Distribution Dynamics of the Per Capita Income in Mexico, 1990-2010: Convergence across Municipalities

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Abstract

This study focuses on the inequality dynamics of the Mexican distribution of the mean per capita income at the municipal level in 1990, 2000 and 2010 using Gaussian finite mixtures. Our results show the formation of a poor component in 2000. It consists of entirely 260 rural municipalities, mostly grouped in the states of Oaxaca, Chiapas, Veracruz and Puebla. The dynamics of income inequality suggest that such administrative entities were unable to move toward non-farm activities during the 1990s and 1980s, a period highlighted by macro developments favouring the expansion of the non-tradable sector in Mexico. On the contrary, the period 2000-2010 is characterized by a catching-up process due to the relative upsurge of the farm-activities. This recovery can be explained, amongst other factors, by productivity improvements, the commodity boom of the mid 2000s, reduction of government subsidies in the US, domestic price stability, remittances and the enhancement of efficient conditional cash transfers programs. Finally, more than ask for special treatment for the 260 rural municipalities, we believe it to be desirable to support the entire traditional agricultural sector encouraging intra and inter sectorial mobility.

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1. Introduction

After the import-substitution industrialization period (ISI), Mexico opened up its economy by signing the General Agreement on Tariffs and Trade (GATT) in 1986. This export-oriented strategy was later enhanced by accessing the North American Trade Agreement (NAFTA) in 1994, the largest free trade region worldwide. In December 1994, an important economic crisis started to affect the Mexican economy. After the crisis, income levels did not recover the observed dynamism previous to the depression. The periods 1994-2000 and 2000-2006 the economy experienced modest growth with some inflation and low expansion with microeconomic stability respectively (Esquivel 2011). On the inequality side, Campos et al. (2012) show that income inequality reached its peak in 1994, followed by income equalization from 1994 to 2006.[1] During the period 2006-2010, the equalization of incomes loses its steam. According to this study, the increasing wage-gap between skilled and unskilled workers explains the rise in labour income inequality during the GATT period.[2] On the contrary, the equalization of the income distribution post 1994 (NAFTA period) relies on the compression of the returns to skills caused by a relative abundance of high-skilled workers and the growing demand for low-skilled workers due to the expansion in assembly-line operations.[3]

After a relative long period of convergence, most authors agree with the idea that this disequalization can be linked to the changes in the trade policy, started in the mid-1980s.[4] However, there are few attempts to study the convergence-divergence problem from a perspective different to the one introduced into the literature by Barro and Sala-i-Martin (1991, 1992). Delgadillo Macías (2008) finds an increasing spatial autocorrelation of the economic activity since 1993 and identifies three groups of states during the NAFTA period

[1] The Gini coefficient for per capita (disposable monetary) income reached its maximum of 0.571 in 1994. In 2006, the Gini coefficient was close to its minimum reaching a 0.512.

[2] Campos et al. (2012) argue that political and institutional changes affecting disproportionately low-skilled labour (reduction in minimum wages and unionization rate) joint with skill bias technological change in the context of the opening up of the economy (GATT) explains this disequalizing trend.

[3] Moreover, social policies changed their focus going from general subsidies towards cash transfers programs targeted to the poor. In 2000, the number of cash receipt was enhanced (Campos et al. 2012).

[4] For instance, Juan-Ramon and Rivera-Batiz (1996) attribute the divergence across the territory between the mid-1980s and 1990s to the GATT. Sánchez-Reaza and Rodríguez-Pose (2002), Fuentes Flores and Mendoza Cota (2003) and Chiquiar (2005) argue in similar way regarding NAFTA's impact on income inequality. Messmacher (2000) finds a rise in absolute inequality with a stagnated relative inequality across the states during the 1990s. Esquivel (1999) finds neither convergence nor divergence for the period 1980-1995. Gómez-Zaldívar and Ventosa-Santulária (2012) argue that the liberalization reforms of the 1980s accelerated the process of convergence between the border and the Capital Region (State of Mexico and the Federal District-DF) during the period 1990-2010. Additionally, they found convergence between the Capital Region and the Gulf Region during the last decade. Cabral and Varella Mollick (2012) use a dynamic panel data approach to find absolute convergence of 9.4% across Mexican regions for the period 1996-2006.

(1993-2004).[5] Aroca et al. (2003) based on the distribution of the per capita income at the state-level and using spatial econometric tools, investigate the spatial dimension of growth in Mexico over the last three decades. As in most studies, they find a decreasing regional dispersion from 1970 to 1985 and a strong process of divergence coinciding with the opening up of the Mexican economy started in the mid 1980s. The authors find that a "south" exists, but the north is restricted to those states along the US border and there has never been a centre.[6] They suggest that the post-1985 divergence is in a great extent driven by the dissimilar paths of these two regions. Complementarily, it is argued that the under performance of the "south", in particular, the agricultural sector and upsurge of a convergence club in the centre of the country are also likely candidates for explaining much of the divergence occurring until 1993.

Quah (1993, 1996) introduced the analysis of convergence to the literature. He argues that the observed bimodal cross-country distribution of GDP per capita reflects the polarization of distribution into a rich and a poor convergence club coining the “twin peaks” term.[7] However, Vollmer et al. (2013b) challenge the twin peak finding in the cross country distribution of GDP per capita arguing that a superior approach to investigate convergence-clubs is based on finite mixture models.[8] Following Vollmer et al. (2013a), studying the number of clusters may be more desirable when investigating convergence. Components in a distribution can have a stronger economic interpretation as they possibly identify relevant sub-groups in a heterogeneous distribution (clusters); for convergence, the existence of these sub-groups and their evolution over time is a fundamental issue.

This paper comes to provide some updated and improved evidence on convergence based on this alternative approach to study income inequality dynamics. It is based on the analysis of the number of convergence clubs that make up the income distribution of the per capita income across municipalities.[9] Based on this information, we draw relevant conclusions for

[5] The author classify the Mexican states in a favoured group: Chihuahua, Coahuila, Nuevo León, Tamaulipas, Durango, Zacatecas, San Luis de Potosí, Aguascalientes; a less favoured group: Sonora, Nayarit, Jalisco, Colima, Michoacán, Guanajuato, Querétaro, Puebla, Tlaxcala and Yucatan. The stagnated groups consist of all remaining states.

[6] However, the authors argue that previous parametric findings of a gradient were imposed by the linear relationship with distance from the border that identified off the high north and south incomes but obscured the randomness in between.

[7] Bianchi (1997) was the first to empirically confirm the statistical significance of the second peak using a nonparametric procedure by Silverman (1981).

[8] According to Vollmer et al. (2013b) the finite mixture models approach is preferred because the number of components does not depend on the scale. Components in the Gaussian mixture arguably correspond better to income clubs in the distribution than peaks. Thus, normal finite mixture models allow for an accurate analysis of the intra-distributional income dynamics by using posterior probability estimates.

[9] Note that paper, we do not use, as usual in the Mexican literature on convergence, information at the state-level but at the municipal one.

policy makers since we are able to identify municipalities belonging to different clubs of convergence. Moreover, we explore in some degree their determinants.

This paper is structured as follows. Next section presents and describes the data. Section 3 briefly summarizes the methodology applied in our study. Results and an analysis on the income inequality dynamics are presented in Section 4. Section 5 concludes.

2. Data

Mexico is structured into 32 states divided into 2438 municipalities. We consider 2372 municipalities for which we have a comparable per capita income at the municipality-level variable for the years of 1990, 2000 and 2010. We use a data set provided by the national council for the evaluation of policies on social development CONEVAL.[10] The data consist of the mean household per capita income, rural, urban and total population at the municipal level and some inequality indicators of the estimated distributions. Income distributions were estimated by using the poverty-map methodology developed by Elbers et al. (2002, 2003). The primary data consist of the household expenditure surveys ENIGH and Census data.

Our income variable corresponds to the estimation at constant prices (Mexican pesos of August 2010), of the monthly average of the household per capita income at the municipality-level on a logarithmic scale with base 10.[11] The income variable consists of all monetary and non-monetary income, including auto consumption, imputed rent and income transfers.[12] Table A.1 in the appendix depicts the subgroups and the number of municipalities included in the study. We consider all municipalities for those we have available the average per capita income in 1990, 2000 and 2010 (balanced panel).

Turning to our variable of interest, Figure 1 shows in the 2000 data, the significant income loss suffered during the 1994 crisis. In real terms, the household per capita income in 2010 lagged behind its 1990 level. In 2000, an important group of municipalities became relatively poorer, putting in evidence the possible formation of a disadvantaged club with incomes around 2.7 log-points.

In the appendix, Figures A.1 to A.3 show the geographic correlation in the distribution of incomes across municipalities. Quite clear is the fact that the crisis of 1994 affected disproportionately the southern part of the country.

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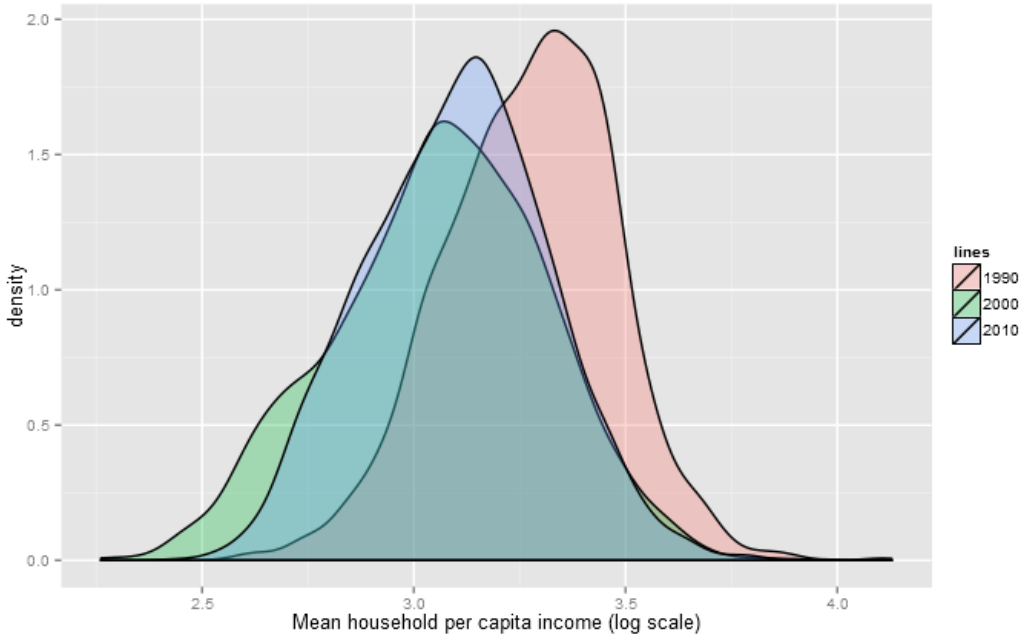
[10] Consejo Nacional de evaluación de la política de desarrollo social.

[11] Income figures were deflated using Mexican CPI (Índice Nacional de Precios al Consumidor - INPC). This income figure is smaller than the GDP household per capita income level. In that sense, this variable does not adjust by national accounts and strictly corresponds to an estimation based on household survey information.

[12] We are thankful to the Poverty, Equity and Gender Unit, PREM-LAC, The World Bank, for their collaboration in obtaining the data. In particular, we thank Eduardo Ortiz-Juarez.

Figure 1: Kernel Densities of the average per capita income by municipalities in 1990, 2000 and 2010.



Source: CONEVAL data on household per capita income

3. Methodology

In general, an intuitive way to model the (potentially heterogeneous) distribution of the average household per capita income at the municipal level is using finite mixture models. In a normal or Gaussian finite mixture, the observations have density

$$f(x|\theta,\lambda) = \sum_{k=1}^{K} \lambda_k \, \phi(x;\theta_k)$$

Where λ_k being the weights determining the relative size of the sub-populations ($\lambda_k > 0$, $\sum_{k=1}^{K} \lambda_k = 1$). $\phi(x;\theta_k)$ represents probability density functions of the Gaussian components. The parameters estimation follows the maximum likelihood method allowing for unequal variances. The log-likelihood in finite mixtures with different variances is unbounded implying that a global maximum of the function does not exist. We employ the Expectation-Maximization (EM) algorithm (see, Dempster et al. 1977 and Vollmer et al. 2013a) to fit the Gaussian finite mixture and the Bayesian Information Criterion (BIC) approximation to the Bayes factor (Schwarz, 1978) is used to choice the best model (number of components and their parameterization).[13] Our methodology aims to find one or more components, which are statistically significant and contribute to make the observed distribution the most probable.

[13] Analysis performed using the R-package {mclust}.

This procedure allows us to estimate the subgroups derived from our mixture and classify the municipalities according to an estimated posterior probability that a certain municipality belongs to a determined sub-group.

Additionally, we extend our analysis in order to explore the possible correlations between our variable of interest, and its income inequality dynamic represented by the bivariate distribution of the 90/10 income inequality ratio. The Gaussian finite mixture of the bivariate distribution is fitted by EM algorithm, and the best model is again selected based on BIC from a variety of variance models depending on the volume, shape and orientation. The resulting clusters are then interpreted as different path of inequality changes between 1990 and 2000.[14]

4. Results

Table 1 shows the number of components from the univariate classification analysis based on a finite normal mixture model for a variety of municipal-based regions. In 1990 and 2010, the income distribution fits a single Gaussian component. Our attention is subsequently captured by the fact that the initial unimodal distribution in 1990 turns into a bimodal distribution in 2000 and then became mono modal again in 2010. The distribution in 2000 is characterized by the birth of an extreme poor sub-group.[15] Moreover, the poor component can be also detected within the southern region and in the states of Michoacán, Oaxaca and Puebla.

Table A.2 in the appendix shows the parameters defining the Gaussian components under consideration. In 2000, the components show means of 2.67 and 3.11, standard deviations of 0.13 and 0.22 and weights of 0.11 and 0.89 at the country level.[16] Both components are displayed in Figure 2.

[14] In this paper, we employ the concept of "cluster" when referring to the outcomes of the Gaussian finite mixture model of the bivariate distribution of the 90/10 income inequality ratio. The outcomes of the univariate distribution of incomes are denominated as components or sub-groups.

[15] This is true at the country level and robust to the exclusion of the municipalities belonging to the Border States and to the exclusion of those from the oil-states of Campeche and Tabasco. See Sánchez-Reaza and Rodríguez-Pose (2002) about the exclusion of oil states.

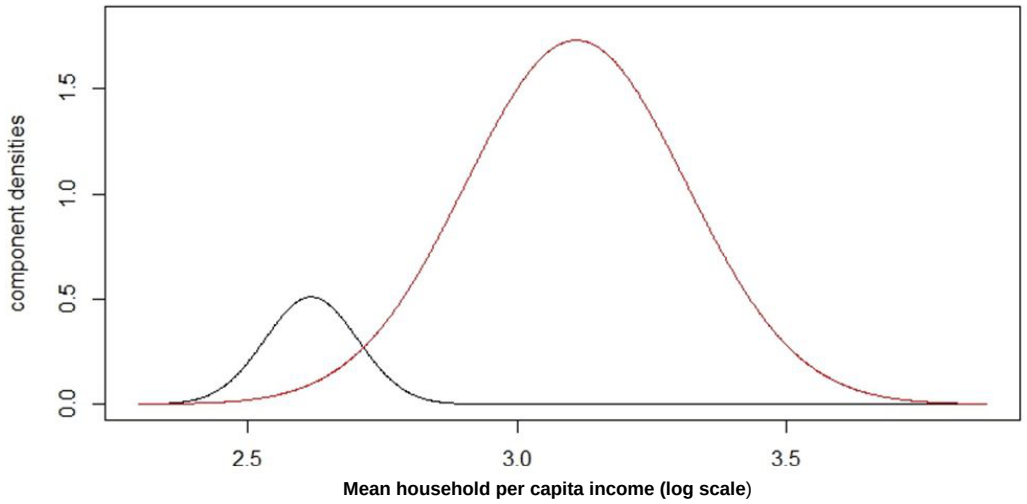
[16] The gap between average incomes of both distributions is equivalent to 821 pesos. A huge gap considering that the mean income of the poor cluster averages just 468 pesos of 2010.

Table 1: Gaussian components of the distribution of the mean household per capita income at the municipal level, by regions.

	Number of Components		
Region / Year	1990	2000	2010
Country Level	1	2	1
Country Level (exc. oil states)	1	2	1
Country Level (exc. border states)	1	2	1
Northern region (exc. border states)	1	2	1
Northern region	1	2	1
Central region	3	1	1
Mexico + DF (C)	2	1	1
Jalisco (C)	1	1	1
Michoacán (C)	1	2	1
Southern region	1	2	1
Southern (exc.oil states)	1	2	1
Chiapas (S)	1	1	1
Chiapas, Oaxaca, Puebla, Veracruz (rural)	1	2	2
Guerrero (S)	1	1	1
Oaxaca (S)	1	2	2
Puebla (S)	1	2	1
Yucatán (S)	1	1	1
Border states (N)	1	1	1

Source: Authors' calculations based on CONEVAL data on household per capita income.

Figure 2: The components of the country level distribution based on our sample of Mexican municipalities in 2000.



Source: Authors' calculations based on CONEVAL data on household per capita income.

4.1 Income dynamics

As discussed previously, there is a general acceptance that trade liberalization reforms implemented during starting in the 1980s and 1990s were disequalizing. Moreover, the impact of the 1994 crisis reinforced this development. Lustig (1995) argues that the lack of available proper safety nets for poor and vulnerable population groups contributes to define the unequal impact of the crisis. Furthermore, differences in the economic structures amongst municipalities yield to believe that the effects of such systemic changes are expected to have dissimilar consequences on the household per capita income distribution and its mean at the communal level. On the contrary, the period 2000-2010 can be characterized by partial recovery and slight convergence. (Table A.2 in the appendix, first row). In this section, we provide some analysis on such development, offering some description of the poor cluster and then theorizing about the reasons of its formation and dissolution.

The period 1990-2000

Figure 3 reveals that over this decade, the whole distribution shifts to the left. The distance between the peak and the upper tail of the distribution increases significantly (clearly divergent). Less trivial is the thickening at the bottom tail of the distribution in 2000. For instance, while only 26% of the municipalities reported average incomes lower than 3.15 log points in 1990, this figure rose up to almost 60% in 2000. Besides this development in terms of income level, the main sub-group in 1990 σ-disequalize over the decade.[17]

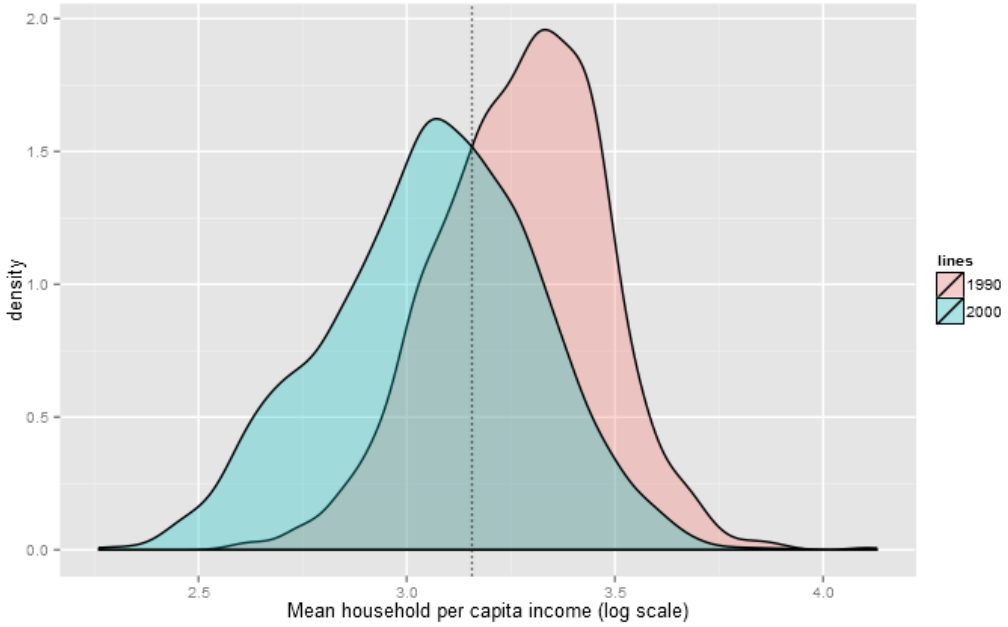
The poor sub-group

Our mixture model shows that there are 260 municipalities where the loss of incomes was much more pronounced. The geographic distribution of this poor component is depicted in Figure A.4 in the appendix. This sub-group has a highly concentrated territorial structure where communes tend to share borders with other municipalities in the same component. Moreover, all municipalities are entirely rural and 92% of them are located the southern states of Oaxaca, Chiapas, Veracruz and Puebla (see Table A.3 in the appendix).[18] This distributional aspects point out that those municipalities were non-random selected into this category.

[17] The standard deviation of the mentioned component increases from 0.20 in 1990 to 0.22 in 2000.

[18] It means that 100% of their populations live in rural areas. The rural nature of the 260 municipalities remains unchanged over the last two decades. Moreover, 257 out of 260 municipalities in this component are landlocked.

Figure 3: Kernel Densities of the average per capita income by municipalities in 1990 and 2000.



Source: CONEVAL data on household per capita income.

Although the poor sub-group is almost entirely located in the south, most southern municipalities did not experience such an enormous income decline.

The dual economy and non-farm activities

Contrary to the predictions of the trade supporters during the 1990s, liberalization reforms of the 1980s and 1990s contributed to consolidation of a systematic net trade deficit of the agricultural tradable goods. According to UN comtrade figures, tariffs on the most relevant farm products were eliminated allowing a 60% growth in trade during the period 1994-2000. Polaski (2004) argues that the relatively efficiency by US producers and the subsidies they receive from its government are causes of such trade imbalance. Moreover, GATT and NAFTA shifted the Mexican agricultural imports to the US producers.[19]

Trade deficit translated into job losses in agriculture in Mexico (Polaski 2004). However, the dynamics this particular labour market was not homogeneous. Although all states showed a reduction in their agricultural employment shares during the 1990s, noteworthy is the fact that the states of Chiapas, Oaxaca, Veracruz and Puebla are one of the few states with increasing employment levels in this sector (see Table A.4).[20] However, more homogeneous is the

[19] According to UN comtrade data, while in 1990, about 65% of the total agricultural imports came from the US, in 2000, this figure rose up to the 80%.

[20] According to the Census 1990 and 2000, the population employed in the agriculture rose in absolute terms in about 38.000 workers at the country level between census years. However, the four mentioned states increased agricultural workers in 236.000. Moreover, in 2003 and according to the national employment survey (ENE

evidence regarding labour earnings in the agriculture. It shows a declining trend over the last two decades. Scott (2010) shows that wages in the primary sector have declined significantly when compared to the rest of the economy and also in absolute terms during the 1990s.[21] At the same time, it can be argued that non-farm activities in rural municipalities were not able to take advantage and develop based on the new opportunities associated with GATT and NAFTA. Chiquiar (2005) argues that after liberalization, an important fraction of export oriented firms found more attractive to move close to the US border in order to reduce transport cost. Thus, the liberalization process may have induced a loss of relative competitiveness in municipalities in the pacific and south regions a consequence of high transport cost and the lack of agglomerations. These ideas are also congruent with Gómez-Zaldívar and Ventosa-Santulária (2012) in favour of a loose catching-up processes for the Northern-Centre and Pacific regions relative the border region. Complementarily, Messmacher (2000) finds that regions where the manufacture sector represented a relatively higher proportion of the product were better off during the nineties.[22]

Unfortunately, these new economic opportunities were not available for all Mexican municipalities, and they were almost absent in the states of Chiapas, Oaxaca, Veracruz and Puebla. As a matter of fact, the *maquila* sector was missing in all communes sorted into the poor component.[23] Thus, the lack of employment associated with the *maquila* industry in the southern rural communes shows the limited impact of dynamic industries encouraged by the GATT and NAFTA.

Our argument is that municipalities belonging to the poor sub-group were unable to change their economic structures toward non-farm activities as other municipalities did. The lack of non-farm activities in such communes seems to be a widespread condition. For instance, Araujo et al. (2004) analyze the expansion of the non-agricultural rural employment in manufacture and services at the municipal level during the 1990s and find that the states of Chiapas, Oaxaca, Veracruz and Puebla have a significant proportion of municipalities with low levels of non-farm employment.[24]

2003), the national average agricultural employment reached 18% while the municipalities of Chiapas, Oaxaca, Veracruz and Puebla report agricultural above-average shares of 47, 41, 32 and 28 percent respectively.

[21] Scott (2010) based on the ENE and ENOE data shows that agricultural wages declined by 2.2% annually during the period 1989-1994 while the mean wage of the economy overall increased 6%. During the last decade, agricultural wages increased 1.4% annually versus the 2.9% for all sectors.

[22] This because the manufacture sector experienced since 1993, one of the highest rates of expansion. Furthermore, transport and communication sectors exhibit high expansion rates.

[23] The Central Bank of Mexico reports within the four states containing the poor sub-group of municipalities, that only the "non-poor" municipality of Puebla has some employment in this sector (www.banxico.org.mx).

[24] Araujo et al. (2004) investigate the role of geographical features in explaining the local and regional demand of non-farm labour.

Thus, the story is that workers in the traditional sector could decide to stay caught in agricultural related activities facing declining labour earnings, or to migrate towards other municipalities or countries with higher wages in the agriculture or in other dynamic sectors.[25]

What can explain the relative decline in the traditional sector during the 1990s? Besides the external factors mentioned by Polaski (2004), the appreciation of the Real Exchange Rate (RER) during the 1990s plays an important role. Urrutia and Meza (2010), state that the financial and trade liberalization accounts for a significant RER appreciation between 1988 and 2002. They find that 80% of the RER appreciation corresponds to a decline in the domestic relative price of tradable goods. Ibarra (2011) indicates that this development was significantly caused by all types of capital inflows.[26] Thus, the declining profitability of the tradable sector stimulated consumption with low investment levels, an important reallocation of capital and labour towards the non-tradable (non-farm) sector.

Inequality dynamics

The literature on the reallocation of resources in the rural economy points out the decline of the farm sector and the expansion of non-farm activities as a country's GDP grows (Chenery and Syrquin, 1975). In a set up with workers' heterogeneity, the ability rural of workers to participate in dynamic non-farm activities tends to be constrained by entry barriers (lack of financial or human capital).[27] In such cases, less-skilled workers get relegated to less-productive agricultural activities or to less-dynamic occupations in the non-tradable sector. Therefore, the development of non-farm activities is usually linked to increasing levels of rural income inequality (see Davis et al. (2007) for a discussion of the role of non-farm activities in the rural development).[28]

The implications in terms of poverty and inequality in the development of non-farm activities are not straightforward. In this case, they depend, on the sectorial composition of the municipal economies and how such a composition translates into different shapes of the

[25] Interestingly, the share agricultural worker in the US coming from the states of Guerrero, Oaxaca, Chiapas, Puebla, Morelos and Veracruz, doubled from 9 percent to 19 percent between 1993 and 2001 (USDA, 2005). This important migration outflow reveals the relative lack of labour opportunities in the non-farm sector and declining expected returns in the farm activities in these southern states. After all, it seems that migration between sectors within a country is often associated with higher moving cost than international migration within the same sector.

[26] This study argues that the high share of FDI in mergers and acquisitions and in the services sector had a strong appreciation effect in real terms. Moreover, Urrutia and Meza (2010) report based on data by the Bank of Mexico and INEGI, that capital flows grew extraordinarily from -0.2% to 10.9% of the GDP between 1988 and 1993. A similar trend was observed between 1996 and 2001, where the peso suffered at least 30% real appreciation.

[27] Workers' heterogeneity implies the correlation between mobility costs and skills.

[28] Klasen et al. (2012) investigate the disequalizing potential effect of workers' heterogeneity and its impact on the Honduran rural economy.

income densities. Are these economies mixing the traditional and the modern sector? Are they just unimodal distributions?

Our idea is that in presence of dominant rural economy (one-sector traditional economy), where most economic activities are closely related to the agriculture, a negative shock against this sector would translate into an income deterioration affecting almost entirely the rural distribution, and thus, reducing the distance between top and bottom incomes. On the contrary, dual economies with inter-sectorial migration possibilities would offer to the labour force imperfect possibilities to transit from the traditional (declining) sector towards the modern (upsurge/non-tradable) sector. Thus, workers' heterogeneity would encourage the appearance of an inter-sectorial labour earnings/income gap expressed as increasing 90/10 income inequality ratio. As we do not have information about the economic sectorial composition at the municipal level, we use this inequality information to provide evidence supporting the mentioned idea.[29]

Table 3 shows evidence supporting the existence of this transmission channel. On average, while rural municipalities classified into the non-poor component increases the distance between top and bottom incomes, the ratio appears to shrink in municipalities belonging to the poor group. It suggests that top incomes in the latter municipalities are highly involved in the (declining) agricultural sector confirming their one-sectorial and traditional nature. Income inequality dynamics in Table 3 are based on the 991 rural municipalities in Chiapas, Oaxaca, Veracruz and Puebla. This sample contains 92% of all municipalities sorted into the poor sub-group. This sample restriction ensures that the dissimilar evolution of the inequality ratio is neither driven by different urbanization levels nor by the geographical location of the communes.

One explanation of this diverging trend may reveal that rural communes with relatively significant non-farm sectors and workers' heterogeneity would offer to high-skilled workers the possibility to migrate towards the dynamic sector within the same municipality. Thus, municipal economy would tend to disequalize because, on the one hand, a portion of the labour force moves to a sector with relative higher wages (although they can also decline in levels), while, on the other hand, less-skilled (immobile) workers remain captured in the traditional sector (with relative declining wages).

[29] Villalobos Barría (2012) and Klasen et al. (2012) offer favourable evidence of this transmission channel. They use observed data to explain the dissimilar Honduran income inequality evolution of this country respect to the general trend in Latin America.

Table 3: Income inequality ratio, selected sample.

	90/10 ratio. Mean (std. dev.)		Change (in mean %)
Municipalities (four states)	1990	2000	
Poor-component (n=239)	5.30 (1.57)	4.20 (1.23)	-21
Non-poor- component (n=752)	6.40 (1.82)	6.72 (3.33)	+5

Souce: Authors' calculations based on CONEVAL data on Household per capita income.

In order to investigate the possible correlation between inequality dynamics and the likelihood of being sorted into the poor component, we estimate the bivariate distribution of the 90/10 income inequality ratio for the period 1990-2000. Our objective is to reveal the existence of Gaussian clusters of municipalities representing different paths of inequality change and how the distribution of such clusters is correlated to the distribution of the poor component amongst the selected rural municipalities.[30]

Table 4: Clusters of municipalities representing different inequality paths, (1990-2000).

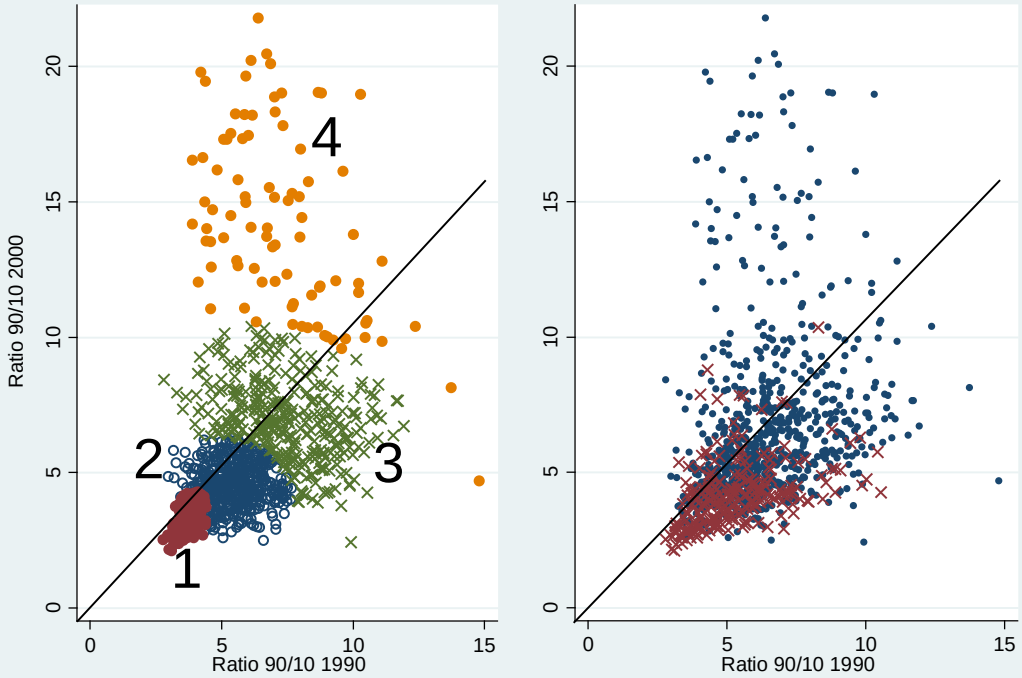
Attribute / Cluster	**1**	**2**	**3**	**4**
Number of Municipalities	98	473	332	88
Mixing Probabilities	0.11	0.44	0.34	0.11
Means				
Ratio 1990	3.95	5.50	7.27	7.39
Ratio 2000	3.58	4.58	6.77	13.14
Variances				
Ratio 1990 - Ratio 1990	0.29	0.94	3.09	4.71
Ratio 1990 - Ratio 2000	0.26	0.06	-0.48	-4.08
Ratio 2000 - Ratio 2000	0.54	0.70	2.27	16.22

Souce: Authors' calculations based on CONEVAL data on income inequality ratios.

Table 4 shows the moments of the selected normal mixture model of bivariate inequality data. It is based on an unrestricted covariance structure (ellipsoidal, varying volume, shape, and orientation). As mentioned previously, the estimation procedure uses the EM algorithm, and the model was chosen following BIC from a variety of covariance structures available in the {*mclust*} *R*-package. Again, the sample is restricted to the 991 rural municipalities of the states of Chiapas, Oaxaca, Veracruz and Puebla. The Gaussian bivariate mixture is displayed in the left panel of Figure 4.

[30] The term „cluster“ refers only to the bivariate sub-populations in terms of inequality paths originated from our Gaussian finite mixture.

Figure 4: Bivariate distribution of the 90/10 income inequality ratio, 1990-2000.



Souce: Authors' calculations based on CONEVAL data on income inequality ratios.

Diagonals in Figure 4 divide municipalities experiencing disequalizing trends from those facing equalizing ones. The right panel shows the bivariate inequality distribution overlaid with the distribution of the poor-component (in red ×). Note that 194 out of 239 (81%) rural municipalities show a decreasing incomes inequality ratio between 1990 and 2000. Therefore, inequality paths (in the left panel) match asymmetrically with the overlaid distribution of the poor component (× in the right panel). Thus, such inequality trends may be correlated to the formation of the poor component (cause), and/or it reflects its formation (consequence).

In general, cluster 1 consists of municipalities with low levels of initial inequality (ratios lower than 4.5) and equalizing change during the period 1990-2000. Cluster 2 is characterized the same dynamic but starting at intermediate levels of inequality (ratios about 4.5 and 7). Both inequality-clusters accumulate 207 out of 239 municipalities (87%) sorted into the poor club of convergence. Amongst them, 174 communes (84%) show an equalizing trend. Cluster 3 consists of municipalities with higher levels of initial inequality with alternatively, equalizing or disequalizing inequality trends. Finally, Cluster 4 represents communes a broad range of levels of initial inequality but experiencing an extraordinary disequalizing process over the decade.

By comparing average income levels by clusters it is possible to assess the validity of our hypothesised transmission channel. Table 5 shows the mean household per capita income at

the municipal level according to the classification into the poor component given the cluster structure originating from the four inequality paths detected by our bivariate normal mixture.

Table 5: Municipal mean household per capita income by income component and inequality cluster classification.

	Number of Observations			Avg. municipal per capita income in 2000	
Group	N	Cluster size	Freq.	Mean	Std. dev.
Poor component	239	-	-	2.61	0.086
Cluster 1 (low initial level – eq.)	58	98	59%	2.61	0.087
Cluster 2 (intermediate initial level – eq.)	149	473	32%	2.61	0.090
Cluster 3 (high initial level)	31	332	9%	2.64	0.068
Cluster 4 (disequalization)	1	88	1%	-	-
Non-poor component	752	-	-	2.98	0.141
Cluster 1 (low initial level – equalization)	40	98	41%	2.88	0.105
Cluster 2 (intermediate initial level – eq.)	324	473	68%	2.94	0.129
Cluster 3 (high initial level)	301	332	91%	3.00	0.145
Cluster 4 (disequalization)	87	88	99%	3.07	0.111
Non-poor component - whole country	2112	-	-	3.11	0.205

Source: Authors' calculations based on CONEVAL data on household per capita income and income inequality ratios.

Results provide support to the idea that inequality dynamics is highly correlated with the income component classification. Within the poor (non-poor) component, inequality clusters are increasingly (decreasingly) represented. For instance, a municipality in cluster 1 has a high ex-post probability to be sorted into the poor component (almost 60 percent). On the contrary, a municipality in cluster 4 has a negligible chance to be sorted in the same disadvantaged sub-group (less than one percent).

In order to investigate the selectivity process into the poor component, we exploit our available data at the municipal level and implement a parsimonious probit model (Table 6).

The explanatory variables consist of the initial population, mean income, inequality ratio (all in 1990) and state dummies. In order to control for the correlation, we include the change in the inequality ration between 1990 and 2000 in an alternative specification without claiming exogeneity of this variable. Both specifications are estimated on an unrestricted sample made up by 2355 urban and rural municipalities from the all Mexican states and on a restricted sample which consist of 991 rural municipalities of Chiapas, Oaxaca, Veracruz and Puebla. As all municipalities in the poor component are rural, this variable could not be including in our models as it predicts perfectly the investigated outcomes.

The probability models show that there is an inverse relationship between the probability of being sorted into the poor component and the initial population size and the 1990 level of municipal income.

Table 6: Probit model.

Dependent Variable: 1 if belongs to the poor cluster in 2000; 0 otherwise				
	Unrestricted sample		Restricted sample	
Population size in 1990	-0.0163***	-0.0101**	-0.0180***	-0.0105*
	(0.005)	(0.00515)	(0.00615)	(0.00625)
Log income in 1990	-3.894***	-5.538***	-2.975***	-4.328***
	(0.334)	(0.504)	(0.500)	(0.623)
90/10 i. ratio in 1990	-0.00282	-0.309***	-0.041	-0.358***
	(0.0313)	(0.0601)	(0.0536)	(0.0765)
Δ 90/10 i. ratio (2000-1990)	-	-0.0381***	-	-0.0371***
	-	(0.00425)	-	(0.00444)
Guerrero	0.149	1.403***	-	-
	(0.28)	(0.33)	-	-
Hidalgo	0.591**	-0.0905	-	-
	(0.236)	(0.293)	-	-
Oaxaca	0.811***	1.197***	0.115	0.565***
	(0.127)	(0.146)	(0.174)	(0.183)
Puebla	0.867***	-0.00777	0.103	-0.690***
	(0.145)	(0.176)	(0.211)	(0.231)
San Luis	0.417	-0.0484	-	-
	(0.307)	(0.331)	-	-
Veracruz	0.953***	0.364*	0.204	-0.371
	(0.157)	(0.201)	(0.234)	(0.264)
Yucatan	0.102	-0.726***	-	-
	(0.229)	(0.254)	-	-
Constant	10.75***	17.32***	8.856***	14.53***
	(0.998)	(1.489)	(1.303)	(1.669)
Observations	2355		991	
Wald chi2(7)	341.80	403.31	128.70	218.20
Prob > chi2	0.0000	0.0000	0.0000	0.0000
Log pseudolikelihood	-545.038	-368.838	-466.974	-316.270
Pseudo R2	0.3337	0.5491	0.1470	0.4223

Ommited category: Chiapas. Robust standard errors in parentheses.

Significance levels *** p<0.01, ** p<0.05, * p<0.1

Inequality dynamics (inequality initial level and its change together) appears to be highly correlated with the income component classification. This result supports our idea that rural communes with a certain degree of initial non-farm development could expand their non-farm activities disequalizing their income distributions but improving mean incomes at the municipal level. Thus, suitable candidates to suffer big losses as a consequence of the financial crisis of 1994, the GATT and NAFTA, were precisely rural municipalities with low

population density (proxied by low initial population) and low real incomes in 1990 product of relatively inefficient and unprofitable farm activities without a significant non-farm sector.

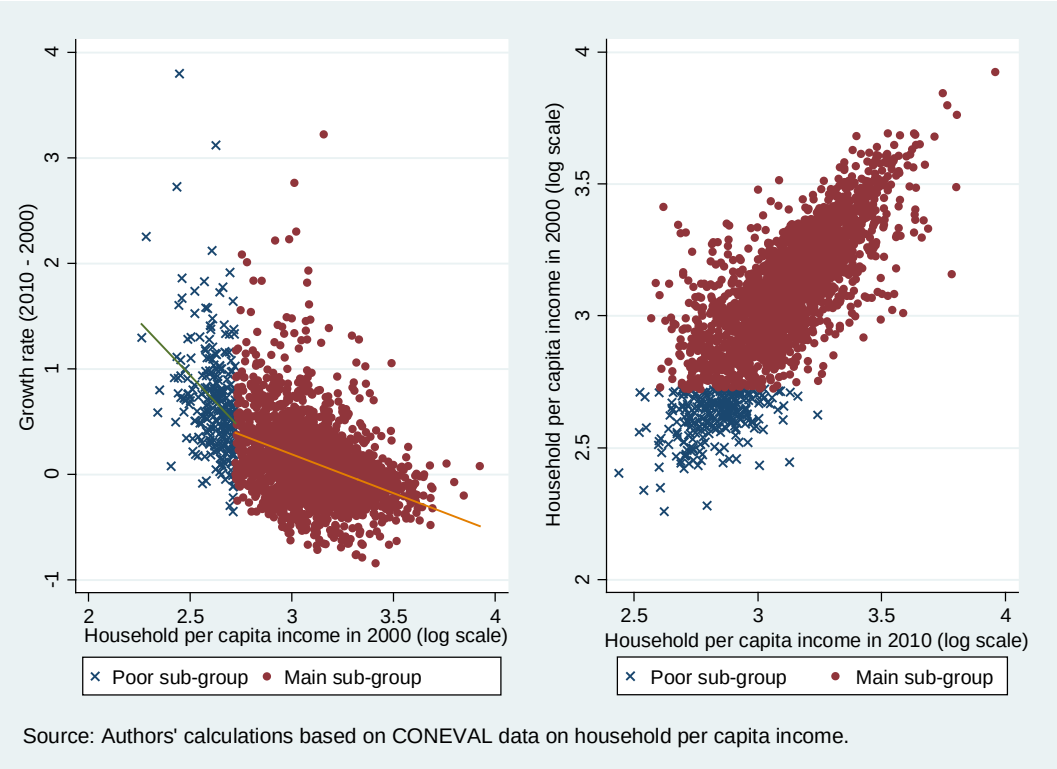
The period 2000-2010

Income dynamics during the period 2000-2010 are characterized by a catching up process by municipalities previously sorted into the poor component in 2000.[31]

Figure 5 shows that municipalities belonging to the poor income component grew faster than the rest of Mexican municipalities (71 vs. 18 percent respectively).[32] The right panel in the same figure shows the assimilation of the same units into the 2010 distribution.

But, what can explain such a dynamic? Three leading factors account for the declining inequality in Mexico. A decreasing earnings gap between skilled and low-skilled workers, and a substantial increase in government transfers targeted to the poor (López-Calva and Lustig 2010) and a progressive distribution of remittances (Esquivel 2010).

Figure 5: Absolute beta convergence and the poor-cluster's income in 2010.



Source: Authors' calculations based on CONEVAL data on household per capita income.

Regarding labour incomes, UNCTAD (2013) provides the basis to the argument that the relative upsurge of the farm-municipalities can be explained, amongst other factors, by the

[31] Figure A.5 in the appendix shows the density change between 2000 and 2010 where the disappearance of the poor sub-group can be seen.

[32] Beta convergence is also found during the period 2000-2010 with slopes of -2.11 and -0.75 respectively.

sustained productivity improvements of the agricultural (traditional) sector together with the international food crises which launched the commodity boom in 2006. Our results suggest that the commodity boom seems to have equalized the income distribution at the municipal level as it favoured disproportionally the poorest farm-municipalities of Chiapas, Oaxaca, Puebla and Veracruz.

Equally important is the reduction of the agricultural subsidies in the US (as they are counter cyclical) from more than $55 to $26 US billion in 1999 and 2010 respectively (UNICTAD 2013). Such developments are reinforced by the fact that the real appreciation in the 1990s was partially reversed during the 2000s (Ibarra 2011). Thus, favourable external conditions and domestic price stability encouraged investments in agriculture and further production improvements during the last decade. Interestingly, our story finds support in Esquivel (2010) who argues that there was a widespread improvement in incomes of the relatively poor rural households.

The post-NAFTA period is characterized by the implementation of two significant social and productive programs: *Progresa* is the most important anti-poverty program in Mexico. It is a focalized conditional-cash transfer program started in 1997. Initially, this program was first devoted to rural areas and expanded since 2001 to urban areas.[33] This program has played an important role in the equalization of incomes during the 2000s and particularly in rural areas. *Procampo*, the second program, began in 1994 when NAFTA came into effect. This program aimed to provide income support for agricultural producers during the structural transition after the signature of the NAFTA. However, Esquivel et al. (2010) consider this program a badly-designed program in terms of its inequality impact. Turning to remittances, Esquivel (2010) finds that such transfers reduce income inequality because their contribution to close the rural/urban income gap.

[33] This program was later known as *Oportunidades.*

5 Conclusions

This study aims to understand the inequality dynamics of the Mexican distribution of the average per capita income at the municipal level in 1990, 2000 and 2010 based on the convergence club's literature. To this end, we employ the Expectation-Maximization (EM) algorithm to fit the Gaussian finite mixture and the (BIC) approximation to the Bayes factor is used to choice the best model in terms of the number of components and their parameterization. Our attention is captured by the fact that the initial unimodal distribution in 1990 turns into a bimodal distribution in 2000 and then became mono modal again in 2010. The poor sub-group of 260 municipalities in 2000 have a highly concentrated territorial structure where communes tend to share borders with other municipalities in the same component. All municipalities are entirely rural and 92% of them are located the southern states of Oaxaca, Chiapas, Veracruz and Puebla.

Our argument is that, given the macro developments of the 1980s and 1990s favouring the expansion of the non-tradable sector, municipalities sorted into the poor component were unable to change their economic structures toward non-farm activities. On the contrary, municipality with relatively significant non-farm sectors allowed high-skilled workers the possibility to migrate towards the dynamic sector within the same district. Thus, in relative terms, mean income rises and disequalize because, on the one hand, a portion of the labour force moves to a sector with relative higher wages, while, on the other hand, less-skilled (immobile) workers remain captured in the traditional sector. Our estimation of the Gaussian finite mixture of the bivariate distribution of the 90/10 income inequality ratio during the 1990s seems to confirm this idea.

Moreover, we exploit our data and estimated a parsimonious probit model to explain what are the factors associated to the over proportional decline of a selected group of communes. We find that municipalities without urban areas (low level of non-farm activities), small population sizes, and low levels of income in 1990 are more likely to be sorted into the poor cluster in 2000. Additionally, without claiming causality, we find a strong negative correlation between the income inequality path during the nineties and the mentioned classification. Municipalities with higher income inequality levels in 1990 and disequalizing income trend (increasing duality) appears reflect an increasing income gap which also increases, in relative terms, the average municipal income avoiding the extraordinary decline experienced by the poor sub-group.

Income dynamics during the period 2000-2010 are characterized by a catching up process by municipalities previously sorted into the poor component in 2000. Municipalities belonging to

the poor income component grew faster than the rest of Mexican municipalities contributing to the disappearance of the poor cluster in 2010.

We argue that the relative upsurge of the farm-communities can be explained by the sustained productivity improvements of the agricultural sector together and the commodity boom started in 2006. Thus, a decreasing earnings gap between skilled and low-skilled workers is observed, compressing the distribution of incomes manifested as the reduction of the rural-urban labour earnings gap. However, there are other well documented factors in the literature explaining the upsurge of the poorest rural municipalities. Amongst them, we find the reduction of the agricultural subsidies in the US, domestic price stability, remittances and the *Progresa/Oportunidades* program.

Finally, we are not stating that the disequalization of incomes is a desirable development as it is negatively correlated with the formation of the poor component. Our argument is that the income disequalization at the municipal level is just a sign of economic transition of local economies with imperfect immobility of labour. Therefore, more than ask for special treatment for the 260 rural municipalities belonging to the poor sub-group, we think desirable to support the entire traditional agricultural sector encouraging intra and inter sectorial mobility. The fact that all 260 rural municipalities in the poor component have small population sizes and presumably low population densities (data not available to us) suggests that grouping municipalities seems to be recommendable. Thus, to encourage the formation of small urban areas with multi sectorial development strategies together with the provision of public goods seems to be a necessary step towards the consolidation of a converging economic process across the territory. Such trend would avoid the overpopulation of the already dense populated Mexican metropolis providing opportunities in areas traditionally excluded from progress.

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Appendix

Table A.1: The number of municipalities by selected groups

Groups	No. of Municipalities	Groups	No. of Municipalities
Country	2372	Border states	273
Country (without oil states)	2346	Chiapas	110
Country (without border states)	2099	Jalisco	124
Northern region	462	Mexico + DF	137
Northern region (without border states)	189	Michoacán	113
Central region	609	Oaxaca	562
Southern region	1302	Puebla	209
Southern region (without oil states)	1276	Yucatán	106
Chiapas, Oaxaca, Puebla, Veracruz (Rural)	911		

Table A.2: Parameters of the components found for each geographic region using the R-package {mlcust}.

Year		1990			2000			2010		
Component number:		1	2	3	1	2	3	1	2	3
Country level	weight	1.00	-	-	0.11	0.89	-	1.00	-	-
	mean	3.27	-	-	2.67	3.11	-	3.10	-	-
	std. dev.	0.20	-	-	0.13	0.22	-	0.21	-	-
Country level (excluding oil states)	weight	1.00	-	-	0.12	0.88	-	1.00	-	-
	mean	3.27	-	-	2.68	3.11	-	3.10	-	-
	std. dev.	0.20	-	-	0.13	0.22	-	0.22	-	-
Country level (excluding border states)	weight	1.00	-	-	0.13	0.87	-	1.00	-	-
	mean	3.25	-	-	2.67	3.08	-	3.08	-	-
	std. dev.	0.19	-	-	0.12	0.20	-	0.20	-	-
Northern (excluding border states)	weight	1.00	-	-	0.14	0.86	-	1.00	-	-
	mean	3.28	-	-	2.87	3.25	-	3.13	-	-
	std. dev.	0.16	-	-	0.14	0.14	-	0.17	-	-
Northern region	weight	1.00	-	-	0.15	0.85	-	1.00	-	-
	mean	3.38	-	-	2.95	3.31	-	3.23	-	-
	std. dev.	0.17	-	-	0.15	0.15	-	0.20	-	-
Border Region	weight	1.00	-	-	1.00	-	-	1.00	-	-
	mean	3.46	-	-	3.30	-	-	3.33	-	-
	std. dev.	0.14	-	-	0.19	-	-	0.19	-	-
México + DF	weight	0.76	0.24	-	1.00	-	-	1.00	-	-
	mean	3.39	3.64	-	3.28	-	-	3.28	-	-
	std. dev.	0.06	0.17	-	0.21	-	-	0.19	-	-
Central Region	weight	0.11	0.84	0.05	1.00	-	-	1.00	-	-
	mean	3.12	3.39	3.70	3.20	-	-	3.20	-	-
	std. dev.	0.11	0.11	0.11	0.19	-	-	0.17	-	-
Southern Region	weight	1.00	-	-	0.23	0.77	-	1.00	-	-
	mean	3.18	-	-	2.66	3.01	-	3.01	-	-
	std. dev.	0.19	-	-	0.12	0.16	-	0.19	-	-
Southern Region (exc. oil states)	weight	1.00		-	0.23	0.74	-	1.00	-	-
	mean	3.18		-	2.66	3.00	-	3.00	-	-
	std. dev.	0.19		-	0.12	0.16	-	0.19	-	-
Chiapas, Oaxaca, Puebla, Veracruz (Rural)	weight	1.00			0.42	0.58		1.00		
	mean	3.16			2.71	3.02		2.96		
	std. dev.	0.18			0.14	0.13		0.18		
Jalisco	weight	1.00	-	-	1.00	-	-	1.00	-	-
	mean	3.41	-	-	3.24	-	-	3.25	-	-
	std. dev.	0.06	-	-	0.11	-	-	0.14	-	-
Michoacán	weight	1.00	-	-	0.06	0.94	-	1.00	-	-
	mean	3.43	-	-	2.81	3.11	-	3.11	-	-
	std. dev.	0.12	-	-	0.01	0.10	-	0.14	-	-
Oaxaca	weight	1.00	-	-	0.44	0.56	-	0.40	0.60	-
	mean	3.14	-	-	2.70	3.05	-	2.81	3.06	-
	std. dev.	0.19	-	-	0.15	0.14	-	0.10	0.19	-
Puebla	weight	1.00	-	-	0.12	0.88		1.00	-	-
	mean	3.26	-	-	2.64	2.96		3.00	-	-
	std. dev.	0.16	-	-	0.05	0.14		0.13	-	-

Table A.2 *(Continuation)*: Parameters of the components found for each geographic region using the R-package {mclust}.

Year		1990			2000			2010		
Component number:		1	2	3	1	2	3	1	2	3
Chiapas	weight	1.00	-	-	1.00	-	-	1.00	-	-
	mean	3.10	-	-	2.89	-	-	2.92	-	-
	std. dev.	0.16	-	-	0.20	-	-	0.18	-	-
Guerrero	weight	1.00	-	-	1.00	-	-	1.00	-	-
	mean	3.17	-	-	2.98	-	-	2.98	-	-
	std. dev.	0.20	-	-	0.18	-	-	0.18	-	-
Yucatan	weight	1.00	-	-	1.00	-	-	1.00	-	-
	mean	3.23	-	-	3.00	-	-	3.13	-	-
	std. dev.	0.14	-	-	0.16	-	-	0.10	-	-

Source: Authors' calculations based on CONEVAL data on household per capita income.

Table A.3: Proportion and number of municipalities in the poor component by states

State	Proportion in the poor component	Number of municipalities
Oaxaca	0.26	148
Chiapas	0.19	21
Veracruz	0.18	38
Puebla	0.15	32
Guerrero	0.08	6
Hidalgo	0.07	6
Yucatan	0.06	6
San Luis de Potosí	0.05	3
Total	1	260

Source: Authors' calculations based on CONEVAL data on household per capita income.

Table A.4: Employment shares in the agriculture by States.

	1990	2000	Delta emp. 2000-1990
Chiapas	58.34	47.25	71849
Oaxaca	52.88	41.10	39464
Zacatecas	39.80	20.68	-44061
Veracruz	39.36	31.74	60207
Nayarit	38.23	27.82	-395
Hidalgo	37.03	25.23	1168
Puebla	36.92	27.91	64510
Sinaloa	36.72	28.10	4685
Guerrero	36.40	26.76	14948
Tabasco	35.61	27.87	27222
Campeche	34.30	24.96	9298
Michoacán	34.00	23.70	-12503
San Luis Potosí	31.13	21.32	-12117
Durango	28.57	15.02	-32595
Tlaxcala	28.56	18.21	3672
Yucatán	27.02	17.17	-3887
Colima	23.98	16.98	1887
Guanajuato	22.98	13.23	-43524
Sonora	22.74	15.89	836
Morelos	20.35	13.52	3585
Quintana Roo	19.62	10.48	4549
Baja California Sur	18.31	11.91	1318
Querétaro de Arteaga	17.91	8.64	-10292
Chihuahua	17.02	8.87	-32471
Tamaulipas	16.27	9.17	-18493
Jalisco	15.07	10.03	2910
Aguascalientes	14.96	7.37	-7374
Coahuila de Zaragoza	12.14	5.30	-27539
Baja California	10.36	6.35	-1026
México	8.67	5.21	-15692
Nuevo León	6.12	3.28	-13409
Distrito Federal	0.66	0.57	1455

Source: INEGI: Censo General de Población y Vivienda 1990, 2000.

Figure A.1: Spatial distribution of the average per capita income by municipalities in 1990.

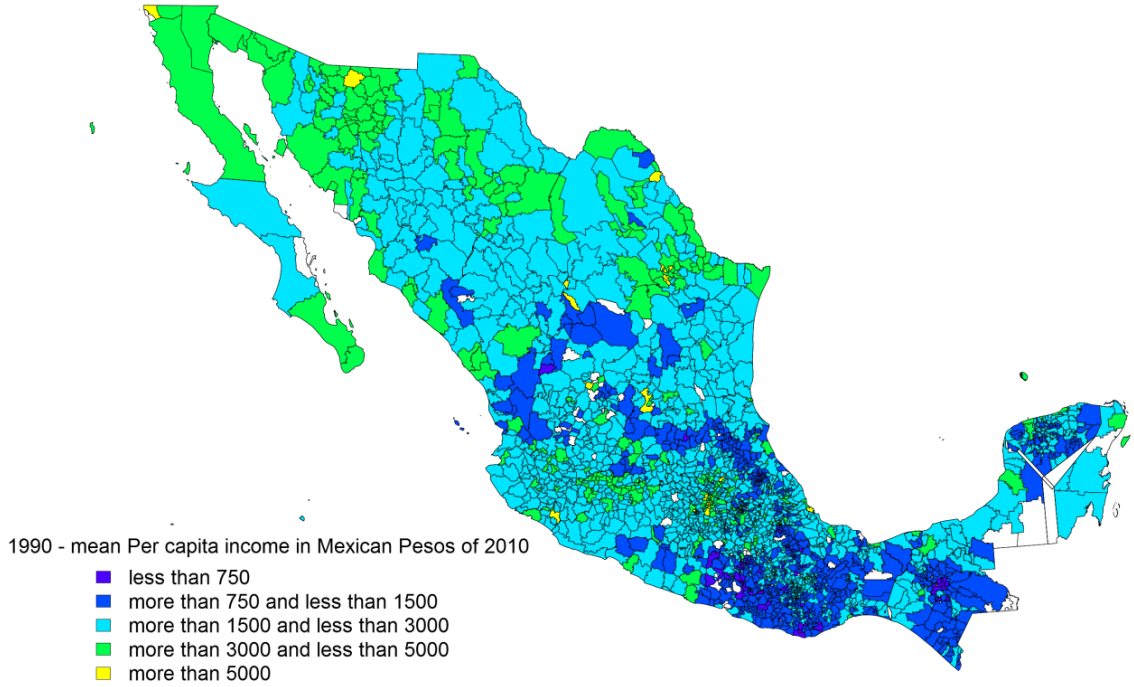


Figure A.2: Spatial distribution of the average per capita income by municipalities in 2000.

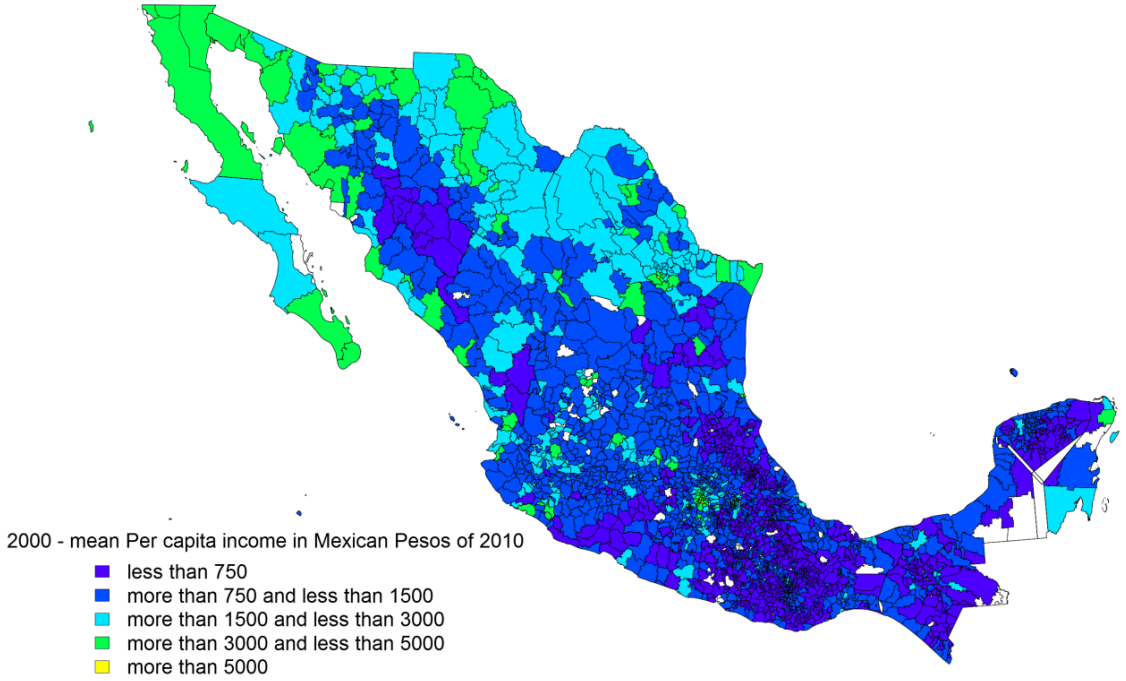


Figure A.3: Spatial distribution of the average per capita income by municipalities in 2010.

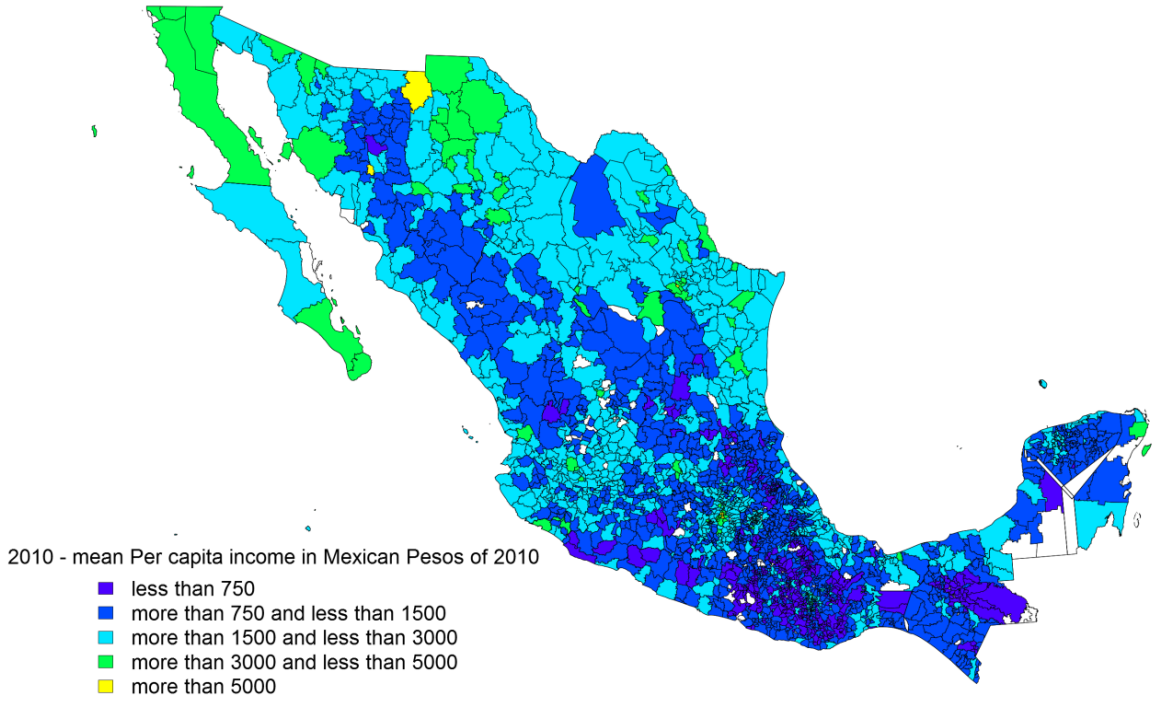


Figure A.4: two convergence clubs in 2000.

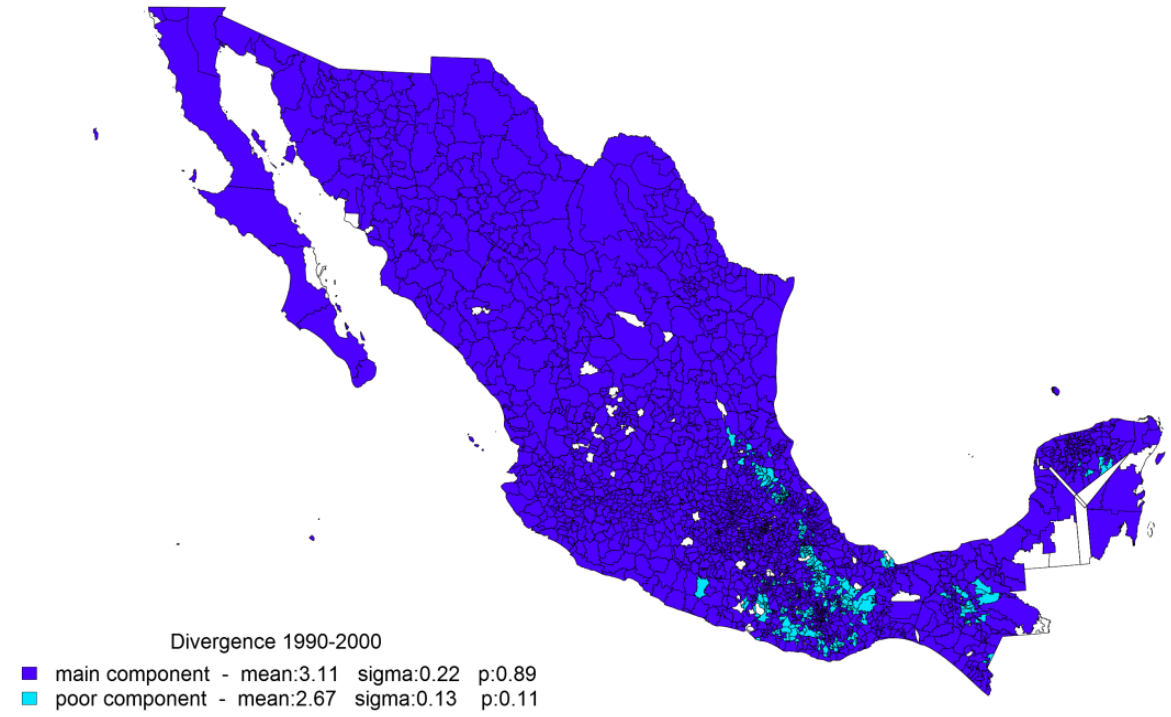
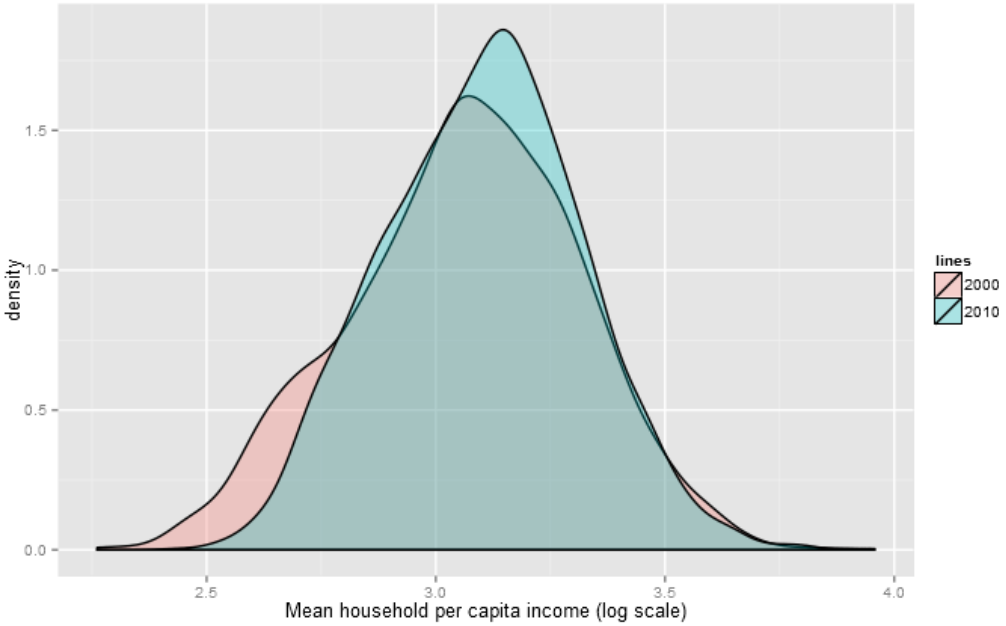


Figure A.5: Kernel Densities of the average per capita income by municipalities in 1990 and 2000.



Source: CONEVAL data on household per capita income.