization<sup>23</sup> limits market access and some marginalized regions also coincide with indigenous regions. In particular the Mexican government estimates a marginalization index to identify states and communities with high marginalization levels. We use this index to analyze the economic growth of these marginalized regions, and we expect that states with higher marginalization index grow slower than the rest of the country.

Using panel data with state level observations for 1993-2004 we analyze productivity measured as Gross State Output (GSP) per working age population controlling for physical capital investments, the working age population growth rate, migration rate, indigenous population, and marginalization levels. In the next section we present a summary of the economic growth literature, and develop a model based on the theoretical framework. Next we describe the data used in this study, present the results of the model, and derive conclusions from this research.

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<sup>23</sup> The CONAPO provide defines marginalized population as “it is the population that for some diverse reasons are integrated in an economic sub-system in the socioeconomic and politic organizations, but that is totally or partially excluded from the access to consumption and enjoyment of goods and services, and of the participation in public business” (own translation, CONAPO, 1993 p. 15).

## **3.2. Economic growth literature review**

### **3.2.1. The neoclassical model**

The neoclassical model (Solow, 1956) dominated economist's thinking about long-term movements in per capita income for almost 5 decades. In 1956 Solow extended the Harrod-Domar model by adding labor as a factor of production; requiring diminishing returns to labor and capital separately, and constant returns to scale for both factors combined. Solow's model assumed full employment, firms and consumers are price takers in perfectly competitive markets of homogeneous goods, zero transportation costs (no space), regionally identical production functions, and fixed labor supply. Solow introduced a time-varying (exogenous) technology variable distinct from capital and labor; he uses the term "technological change" to define any kind of shift in the production function. Solow's production function can be summarized by:

$$Y = f(K, AL)$$

According to Solow (1956) in this equation  $A$  represents effectiveness of labor (some authors also call this variable technological change and/or knowledge level (Romer, 1996; Barro and Sala-i-Martin, 1991, 1992)). At any time, the economy has some amounts of capital  $K$ , labor  $L$ , and knowledge  $A$ , and these are combined to produce output.



Solow (1956) focused attention on the process of capital formation. Aggregate savings finance additions to the national capital stock. Assuming a closed economy with an initially low capital-labor ratio, it will have a high marginal output of capital. Then, if a constant fraction of the income generated by a new piece of equipment is saved, the gross investment in new capital goods may exceed the amount needed to offset depreciation and to equip new members of the workforce. Over time, capital per worker will rise, which (with constant returns to scale and fixed technology) will generate a decline in the marginal output of capital. As the marginal output of capital continues to fall, the savings generated by the income accruing to new capital also will fall, and will eventually be only just sufficient to replace worn-out machines and equip new workers. At this point the economy enters a stationary state with an unchanging standard of living.

To ensure convergence to a steady state Inada conditions (Romer, 1996)<sup>24</sup> on a production function can guarantee the stability of an economic growth path in the neoclassical growth model. “These conditions state that the marginal output of capital is very large when the capital stock is sufficiently small and that it becomes very small as the capital stock becomes large; their role is to ensure that the path of the economy

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<sup>24</sup> The Inada conditions are:

1)  $f(0) = 0$ ; 2) the function is continuously differentiable; 3) the function is strictly increasing in  $k$ ,  $f'(k) > 0$ ; 4) the derivative of the function is decreasing (thus the function is concave)  $f''(k) < 0$ ; 5) the limit of the derivative towards 0 is positive infinity,  $\lim_{k \rightarrow 0} f'(k) = \infty$ ; and 6) the limit of the derivative towards positive infinity is 0,  $\lim_{k \rightarrow \infty} f'(k) = 0$ .

does not diverge” (Romer, 1996 p. 9). The rate of growth as the economy converges to the steady state is determined by the rate of capital accumulation. Capital accumulation is in turn determined by the savings rate and the rate of capital depreciation. In this sense, policies that alter the savings rate can affect growth. Solow (1956) showed that with exogenous advances in technology the marginal output of capital need not decline as capital per worker increased. Rather, improvements in labor productivity would augment the stock of “effective” workers.

The neoclassical growth models predict that the long-run rate of economic growth is exogenously determined --in other words, the steady state is determined outside of the model. A common prediction of the neoclassical model is that economies will converge to a common level because poorer economies will grow more rapidly than richer ones, because poorer economies have initially lower capital-labor rates. Studies by Barro and Sala-i-Martin (1991; 1992) initiated a wave of studies to test the convergence hypothesis.

Barro and Sala-i-Martin (1991; 1992) investigate whether Solow’s (1956) conclusion on convergence to a steady state in the standard neoclassical growth model with exogenous technological progress and a closed economy holds for the U.S. states, European countries, 98 countries, and the 20 original OECD members. Later Quah (1996), Carlino and Mills (1996), Pritchett (1997), Button (2000), McCoskey (2002), Duranton and Monastiriotis (2002), Lim and McAleer (2004), and Tortosa-Ausina, et al. (2005) tested

for convergence and found very different economic growth patterns among countries and regions. The empirical findings have not been consistent, and the neo-classical model cannot fully explain the divergence or the not-catching up among different economies.

Mankiw, Romer, and Weil (1992) argue that the evidence on the international disparity in levels of per capita income and rates of growth is quite consistent with a standard Solow model, once it has been augmented to include human capital  $H$  as an accumulative factor ( $Y = f(K, AL, H)$ ) and allowing for cross-country differences in savings rates that reflect differences in tastes or culture, which, in Solow's model, would imply convergence to different steady-state paths for per capita income. These observations have led to the adoption of the conditional convergence concept developed by Barro and Sala-i-Martin (1991). Augmenting the neoclassical model to include more explanatory variables, and the relaxation of some of the core assumptions of this model led to the development of the endogenous growth models.

In 1994 Romer analyzed and described what he calls the convergence controversy criticizing the conclusions of the neoclassical model. Romer (1994) notes that poor countries have not grown faster than the rich countries, and that the failure of cross-country convergence has motivated models of growth that drop the two central assumptions of the neoclassical model: that technological change is exogenous and that the same technological opportunities are available in all countries of the world.

Another critique of the neoclassical model is that it fails to explain how or why technological progress occurs. The non-rivalry and non-excludability characteristics of knowledge and technology accumulation do not fit with the production assumptions of perfect competition in the neoclassical model elapsed time. Thus the lack of convergence among economies, and the study of the role of knowledge and technology production, accumulation, and diffusion in economic growth have led to the development of endogenous growth theory, which endogenizes technological progress and/or knowledge accumulation (Romer, 1994). Romer (1994) proposes that growth theorists would eventually have to do what economists working at the industry and firm level have done: abandon the assumption of price-taking competition.

Lucas (1988) also criticized the neoclassical model emphasizing the fact that international patterns of migration and wage differentials are very difficult to reconcile with the neoclassical model. If the same technology were available in all countries, human capital would not move from places where it is scarce to places where it is abundant and the same worker would not earn a higher wage after moving from the poor economies to the more developed ones.

These critiques had led the development of endogenous growth models.

### **3.2.2. The endogenous models**

Grossman and Helpman (1994) note that “different countries have remained on seemingly disparate growth paths for relatively long periods of time” (p. 23). They found that national and regional growth rates are correlated with a variety of economic, social, and political variables, including many that are affected by government policies. The inclusion of these variables has led to the current generation of endogenous growth models in which per capita income grows indefinitely and long-run performance reflects structural and policy parameters of the local and global economies.

Endogenous growth theory was developed in the 1980s as a response to criticisms of the neo-classical growth model. Endogenous models assume that the driving force of growth is the accumulation of knowledge and human capital; it differs from the neoclassical model in explicitly interpreting and formally modeling the effectiveness of labor and knowledge evolution over time (Romer, 1996).

In general, according to Romer (1996) the endogenous models assume the existence of an explicit research and development (or R&D) sector, and model the production of new technologies. The allocation of resources between the production of conventional goods and R&D is also a reason to develop endogenous models. Endogenous growth models assume that there is imperfect and monopolistic competition, technology is

endogenously provided as a side effect of private investment decisions, technology is non-rival and non-excludable, and there are aggregate increasing returns to physical and human capital.

Given the variety of economic, social, and political variables, that could be included in the endogenous models there exist different kinds of endogenous models, Romer (1994) distinguishes three main branches: spillover models (Arrow, 1962; Romer, 1986; and Lucas, 1988), linear models (Romer, 1994), and Neo-Schumpeterian models (Dixit and Stiglitz, 1977). For the purpose of this paper, we describe in more detail the linear models.

The linear models of endogenous growth assume that output can be written as  $Y = F(R, K, H)$  for a homogeneous of degree 1 production function  $F$ . "These models assumed that research  $R$ , physical capital  $K$ , and human capital  $H$  were like ordinary inputs. If there are non-rival goods, there are increasing returns. It is then a relatively simple matter to build a perfectly competitive model of growth. To simplify still further, these models often aggregate  $R$ ,  $K$ , and  $H$  into a single broad measure of capital. Suppose we call it  $X$ . Then we can write  $F(X)$  is a linear function:  $Y = F(X) = aX$ , hence the name linear models. If we assume that a constant fraction of output  $Y$  is saved and used to produce more  $X$ , the model generates persistent, endogenous growth. Relative to a neoclassical model, these models capture Romer's fact --that technological change comes from investments that people make--at the cost of

abandoning fact 2, that technology or knowledge is a non-rival good” (Romer, 1994 p. 16).

Endogenous growth theory demonstrates that policy measures can have an impact on the long-run growth rate of an economy. In contrast, with the Solow model, in which only a change in the savings rate could generate growth, subsidies to R&D or education can increase the growth rate.

Grossman and Helpman (1994) argue that with endogenous models “one can ... investigate whether a decentralized market economy provides adequate incentives for rapid accumulation of commercial technology, and one can examine how variations in economic structures, institutions, and policies translate into different rates of productivity gain” (Grossman and Helpman, 1994 p. 24) .

Human capital can be understood as the accumulation of effort devoted to schooling and training. Countries with more human capital grow faster but sheer size does not always promote growth. That is why a lot of countries and international organizations devote resources to training and education. However it is important to mention that it is not just a matter of more in the quantity sense, but also more in the quality sense. Schools are necessary, but also well prepared teachers.

The endogenous models have shown some weaknesses. In particular Solow (1994) critiques the endogenous models because “there is an internal logic... to the advance of knowledge that may be orthogonal to the economic logic. This is not at all to deny the partially endogenous character of innovation but only to suggest that the ‘production’ of new technology may not be a simple matter of inputs and outputs... the hard part is to model what happens then” (Solow, 1994 p. 52). Solow argues that modeling new technology production is not that trivial. Solow also points out the large uncertainty surrounding research projects and the lack of analytical techniques to model it generate extra difficulties in defining a technology production function.

Solow (1994) also indicates that even when conditional convergence does not occur (as measured in the Barro and Sala-i-Martin, 1991 model) it does not prove that the endogenous theory is true, nor does it necessarily invalidate the Solow model. In this sense Pack (1994) argues that “the diversity of growth experience ... is consistent with values of  $A$  [technological change] that differ across countries. It is regardless of whether one is using a neoclassical or endogenous growth approach (Pack, 1994 p. 66).

Pack (1994) points out that most empirical research generated by endogenous growth theory has tested earlier growth models (neoclassical), rather than testing endogenous theory itself. “Many analysts have augmented the simple production function to include not only investment in physical and human capital, but also changes in measured R&D levels, the effects of environmental and safety regulation and a large number of other



variables” (Pack, 1994 p. 59). Endogenous growth models should focus on describing how knowledge is accumulated and the process of technology production.

According to Pack (1994) “the same sort of regression equations that have been used in the study of conditional convergence have been used as a basis for more extensive investigations of the determinants of growth. In these studies the variables employed in testing for conditional convergence are supplemented by a large number of other variables” (Pack, 1994 p. 67).

### **3.2.3. Migration**

According to Barro and Sala-i-Martin (1995) the migration of people is one mechanism for change in an economy’s population and labor supply. Labor mobility is analogous to physical capital mobility from places with low rates of return to those with high rates of return. Labor tends to move from places with low wage rates or other unfavorable characteristics to those with high wage rates or other favorable elements. Capital mobility tends to speed up an economy’s convergence toward its steady-state; similarly, labor mobility would tend to speed up convergence. The effect on total output would also be positive, but the effect on output per capita or per unit of labor would be uncertain.

“Migration differs in some respects from changes in natural population growth.... First, in the case of migration, gains in population for a destination economy represent corresponding losses for the source economy.... Second... migrants come with accumulated human capital. Since a movement of a person entails the movement of this human capital, labor mobility or migration implies some degree of capital mobility (Barro and Sala-i-Martin, 1995p. 285-286). Furthermore, the extension of economic growth models to incorporate migration means that economies are opened to some extent.

In particular, migration affects the working age population growth rate, because the decisions to migrate are made pretty much by working age population.

Economic growth can be analyzed either within the neoclassical and/or the endogenous frameworks. We model the behavior of output per worker across Mexican states for the period 1990-2005. We do not estimate a direct endogenous model because of some data limitations for measures of technology and our research questions can be addressed with a modified neoclassical model. As in neoclassical and endogenous models we control for investments in physical and human capital. We assume that Mexican states are open economies and that labor can move from one state to another freely. We will also control for state’s indigenous population percentage and the state’s marginalization level.

### 3.3. Model specification

The theoretical assumptions of the neoclassical and endogenous models lead to a very particular empirical model specifications. In particular Mankin, Romer, and Weil (1992) used a Cobb-Douglas Production function to specify Solow's model in a neoclassical framework:

$$Y(t) = K(t)^a (A(t)L(t))^{1-a} \quad (0 < a < 1)$$

Where  $Y$  is output;  $K$  refers to physical capital;  $A$  represents the level of technology;  $L$  represents labor;  $AL$  are the effective units of workers, and  $t$  represents time. This function has constant returns to scale and each factor of production shows positive but diminishing marginal productivity.

After some algebra manipulations Mankin, Romer, and Weil (1992) derive this empirical equation to estimate the standard neoclassical growth model:

$$\ln\left(\frac{Y}{L}\right) = \alpha + \frac{a}{1-a} \ln(s_k) - \frac{a}{1-a} \ln(n + g + \delta) + \varepsilon$$

where  $\alpha$  is a constant,  $s_k$  is the fraction of income invested in physical capital,  $n$  is the labor growth rate,  $g$  and  $\delta$  are the technological growth rate and depreciation rate respectively; and  $\varepsilon$  is a economy-specific shock. We expect a positive relation between

output per unit of labor  $Y/L$  and  $s$  and  $g$ , an undetermined relation with  $n$ , and negative for  $\delta$ .

Similarly Mankin, Romer, and Weil (1992), define a production function adding human capital ( $H$ ) accumulation to the Solow model

$$Y(t) = K(t)^a H(t)^c (A(t)L(t))^{1-a-c} \quad a + c < 1$$

And the empirical equation that they use to estimate, what they call the augmented neoclassical model was:

$$\ln\left[\frac{Y}{L}\right] = \frac{a}{1-a} \ln(s_k) - \frac{a}{1-a} \ln(n + g + \delta) + \frac{c}{1-a} \ln(h^*) + \ln A(0) + gt$$

Variables are as defined above where  $s_k$  represents the fraction of income invested in physical capital,  $h^*$  is the level of human capital in the economy, and 0 represents the initial point of the economy. I expect a positive relation between output per unit of labor  $Y/L$  and  $s_k$ ,  $g$ ,  $h^*$ , and  $A(0)$ ; but again, an undetermined relation with  $n$ , and negative for  $\delta$ .

“Because the saving and population growth rates influence  $h^*$ , one should expect human capital to be positively correlated with the saving rate and negatively correlated with population growth. Therefore, omitting the human-capital term biases the coefficients on saving and population growth” (Mankin, Romer, and Weil, 1992, p. 418).

To test the augmented neoclassical model, a primary question is whether the available data on human capital correspond more closely to the rate of accumulation or to the level of human capital (Mankin, Romer, and Weil, 1992).

As mentioned in previous sections migration plays a very important role in economic growth (Barro and Sala-i-Martin, 1995). I modify Mankin, Romer, and Weil's (1992) empirical equations, to open state economies and to incorporate labor migration into our basic empirical equation, instead of just the working age population growth rate:

$$(1) \quad \ln\left(\frac{Y}{L}\right)_t = \alpha_0 + \alpha_1 \ln\left(\frac{I}{Y}\right)_{t-i} + \alpha_2 \ln\left(\frac{n}{N}\right)_{\text{Avg}(t-i,t)} + \varepsilon$$

Where productivity  $Y/L$  is measured as GSP per working age population,  $I/Y$  is the investment in fixed capital per amount of GSP,  $n$  is the average annual working age population growth rate at the state level for the  $t-i$  to the  $t$  period<sup>25</sup>.  $N$  is the average annual working age population growth rate at national level for the  $t-i$  to the  $t$  period. The ratio  $n/N$  is used as a proxy for the net migration rate in each state,  $n/N < 1$  would indicate state net out-migration, and  $n/N > 1$  state net in-migration. Notice that the explanatory variables contain information about the past.

$\alpha_0$  is a constant, I expect that  $\alpha_1$  would be positive because investments in fixed capital are positively related to increases in output, in this case measured as GSP. The sign of

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<sup>25</sup> The value of  $i$  could be determined by some research; however, due to some data availability plays a role and restricts its value. In this study I use  $t$  to 1995, 2000, and 2004, and  $i = 2, 5,$  and  $3$  respectively.

$\alpha_2$  is undetermined because population growth and migration have two effects. First an increase in the working age population will lead to an increase in output (positive relation between  $Y$  and  $L$ ). On the other hand, the dependent variable is the output per unit of labor (GSP per working age population), so that an increase in  $L$  would decrease  $Y/L$ .

An augmented version of equation (1) to include human capital measures is:

$$(2) \quad \ln\left(\frac{Y}{L}\right)_t = \alpha_0 + \alpha_1 \ln\left(\frac{I}{Y}\right)_{t-5} + \alpha_2 \ln\left(\frac{n}{N}\right)_{\text{Avg}(t-5,t)} + \alpha_3 \ln(HC)_{t-5} + \eta$$

Where  $HC$  stands for human capital variables. For this study I use two human capital control variables:

First I considered the number of students enrolled in higher education as a proportion of the working age population. Higher education levels include: college, graduate, teachers training, and job training. I called this indicator  $HC1$ . The second indicator  $HC2$  is the population 15 or older with higher education divided by the working age population.

I expect the described above signs for  $\alpha_0$ ,  $\alpha_1$ , and  $\alpha_2$ . For  $\alpha_3$ , I expect a positive sign, that is I expect investments in human capital are positively related to increases in output and productivity.

To test if regions with larger indigenous population grow more slowly I include the log of the proportion of population of 5 years and older that speaks an indigenous language *INDI* lagged five years in equations (1) and (2) because data for this variable is only available from census every five years. In general I expect a negative signs associated the indigenous variable.

To test if the marginalized areas grow more slowly I include a marginalization dummy variable *MD* and interaction terms with the other control variables in equations (1) and (2). I expect a negative sign for the simple dummy variable and for the interaction terms signs opposite to those predicted above for  $\alpha_1$ ,  $\alpha_2$ , and  $\alpha_3$ .

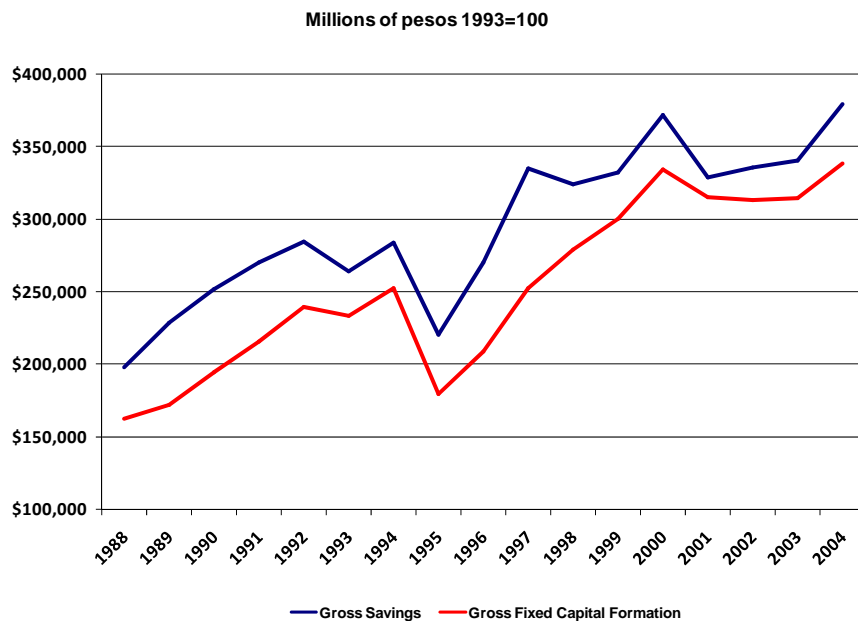
### **3.4. Data**

As mentioned in the introduction, we have data at the state level for the period 1993-2004 for the following variables:

**Gross State Output (GSP)** is used to proxy output  $Y$ . The Statistics, Geography, and Informatics National Institute (INEGI) publishes the GSP for the 1993-2004 period that is measured in millions of constant pesos 1993=100 (INEGI, 2007a).

Figure 3-3 plots national gross savings and gross fixed capital formation. They move together and gross fixed capital formation represents on average 85 percent of gross savings. It is important to mention that even when at national level the correlation is high, this might not be true at state level. I used **gross fixed capital formation** to measure *I* because gross savings data is only available at the national level. The INEGI publishes data on each state's percentage contribution to national gross fixed capital formation for the period 1993 to 2003 (INEGI, 2007c) that includes the private and the public investments. I multiply the state's contributions by the national gross fixed capital formation to get the state's gross fixed capital formation.

Figure 3-3. Mexican Capital Account, 1988-2004.





I measure  $n$  as the rate of growth of the **working-age population** (WPOP), where working age is defined as people from 15 to 64 years old. The annualized growth rate for a period is calculated as  $[(WPOP_t - WPOP_{t-i}) / WPOP_{t-i}] / i$ . This procedure was used to calculate WPOPG 1993-95, 1995-2000, and 2000-2004. The state data for this variable were taken from publications of the National Council of Population (CONAPO) for the period 1980-2006 (CONAPO, 2006). Variable  $N$  is calculated as  $n$ , but using national data.

As mentioned before, to measure human capital I used two indicators. A flow variable  $HC1$  the **number of students enrolled in higher education** as a proportion of the working age population. The number of students enrolled in higher education levels data is published annually by the Mexican Ministry of Education (SEP) for the period 1990-2006 (SEP, 2007).

The second indicator a stock variable  $HC2$  is the **population 15 or older with higher education** divided by the working age population. The population 15 or older with higher education data comes from the National Census of 1990 and 2000, and the National Counts for 1995 and 2005 published by CONAPO. When this variable is used in the equation (10) I used 1990 data instead of 1993.

Austin and Schmidt (1998) tested if the presence of Native American populations affects the sensitivity of convergence among the U.S. counties in the Great Plains. Excluding

counties with greater than 25 percent of Native American population they found an increase in the rate of convergence. To study the behavior of the Mexican states with higher indigenous population we used the **proportion of population 5 years and older that speaks an indigenous language, *INDI***, for the years 1990, 1995, 2000, and 2005. There are ten states in which 8 percent or more of the population is indigenous for each one of these periods: Campeche, Chiapas, Guerrero, Hidalgo, Oaxaca, Puebla, Quintana Roo, San Luis Potosí, Veracruz, and Yucatán.

Finally the **marginalization** dummy, *MD*, is based on the marginalization index that the CONAPO publishes. In particular, I used the 1990 index at state level (CONAPO, 2001). The marginalization index in México is an exclusion index (CONAPO, 2002. p. 221). Exclusion in four dimensions that the Census data capture: education, housing, income, and population distribution.

**Education:** Knowledge access is a crucial aspect for people's living projects. The population's education is a key factor to increase labor productivity, to adopt technological innovations, and to strengthen local and regional competitiveness. The most intense social marginalization, derived from the lack of the participation in the educative system, is registered among the adult population that does not know how to write or read (illiterate). Low quality or incomplete primary instruction limits the opportunities for access to new technologies; it also isolates the individuals from labor markets and better wages and salaries.

**Housing:** Housing includes a variety of measures of housing quality (Appendix E). These measures not only affect quality of life but also affect development of human capital and economic activity. Housing crowding affects educational achievement of children, and increases health risks and problems. Population living in households without electric power, running water, hard floor, and/or an exclusive sanitary sewer is exposed to more health risks. These obstacles also inhibit economic activity, such as home-based business entrepreneurship, communication, and information with the outside world, etc.

**Income:** In market economies, like México, monetary income plays a very important role because it determines the capacity to acquire goods and services. The lack of income represents one of the most important forms of exclusion, because it prevents the individuals from participating in markets to acquire goods and services. It also limits the ability to acquire assets for economic activity.

**Population Distribution:** the spatial dispersion of population in small communities can result in geographical isolation. Particularly, low population density prevents the creation and the use of economies of scale that urban areas provide, such as services, modern technologies, high productivity, etc. Low population density increases the social investment costs per person that are needed to provide health, education, electric power, drains, and running water services in isolated communities.

Nine indicators measuring these four dimensions have been used to calculate the Marginalization Index at national, state and municipal levels using Census data<sup>26</sup>. For 1990 the Index ranges from -1.69 to 2.36. The 32 Mexican states are classified into four marginalization categories: very low, low, high, and very high marginalization. This index has been calculated for 1995, 2000, and 2005 (CONAPO, 2001).

The *MD* variable takes a value of one in 14 states with high and very high marginalization levels: Campeche, Chiapas, Guanajuato, Guerrero, Hidalgo, Michoacán, Nayarit, Oaxaca, Puebla, San Luis Potosí, Tabasco, Veracruz, Yucatán, and Zacatecas and zero in the rest of the country.

### **3.5. Results**

The results of this study are summarized in Tables 3-1, 3-2, and 3-3. The column labeled *Base* corresponds to the direct estimation of equations (1) and (2); *Indigenous* column corresponds to the estimations including the proportion of indigenous population,

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<sup>26</sup> For more detail in these nine indicators see Appendix E.

$INDI$ , in  $t-5$  period; and the *Marginal* columns correspond to estimations with the marginalization dummy (*Marginal 1*) and its interaction terms (*Marginal 2*).

Estimation results for equation (1) are presented in Table 3-1. Note that under all the columns the intercept is positive and significant, indicating that when everything else is held constant, Mexican states increase their productivity. However, contrary to expected, the coefficients associated with the ratio of investment to GSP ( $(I/Y)_{t-5}$ ) are negative in all cases, and only after controlling by marginalization and the interaction terms (*Marginal 2* column) it becomes significant. The *base* estimation indicates that investments in physical capital do not have a significant impact on productivity growth. On the other hand, the coefficient associated with net migration indicates that output per unit of labor increases when net migration increases. This is indicating that the effect of increasing labor on total output is large enough to offset the decreasing effect of labor in the  $Y/L$  ratio. A one percent increase in the  $n/N$  ratio generates a 0.21 percent increase in  $Y/L$ .

Under the *Indigenous* column, as expected, we observe a negative sign associated with the indigenous population variable, indicating that productivity in states with larger indigenous population grows more slowly than the rest of the country. A one percent decrease in the proportion of indigenous population could generate an increase in output per unit of labor of 0.09 percent. Also notice that when indigenous population is

controlled for the coefficient associated with migration increases and the adjusted  $R^2$  also increases.

**Table 3-1. Productivity growth equation**  
**Dependent variable: log GSP per working-age person 1995, 2000, and 2004.**

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
Constant	9.8527 ***	9.5772 ***	9.9800 ***	9.8039 ***
$\ln(I/Y)_{t-i}$	-0.0916	-0.0619	-0.0884	-0.2045 **
$\ln(n/N)_{Avg(t-i,t)}$	0.2128 **	0.2503 ***	0.1181	-0.0885
$\ln(INDI)_{t-5}$		-0.0862 ***		
<b>Marginalization dummy</b>			-0.2527 ***	0.1356
Interaction terms with:				
$\ln(I/Y)_{t-i}$				0.2167 *
$\ln(n/N)_{Avg(t-i,t)}$				0.5656 ***
$\bar{R}^2$	0.0618	0.1877	0.1448	0.2237
Significance: *	0.10	** 0.05	*** 0.01	

Estimation results under *Marginal 1* column indicate that output per unit of labor in states with higher marginalization levels grows more slowly than the rest of the country by 0.25 percent. When this dummy variable is included the coefficients associated with physical capital investment and migration become non-significant. Results of *Marginal 2* column indicate that while increasing physical capital in all the states decreases the output per unit of labor, in marginalized states the opposite happens (increasing physical capital increases output per unit of labor); and marginalized states attracting working age population increase their output per unit of labor.

Results for equation (2) with human capital measured as number of students enrolled in higher education as a proportion of the working age population (HC1) are presented in Table 3-2. Notice again, that all the intercepts are positive and significant. The *base* estimation shows, contrary to what I expected, a negative significant sign associated with investments in physical capital as a proportion of GDP, implying that increasing this proportion would decrease the product per labor unit (a possible explanation is that labor is not sufficiently skilled to manage new machinery and equipment). On the other hand the coefficients associated with net migration and human capital (this measuring the quality of labor rather than number of workers) are positive and significant, indicating that net migration and human capital are positively related to productivity growth in Mexico for these periods. A one percent increase in net migration will generate a 0.26 percent increase in the productivity growth.

**Table 3-2. Productivity growth equation with human capital 1**  
**Dependent variable: log GSP per working-age person 1995, 2000, and 2004.**

	<i>Base</i>		<i>Indigenous</i>		<i>Marginal 1</i>		<i>Marginal 2</i>	
Constant	11.5679	***	11.2781	***	11.5246	***	11.3302	***
$\ln(I/Y)_{t-i}$	-0.1445	***	-0.1256	***	-0.1416	***	-0.2068	***
$\ln(n/N)_{Avg(t-i,t)}$	0.2648	***	0.2776	***	0.2421	***	0.1509	
$\ln(HC1)_{t-i}$	0.5578	***	0.5057	***	0.5347	***	0.5052	***
$\ln(INDI)_{t-5}$			-0.0405	**				
<b>Marginalization dummy</b>					-0.0550		0.0647	
Interaction terms with:								
$\ln(I/Y)_{t-i}$							0.1310	
$\ln(n/N)_{Avg(t-i,t)}$							0.2353	
$\ln(HC1)_{t-i}$							-0.0303	
$\bar{R}^2$	0.4519		0.4727		0.4728		0.4515	
Significance: *	0.10	**	0.05	***	0.01			

As in Table 3-1, the positive coefficient on net migration indicates that states attracting working age population increase growth in output per unit of labor. The human capital coefficient is indicating that an increase of one percent in the number of enrolled students in higher education per working age population will increase the product per worker by 0.56 percent five years later. Notice also that the adjusted  $R^2$  increased from 0.0618 (Table 3-1, *Base*) to 0.4519 just adding this flow human capital indicator.

Results under the *indigenous* column indicate that output per unit of labor growth is slower in states with larger indigenous population. If the percentage of indigenous population increases one percent we can expect that the output per unit of labor would be 0.04 percent less than in the rest of the country. Again, comparing the *base* and the *indigenous* columns we can observe an increase in the size of the coefficient associated with migration and the adjusted  $R^2$ , while the coefficient associated with investment as a proportion of GSP decreased.

Compared with the *base* estimation, the inclusion of the marginalization dummy variable (*Marginal 1*) reduces the size of the coefficients, and even when the sign associated with the marginalization dummy is negative, it is not significant. When the marginalization interaction terms are included (*Marginal 2*) the marginalization dummy still not significant, suggesting that marginalized areas' productivity is not growing differently from the rest of the country. The physical investment as a proportion of GSP



coefficient increases its absolute value, and is still negative and significant; the investment interaction term with the marginalization dummy is positive but not significant.

Results for equation (2) with human capital measured as the stock of the population 15 or older with higher education as a proportion of the working age population (HC2) are presented in Table 3-3. As in the previous results, once again, the intercepts are all positive and significant; suggesting that holding everything constant, Mexican states productivity will be growing. As in Table 3-2, the *base* estimation shows, contrary to what we expected, a negative significant sign associated with investments in physical capital, implying that increasing investment as proportion of GSP would decrease the product per unit of labor.

**Table 3-3. Productivity growth equation with human capital 2.**  
Dependent variable: log GSP per working-age person 1995, 2000, and 2004.

	<i>Base</i>		<i>Indigenous</i>		<i>Marginal 1</i>		<i>Marginal 2</i>	
Constant	12.3516	***	12.1677	***	12.4189	***	12.6012	***
$\ln(I/Y)_{t-i}$	-0.0892	**	-0.0821	**	-0.0897	**	-0.1255	**
$\ln(n/N)_{Avg(t-i,t)}$	0.2206	***	0.2294	***	0.2381	***	0.2441	***
$\ln(HC2)_{t-i}$	1.0922	***	1.0401	***	1.1303	***	1.2441	***
$\ln(INDI)_{t-5}$			-0.0212					
<b>Marginalization dummy</b>					0.0460		-0.7397	
Interaction terms with:								
$\ln(I/Y)_{t-i}$							0.0877	
$\ln(n/N)_{Avg(t-i,t)}$							0.0857	
$\ln(HC2)_{t-i}$							-0.4051	*
$\bar{R}^2$	0.6067		0.6094		0.6048		0.6090	
Significance: *	0.10	**	0.05	***	0.01			

On the other hand, the coefficients associated with net migration are positive and significant, as in Table 3-2, these coefficients on the net migration variable indicate that states attracting working age population increase their productivity levels measured as output per unit of labor.

The human capital coefficient indicates that for an increase of one percent in the proportion of population with higher education per working age population causes an increase between 1.09 and 1.24 percent in the output per worker. Notice that this coefficient is almost the double of the one observed in Table 3-2, suggesting that the stock of human capital has a greater impact than the flow of human capital, however this result could be different with other human capital flows and stocks indicators, and further research can be done to test the robustness of this result. The adjusted  $R^2$  increased from 0.0618 (*Base*, Table 3-1) to 0.6067 just adding this stock human capital indicator (*Base*, Table 3-3).

The results under the *Marginal 1* column indicate that once controlling for the stock of human capital the marginalization dummy is as in Table 3-2, not significant; however notice that the size of the migration and the stock of human capital coefficients increased to those observed in the *base* column; and the adjusted  $R^2$  decreased its size suggesting that the marginalization dummy should not be included in the model.

As in Table 3-2, the investment as portion of GSP coefficient and its interaction term with the marginalization dummy (*Marginal 2* column) have opposite signs but the size of the interaction term is not large enough to offset the effect of the investment coefficient, suggesting that even when investments in physical capital in marginalized areas is more “productive” than in the rest of the country is not enough to increase output per unit of labor.

The marginalization interaction term with the stock of human capital shows a negative and significant size, suggesting that the positive effect that more workers with education has on increasing output per unit of labor is about one third less in marginalized regions than in the rest of the country.

### **3.6. Conclusions**

In this study, I analyzed the behavior of productivity measured as output per unit of labor among Mexican states for the period 1993-2004. As noted in the introduction, differences in output per unit of labor across Mexican states have traditionally been high and fairly persistent. Using panel data with state level observations for 1993-2004 I analyze Gross State Output (GSP) per working age population controlling for physical

capital investments, the working age population growth rate, migration rate, indigenous population, and marginalization levels.

Based on neoclassical and endogenous economic growth theory I expected that growth in output per unit of labor would be positively related to investments in both physical and human capital. However, I found that investments in physical capital are negatively related to increases in output per unit of labor. I suspect that these results could be due to either: 1) a data collection problem, i.e. the gross fixed capital formation data is not actually a good measure for physical investment; or 2) a problem in the lags in the model, physical investments take more time to have an effect on economic growth, we need a more detailed analysis of these data to figure out the appropriate lag; 3) it could be that even when at national level the gross fixed capital formation is very highly correlated to gross savings, this might not hold at state level; 4) perhaps institutional problems are not allowing physical investments to behave the way theory suggests. In addition, it may be useful to separate the public and the private investments to analyze if they both present the same problems, but there are no data available at the state level to allow this.

I found that states attracting labor force are experiencing increases in their productivity, because the increase in total output is enough to offset the opposite effect on the output per unit of labor, confirming that movement increase productivity. This effect is

actually reinforced once I controlled for human capital, because migrants come with a stock of human capital that they can use in the economy where they move.

I found that human capital either measured as a stock or as a flow, is a very important factor in determining productivity growth. The size of the coefficients associated with these variables suggest that increasing human capital contributes more to productivity growth than physical capital or labor increases. Thus the Mexican government should promote higher education among its population to increase the country's productivity.

As for indigenous population, I found that productivity in states with a higher percentage of indigenous population on average grow more slowly than the rest of the country. This could be explained because the indigenous population faces some barriers to access the markets: language, discrimination, historical lag of investment, etc. and these effects were captured by the negative sign associated with our indigenous variable. Thus policies oriented to eliminate these barriers would contribute to the productivity growth of Mexican indigenous areas.

Marginalization, like indigenous condition, limits market access. The Mexican government estimates a marginalization index to identify states and communities with high marginalization levels. I use this index to analyze the economic growth of these marginalized regions. When I do not control for human capital, the marginalization variable is negative and significant, and as I expected, productivity in states with higher

levels of marginalization is on average growing slower than the rest of the country. However these results do not hold once I controlled for human capital, meaning that investments in human capital are offsetting the effects of marginalization, so the Mexican government can support human capital to benefit marginalized areas.

## Appendix A

### *Descriptive statistics.*

	Dependent Variable	Log (Population)	Population growth rate 1990-2000	Sales tax rate	City's county in the border	# of cities in surrounding counties	# of cities in the county	City's county staying in the holiday
<b>Mean</b>	0.8037	6.5311	0.1140	0.0631	0.5318	45.4759	17.5559	0.4518
<b>Median</b>	1.0000	6.2719	0.0327	0.0623	1.0000	42.0000	9.0000	0.0000
<b>Maximum</b>	1.0000	12.9980	9.2238	0.0835	1.0000	141.0000	90.0000	1.0000
<b>Minimum</b>	0.0000	1.6094	-0.8338	0.0473	0.0000	10.0000	1.0000	0.0000
<b>Std. Dev.</b>	0.3974	1.6509	0.4639	0.0083	0.4993	21.6223	24.1487	0.4979
<b>Skewness</b>	-1.5294	0.5596	10.2543	-0.1577	-0.1275	2.1373	2.5496	0.1939
<b>Kurtosis</b>	3.3392	3.2480	176.5374	2.0859	1.0162	8.9490	7.8612	1.0376
<b>Jarque-Bera</b>	359.9259	49.9392	1,160,362	35.5302	152.0100	2,039.20	1,886.08	152.0537
<b>Probability</b>	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

### *Correlation matrix*

	Dependent Variable	Log (Population)	Population growth rate 1990-2000	Sales tax rate	City's county in the border	# of cities in surrounding counties	# of cities in the county	City's county staying in the holiday
<b>Dependent Variable</b>	1.0000	-0.4741	-0.0361	-0.3550	-0.0100	-0.0608	-0.1748	-0.0118
<b>Log (Population)</b>	-0.4741	1.0000	0.1178	0.5895	0.1092	0.1405	0.2891	0.1505
<b>Population growth rate 1990-2000</b>	-0.0361	0.1178	1.0000	0.0374	0.0064	0.0220	-0.0605	-0.0566
<b>Sales tax rate</b>	-0.3550	0.5895	0.0374	1.0000	-0.0097	0.0541	0.1109	0.1458
<b>City's county in the border</b>	-0.0100	0.1092	0.0064	-0.0097	1.0000	-0.1195	0.3920	0.2115
<b># of cities in surrounding counties</b>	-0.0608	0.1405	0.0220	0.0541	-0.1195	1.0000	0.0201	0.1106
<b># of cities in the county</b>	-0.1748	0.2891	-0.0605	0.1109	0.3920	0.0201	1.0000	0.3410
<b>City's county staying in the holiday</b>	0.0086	0.1434	-0.0466	0.1062	0.2337	0.3669	0.1352	1.0000

## Scatter Diagrams

These are the scatter diagrams of the dependent variable in the logit model.

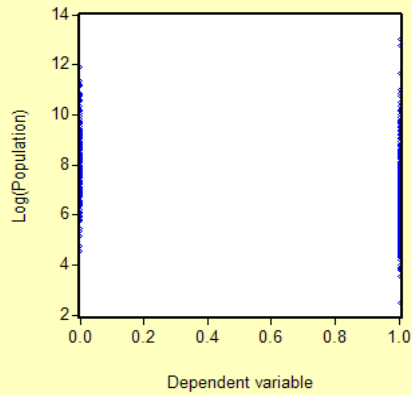


Figure a

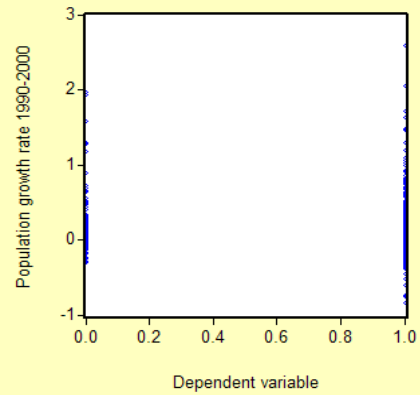


Figure b

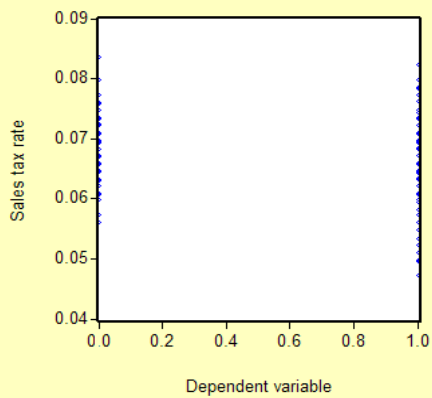


Figure c

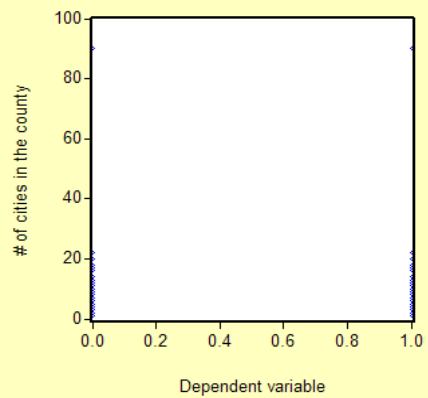


Figure d

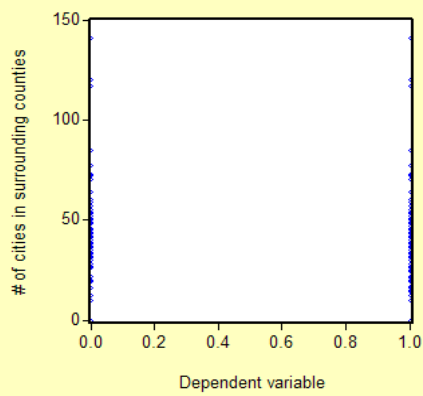


Figure e



## Appendix B

### **Summary of Output: Ordinary Least Squares Estimation**

Dependent Variable : **Proportion of cities participating in the 2004 Missouri sales tax holiday.**

Number of Observations: 115

Mean dependent var : 0.689343

Number of Variables : 10

S.D. dependent var : 0.193374

Degrees of Freedom : 105

R-squared:	0.210525	F-statistic:	3.11109
Adjusted R-squared:	0.142856	Prob(F-statistic):	0.00235251
Sum squared residual:	3.39495	Log likelihood:	39.3741
Sigma-square:	0.0323328	Akaike info criterion:	-58.7481
S.E. of regression:	0.179813	Schwarz criterion:	-31.2988
Sigma-square ML:	0.0295213		
S.E of regression ML:	0.171818		

Variable	Coefficient	Std.Error	t-Statistic	Probability
CONSTANT	0.1928223	0.3095452	0.6229214	0.5346885
Log(Population)	0.07308107	0.02861853	2.553628	0.0120968
Population growth rate 1990-2000	-0.001436165	0.00170084	-0.8443856	0.4003733
Proportion of population living in urban areas	-0.2022771	0.1182801	-1.710153	0.0901909
Sales tax rate	-0.8521011	3.504931	-0.2431149	0.8083871
County in state border	-0.1100817	0.03891651	-2.828662	0.0056000
County participated in holiday	0.0980676	0.03612921	2.714358	0.0077641
Income	-2.66273e-006	7.482768e-006	-0.3558482	0.7226657
# of cities in the county	-0.001260897	0.002653044	-0.4752641	0.6355844
# of cities in surrounding counties	-6.641907e-006	0.001042637	-0.006370297	0.9951223

#### REGRESSION DIAGNOSTICS

MULTICOLLINEARITY CONDITION NUMBER 67.64067

TEST ON NORMALITY OF ERRORS

TEST	DF	VALUE	PROB
Jarque-Bera	2	9.481025	0.0087342

#### DIAGNOSTICS FOR HETEROSKEDASTICITY

RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	9	13.30321	0.1493593
Koenker-Bassett test	9	8.799453	0.4559888

SPECIFICATION ROBUST TEST

TEST	DF	VALUE	PROB
White	54	N/A	N/A

#### DIAGNOSTICS FOR SPATIAL DEPENDENCE

FOR WEIGHT MATRIX : rook\_newcounty5.GAL (row-standardized weights)

TEST	MI/DF	VALUE	PROB
Moran's I (error)	0.019228	0.8152578	0.4149247
Lagrange Multiplier (lag)	1	0.3875175	0.5336072
Robust LM (lag)	1	1.0234997	0.3116903
Lagrange Multiplier (error)	1	0.1013394	0.7502282
Robust LM (error)	1	0.7373216	0.3905202
Lagrange Multiplier (SARMA)	2	1.1248391	0.5698287

## Summary of Output: Spatial Lag Model-Maximum Likelihood Estimation

Spatial Weight : **Rook continuity**

Dependent Variable: **Proportion of cities participating in the 2004 Missouri sales tax holiday.**

Number of Observations: 115

Mean dependent var : 0.689343

Number of Variables : 11

S.D. dependent var : 0.193374

Degrees of Freedom : 104

Lag coeff. (Rho) : 0.0872532

R-squared: 0.214493

Log likelihood: 38.1993

Sq. Correlation: -

Akaike info criterion : 56.3986

Sigma-square: 0.0293729

Schwarz criterion: 28.9493

S.E of regression: 0.171385

Variable	Coefficient	Std.Error	z-value	Probability
Weighted dependent variable	0.08725319	0.1325952	0.6580417	0.5105112
CONSTANT	0.1604864	0.2996615	0.535559	0.5922633
Log(Population)	0.06828759	0.02801433	2.437595	0.0147853
Population growth rate 1990-2000	-0.001380894	0.001627552	-0.8484485	0.3961881
Proportion of population living in urban areas	-0.1904425	0.1159029	-1.643121	0.1003579
Sales tax rate	-0.6221405	3.34135	-0.1861943	0.8522924
County in state border	-0.105378	0.03778582	-2.788824	0.0052901
County participated in holiday	0.09435509	0.03443909	2.739768	0.0061484
Income	-2.804677e-006	7.132243e-006	-0.3932391	0.6941430
# of cities in the county	-0.001150779	0.002528901	-0.4550509	0.6490726
# of cities in surrounding counties	5.806515e-005	0.0009945173	0.05838526	0.9534416

### REGRESSION DIAGNOSTICS

#### DIAGNOSTICS FOR HETEROSKEDASTICITY

##### RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	9	2.99564	0.9644676

#### DIAGNOSTICS FOR SPATIAL DEPENDENCE

##### SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : **newcounty5rook.GAL**

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	0.4002744	0.5269476

## Summary of Output: Spatial Error Model - Maximum Likelihood Estimation

Spatial Weight : **Rook continuity**

Dependent Variable: **Proportion of cities participating in the 2004 Missouri sales tax holiday.**

Number of Observations: 115

Mean dependent var: 0.689343 Number of Variables: 10

S.D. dependent var : 0.193374 Degree of Freedom: 105

Lag coeff. (Lambda): 0.055067

R-squared: 0.211851

R-squared (BUSE) :-

Sq. Correlation: -

Log likelihood: 39.435333

Sigma-square: 0.029472

Akaike info criterion: -58.8707

S.E of regression: 0.171673

Schwarz criterion: -31.421344

Variable	Coefficient	Std.Error	z-value	Probability
CONSTANT	0.1909138	0.2985459	0.6394791	0.5225112
Log(Population)	0.07264327	0.02766634	2.625691	0.0086474
Population growth rate 1990-2000	-0.001490907	0.001650915	-0.9030792	0.3664838
Proportion of population living in urban areas	-0.2074183	0.1142751	-1.815079	0.0695117
Sales tax rate	-0.5854528	3.374144	-0.1735115	0.8622494
County in state border	-0.1101028	0.03787962	-2.90665	0.0036533
County participated in holiday	0.09402606	0.03438525	2.734488	0.0062478
Income	-2.923964e-006	7.189713e-006	-0.4066871	0.6842379
# of cities in the county	-0.001215444	0.002506513	-0.4849141	0.6277373
# of cities in surrounding counties	4.060765e-005	0.00100289	0.04049062	0.9677019
LAMBDA	0.05506745	0.1412843	0.3897633	0.6967117

### REGRESSION DIAGNOSTICS

#### DIAGNOSTICS FOR HETEROSKEDASTICITY

##### RANDOM COEFFICIENTS

TEST	DF	VALUE	PROB
Breusch-Pagan test	9	2.783094	0.9722773

#### DIAGNOSTICS FOR SPATIAL DEPENDENCE

##### SPATIAL ERROR DEPENDENCE FOR WEIGHT MATRIX : newcounty4rook.GAL

TEST	DF	VALUE	PROB
Likelihood Ratio Test	1	0.1225464	0.7262889

## Appendix C. Convergence results for 1990-2005

As mentioned in Chapter 2, the INEGI publishes GSP from 1993 to 2004, and the shares of the gross fixed capital formation for 1993-2003. In this Appendix I present the results for equations (8), (9), and (10) from Chapter 2 for the 1990-2005 period using data for the 1990 and 2005 state observations.

Gross State Output (GSP) is used to proxy output  $Y$ . It is measured in millions of constant pesos 1993=100 (INEGI, 2007a). The national data (GDP) from 1990-2004 were taken from the National Accounting System (SNCNM) administrated by the Statistics, Geography, and Informatics National Institute (INEGI). The national observation for 2005 was taken from the GDP quarterly series that the INEGI (2007b) published. The INEGI also publishes the GSP for the 1993-2004 period, so data for 1990 and 2005 were estimated. Each state percentage contribution to GDP was calculated for 1993 and 1994. The average percentage of these two years was multiplied by 1990 GDP to estimate each state 1990 GSP. A similar calculation using 2003 and 2004 data was used to estimate 2005 GSP for each state.

I used gross fixed capital formation to measure  $I$  because gross savings data is only available at the national level. The INEGI publishes data on each state's percentage contribution to national gross fixed capital formation for the period 1993 to 2003

(INEGI, 2007c). To calculate the 1990 and 2005 observations we used the same procedure as for calculating GSP.

These results are different from those in Chapter 2 since in this case we are observing  $\beta$  conditional convergence in Tables A and B after controlling for indigenous condition, while in Chapter 2 we only observe  $\beta$  conditional convergence after we controlled for flow of human capital.

**Table A. Unconditional  $\beta$  convergence**

Dependent variable  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-5}}{L_{t-5}} \right) \right] / 5$  for t= 1995, 2000, and 2005.

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
<b>Constant</b>	<b>0.0669</b>	<b>0.0994</b> *	<b>0.0507</b>	<b>0.0619</b> ***
$\ln(Y_{t-5} / L_{t-5})$	-0.0061	-0.0107 *	-0.0046	-0.0057 **
$\ln(INDI)_{t-5}$		-0.0037 ***		
<b>Marginalization dummy</b>			-0.0030	-0.0256
Interaction terms with:				
$\ln(Y_{t-5} / L_{t-5})$				0.0029 **
$\bar{R}^2$	0.0029	0.0761	-0.0033	-0.0136

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01

**Table B. Conditional  $\beta$  convergence**

Dependent variable	$\ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-5}}{L_{t-5}} \right) / 5$ for t= 1995, 2000, and 2005.				
	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>	
Constant	0.0325	0.0681 *	0.0286	0.0853	
$\ln(Y_{t-5} / L_{t-5})$	-0.0033	-0.0079 *	-0.0029	-0.0093	
$\ln(I / Y)_{t-5}$	-0.0037	-0.0032	-0.0037	-0.0085	
$\ln(n / N)_{Avg(t-5,t)}$	-0.0117 **	-0.0092 *	-0.0115 **	-0.0128 *	
$\ln(INDI)_{t-5}$		-0.0033 **			
<b>Marginalization dummy</b>			-0.0008	-0.1370	
Interaction terms with:					
$\ln(Y_{t-5} / L_{t-5})$				0.0151	
$\ln(I / Y)_{t-5}$				0.0071	
$\ln(n / N)_{Avg(t-5,t)}$				-0.0016	
$\bar{R}^2$	0.0427	0.0933	0.0326	0.0246	
Significance: * 0.10    ** 0.05    *** 0.01					

**Table C. Conditional  $\beta$  convergence and human capital 1**

Dependent variable	$\ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-5}}{L_{t-5}} \right) / 5$ for t= 1995, 2000, and 2005.				
	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>	
Constant	0.1538 **	0.1616 **	0.1504 *	0.1952 *	
$\ln(Y_{t-5} / L_{t-5})$	-0.0119 *	-0.0144 **	-0.0114	-0.0163 *	
$\ln(I / Y)_{t-5}$	-0.0055	-0.0047	-0.0057 *	-0.0099 *	
$\ln(n / N)_{Avg(t-5,t)}$	-0.0084	-0.0068 *	-0.0071	-0.0066	
$\ln(HCI)_{t-5}$	0.0116 *	0.0093	0.0128 **	0.0137	
$\ln(INDI)_{t-5}$		-0.0028 **			
<b>Marginalization dummy</b>			0.0035	-0.1424	
Interaction terms with:					
$\ln(Y_{t-5} / L_{t-5})$				0.0145	
$\ln(I / Y)_{t-5}$				0.0069	
$\ln(n / N)_{Avg(t-5,t)}$				-0.0056	
$\ln(HCI)_{t-5}$				-0.0042	
$\bar{R}^2$	0.0710	0.1077	0.0661	0.0411	
Significance: * 0.10    ** 0.05    *** 0.01					

**Table D. Conditional  $\beta$  convergence and human capital 2**

Dependent variable	$\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-5}}{L_{t-5}} \right) \right] / 5$ for t= 1995, 2000, and 2005.			
	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
Constant	0.1687 *	0.1548	0.1787	0.3726 **
$\ln(Y_{t-5} / L_{t-5})$	-0.0129	-0.0139	-0.0133	-0.0292 **
$\ln(I / Y)_{t-5}$	-0.0044	-0.0036	-0.0045	-0.0095 *
$\ln(n / N)_{Avg(t-5,t)}$	-0.0091	-0.0076	-0.0075	-0.0026
$\ln(HC2)_{t-5}$	0.0178	0.0117	0.0213	0.0411 **
$\ln(INDI)_{t-5}$		-0.0029 **		
<b>Marginalization dummy</b>			0.0038	-0.4052 *
Interaction terms with:				
$\ln(Y_{t-5} / L_{t-5})$				0.0337 *
$\ln(I / Y)_{t-5}$				0.0079
$\ln(n / N)_{Avg(t-5,t)}$				-0.0117
$\ln(HC2)_{t-5}$				-0.0380
$\bar{R}^2$	0.0550	0.0927	0.0507	0.0567

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01

**Table E. Standard deviations for  $Y/L$  and  $\ln(Y/L)$**

<i>Year</i>	$Y / L$ (\$)	$\ln(Y / L)$
<b>1990</b>	10,213.38	0.3997
<b>1995</b>	9,226.65	0.3848
<b>2000</b>	11,004.86	0.4078
<b>2005</b>	10,923.46	0.3995

**Table F. Standard deviations for  $\left[ \ln \left( \frac{Y_t}{L_t} \right) - \ln \left( \frac{Y_{t-i}}{L_{t-i}} \right) \right] / i$**

<i>Period</i>	<i>Standard Deviation</i>
<b>1990-1995</b>	0.0121
<b>1995-2000</b>	0.0160
<b>2000-2005</b>	0.0119

## Appendix D. Productivity growth results for 1990-2005

As mentioned in Chapter 3, the INEGI publishes GSP from 1993 to 2004, and the shares of the gross fixed capital formation for 1993-2003. In this Appendix I present the results for equations (1) and (2) from Chapter 3 for the 1990-2005 period. I estimated the 1990 and 2005 state observations.

Gross State Output (GSP) is used to proxy output  $Y$ . It is measured in millions of constant pesos 1993=100 (INEGI, 2007a). The national data (GDP) from 1990-2004 were taken from the National Accounting System (SNCNM) administrated by the Statistics, Geography, and Informatics National Institute (INEGI). The national observation for 2005 was taken from the GDP quarterly series that the INEGI (2007b) published. The INEGI also publishes the GSP for the 1993-2004 period, so data for 1990 and 2005 were estimated. Each state percentage contribution to GDP was calculated for 1993 and 1994. The average percentage of these two years was multiplied by 1990 GDP to estimate each state 1990 GSP. A similar calculation using 2003 and 2004 data was used to estimate 2005 GSP for each state.

I used gross fixed capital formation to measure  $I$  because gross savings data is only available at the national level. The INEGI publishes data on each state's percentage contribution to national gross fixed capital formation for the period 1993 to 2003



(INEGI, 2007c). To calculate the 1990 and 2005 observations we used the same procedure as for calculating GSP.

**Table A. Growth equation**  
Dependent variable: log GSP per working-age person 1995, 2000, and 2005.

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
Constant	9.8698 ***	9.5830 ***	10.004 ***	9.7747 ***
$\ln(I/Y)_{t-5}$	-0.0823	-0.0564	-0.0743	-0.2182 **
$\ln(n/N)_{Avg(t-5,t)}$	0.2027 **	0.2392 ***	0.1100	-0.1002
$\ln(INDI)_{t-5}$		-0.0866 ***		
<b>Marginalization dummy</b>			-0.2499 ***	0.2347
Interaction terms with:				
$\ln(I/Y)_{t-5}$				0.2692 **
$\ln(n/N)_{Avg(t-5,t)}$				0.5789 ***
$\bar{R}^2$	0.0515	0.1803	0.1327	0.2298

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01

**Table B. Growth equation with human capital 1**  
Dependent variable: log GSP per working-age person 1995, 2000, and 2005.

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
Constant	11.5858 ***	11.2873 ***	11.5497 ***	11.2975 ***
$\ln(I/Y)_{t-5}$	-0.1410 ***	-0.1240 **	-0.1374 ***	-0.2220 ***
$\ln(n/N)_{Avg(t-5,t)}$	0.2538 ***	0.2664 ***	0.2344 ***	-0.1390
$\ln(HC1)_{t-5}$	0.5614 ***	0.5085 ***	0.5413 ***	0.5050 ***
$\ln(INDI)_{t-5}$		-0.0413 **		
<b>Marginalization dummy</b>			-0.0473	0.1314
Interaction terms with:				
$\ln(I/Y)_{t-5}$				0.1709 *
$\ln(n/N)_{Avg(t-5,t)}$				0.2457
$\ln(HC1)_{t-5}$				-0.0336
$\bar{R}^2$	0.4474	0.4696	0.4441	0.4533

Significance: \* 0.10    \*\* 0.05    \*\*\* 0.01

**Table C. Growth equation with human capital 2.**  
**Dependent variable: log GSP per working-age person 1995, 2000, and 2005.**

	<i>Base</i>	<i>Indigenous</i>	<i>Marginal 1</i>	<i>Marginal 2</i>
Constant	12.3716 ***	12.1755 ***	12.4407 ***	12.5574 ***
$\ln(I/Y)_{t-5}$	-0.0821 **	-0.0760 *	-0.0837 ***	-0.1389 **
$\ln(n/N)_{Avg(t-5,t)}$	0.2100 ***	0.2189 ***	0.2292 ***	0.2290 **
$\ln(HC2)_{t-5}$	1.0938 ***	1.0398 ***	1.1360 ***	1.2359 ***
$\ln(INDI)_{t-5}$		-0.0219		
<b>Marginalization dummy</b>			0.0509	-0.6765
Interaction terms with:				
$\ln(I/Y)_{t-5}$				0.1282 *
$\ln(n/N)_{Avg(t-5,t)}$				0.1013
$\ln(HC2)_{t-5}$				-0.4096 *
$\bar{R}^2$	0.6010	0.6042	0.5996	0.6085
Significance: *	0.10	** 0.05	*** 0.01	

As can be observed, results are not very different from those presented in Chapter 3.

The size of the coefficients and the significance did not changed. Then the conclusions of Chapter 3 also apply to the results presented in this Appendix.

## Appendix E. Conceptual scheme of the marginalization in Mexico

CONCEPT	SOCIO-ECONOMIC DIMENSIONS	FORMS	INDICATOR TO MEASURE INTENSITY	MARGINALIZATION INDEX
Structural multiple phenomenon that values dimensions, forms and intensities of the exclusion in the development process and its benefits	Education	Illiteracy	$I_1 =$ % of illiterate population of 15 years or more	Global intensity of the socioeconomic marginalization
		Population that not complete primary school	$I_2 =$ % of incomplete primary school of 15 years or more	
	Housing	Households without running water	$I_3 =$ % of occupants in particular households without running water	
		Households without sanitary sewer and drains	$I_4 =$ % of occupants in particular households without sanitary sewer available in the household	
		Households with no-hard floor	$I_5 =$ % of occupants in particular households with no-hard floor	
Households without electricity power		$I_6 =$ % of occupants in particular households without electricity		
	Households of inadequate size	$I_7 =$ % of particular households with some piling level		
Income	Occupied population that receive up to 2 minimum wages	$I_8 =$ % of occupied population that receive up to 2 minimum wages		
Population Distribution	Communities with less than 5 000 inhabitants	$I_9 =$ % of population in communities with less than 5 000 inhabitants		

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