INEQUALITY PERSISTENCE IN MEXICO, 1940-2015

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Abstract

This work examines the inequality persistence in Mexico using unit root and stationarity tests. Inequality is measure by constructing the Theil index for México, from 1940-2015, and separating the states in Mexico by regional convergence clusters in addition to decomposing the theil index for inequality within and between the clusters. Results suggest that its no possible to reject the null hypothesis for non-stationarity as well as rejecting the null for stationarity depending on the test. Furthermore, structural breaks were considered and tested. The test shown persistence on inequality for the majority of the variable for inequality in Mexico in the last 75 years.

Keywords: inequality, persistence, theil index, regional inequality convergence cluster, Mexico, unit root test, stationarity, structural change.

JEL classifications*: C12, B23, D31, D63, C22, E23*

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Inequality persistence in Mexico, 1940-2015

Introduction

It was 1811 and Alexander Von Humboldt wrote about how Mexico was the country of inequality. Back then there were two kind of Mexicos; one with villages and hamlets on which it cannot be found ten or twelve persons to the square league. Then it was the capital and other cities that have scientific establishments, architecture of the public and private edifices, elegance of the furniture, luxury and dress of the women which compared with the ignorance, and crudity of standard of living of the poorer ones was such an outstanding contrast. But, how has been the evolution of inequality in Mexico. Unfortunately, the answer is not, income inequality in Mexico is quite high.

We understand income inequality as measurement of the distribution of income that highlights the gap between individuals or households making most of the income where differences in income can be by individuals or families, or between different groups, areas, or countries.

It is well known the statement that "the rich man becomes richer and the poor become poorer". Now a days Mexico is the second most unequal countries of the 34 countries part of the OECD. Is immersed in a vicious cycle of inequality, lack of economic growth and poverty. This has caused an intermission on Mexico´s physical, human and social capital slowing the potential of the country (Esquivel, 2015).

The distribution of income is an indicator of the dynamism and efficiency of an economy to allocate output among individuals. The study of the problem of inequality and poverty in Mexico is especially complex by the economic and social heterogeneity of the country. However, it is an Important issue, because the inequality in the distribution of income is a a factor that limits social and economic development.

A more equal society means that individuals can achieve development. The impact of the level of income and the distribution of income generates social decomposition and conflict, whereas in a more egalitarian, its members have greater opportunities for development and increase.

For this work the Theil index to measure inequality was build for Mexico, its regions as well as for within and between regions for the four cluster convergence groups for regional inequality in Mexico. In order to analyze the evolution of inequality from 1940 to 2015. Inequality persistence using different unit root and stationarity tests was examining. Furthermore, structural breaks were considered and tested. The test shown persistence on inequality for the majority of the variable for inequality in Mexico in the last seven decades.

Section 2 reviews some researches about income inequality persistence as well as regional income inequality. On Section 3 a summary of the methodology used for the stationary and unit root tests for income inequality is presented. Augmented Dickey-Fuller test and M-test of Ng and Perron (2001) for unit root test and the KPSS test for stationarity were tested. Followed by unit root tests considering one and two structural breaks with Perron and Rodríguez (2003) and Lee and Strazicich (2003) tests respectively. Section 4 shows the results about testing income inequality persistence and finally Section 4 concludes; the majority of the tests demonstrate that unit root in inequality in Mexico and their regions cannot be rejected. Thus, there is persistence on income inequality.

Literature Review

Metwally and Jensen (1973), acknowledged that the measure of regional income inequality based on regional mean incomes relative to the national mean income fail to explain the dispersion of individual incomes nationally or the dispersion of incomes within regions. For this reason, being able to measure inequality by subgroups might be important in the design of policy actions, their effects and in evaluation of the impacts of inequality and redistributive policies on welfare among regions, subgroups and sectors. It is possible to measure inequality at national level and be decomposed into within-subgroup and between-subgroup components. In a similar way at the international level.

According to the World of Work Report 2008, there are different ways to measure inequality. Three main methods can be distinguished:

- Within- or intra-country inequality, which addresses income inequalities within a country or regions;
- Between-, cross- or inter-country inequality
- Global inequality, which encompasses both within- and between-country inequalities.

Large emerging economies, inequalities are high and have been also increasing in the past two decades. Income inequality trends in large emerging economies show that strong economic growth has not benefited all segments of the population similarly (Vieira, 2012).

Inequalities within countries have risen where the income of the richest 10% of the population was 9 times higher than the poorest 10 %, on average across OECD countries. That gap is however considerably smaller in Scandinavian and some Eastern European countries. In contrast, the income of the richest 10 % is 27 times higher than the poorest 10% in countries such as Mexico and Chile (Vieira, 2012). Despite the recent convergence trend between developing and developed countries, international inequalities remain historically high.

It is worth highlighting that very little information is available about developing countries about the evolution on economic distribution and that probably have been far different from those of the industrialized countries. In the case of Mexico, it has one of the highest rates of inequality among develop countries, according to the OECD. The OECD has revealed that incomes at the bottom of the distribution are still well below pre-crisis levels while top and middle incomes have recovered much of the ground lost during the crisis.

Mexico has had several dimensions on the long-term evolution of regional income inequality, from 1895–2010. First, the ten years of export-led growth, from the late 19th to the 1930s, were characterized by a strong regional divergence process. By contrast, during the Import Substitution Industrialization (ISI) period (1940-1980), there was intense convergence among the Mexican regional economy and, finally, in the context of increasing international integration that started in the 1980s, divergence has again been the norm. Beyond those fluctuations, and regardless the historical period under consideration, regional inequality in Mexico has always been comparatively high (Aguilar-Retureta, 2015).

For analyzing the income distribution in Mexico, many researches had been done by analyzing the inequality by regions. Gutiérrez Flores (2008) examines regional income inequality in Mexico for the period 1990-2004 by utilizing regional income distribution functions, together with some inequality indicators. For the distribution analysis, distinct regions have been established based on different degrees of exposure experienced by the country's federal entities in the face of the Mexican economy's process of opening. However, some regions that have been more exposed to processes of economic opening show lower levels of inequality. The opposite occurs for the other regions in that same arrangement.

A high degree of income inequality has been a persistent and problematic feature of the Mexican economy in recent years. However, the results show that the level of inequality is not similar in the different regions of the country (Gutiérrez Flores, 2008).

Germán-Soto, Mendoza-Velázquez, Monfort and Ordoñez (2016) analyzed inequality and income convergence patterns for the Mexican states over the period 1940-2010. Using regional real GDP per capita and develop an index for ineuqaliry using the Euclidean norm properties. Even though the states do not converge to the same equilibrium it allows them to identify regional cluster for income and growth heterogeneity in a non-linear time-varying framework. The predictions of the neoclassical growth model for by examining inequality and income convergence for the Mexican states over the period studied in this paper reflect the lack of convergence reflects the heterogeneous development of regions in Mexico.

The persistent inequality in Mexico is notorious when measured against other OECD member countries. The high inequality that prevails in Mexico experienced in the last decades has affected the growth of the Mexican economic development. The measurement of the evolution of inequality in societies alludes a possible analytical strategy that draws on both economic and political approaches to account for the origins and varying persistence of inequality models. For instance, Carles Boix (2010) explores the evolution of inequality in societies already with state structures.

It Shows the temporal (intergenerational) persistence of inequality model. It is employed to give a coherent account of some broad historical trends in the evolution of income inequality. These models take the following function form:

$$K_{i,\,t+1} = f(k_{i,t}) - c_{i,t} + \varepsilon_t,$$

where k represents the assets of individual i, c is the fraction any individual i consumes at period t, and ε is some idiosyncratic shock that may affect assets k at time t. The interpretation of this functional form is that there is intergenerational transmission of wealth among families or individuals. Individuals have some initial wealth k, inherited from their parents, which they allocate to maximize their expected wealth at the end of the period.

Also, adds that the rise of economic inequality and violence encouraged a key transformation in the existing political structure, which then affected the distribution of wealth and income. After the formation of the state, the overall distribution of income continues to be a function of both technological shocks and military and political factors.

These models overcome one of the central weaknesses of factor-share models of income distribution. They offer an endogenous theory of growth and inequality. Is carried out to give a coherent account of some wide historical trends in the evolution of income inequality.

There has been some research about testing inequality persistence, Christopolus and Mcadam (2017) examine inequality persistence in a multi-country unbalanced panel using a battery of stationary and long-run memory test. The inequality measure used was the gini index for 47 countries from 1960–2012/13.

Results show that inequality measures are persistent because of the rejection of the null hypothesis on the P, P_m, and the Z panel unit root tests. This is robust to the presence of Structural Breaks. While redistributive measures have reduced the level of inequality, they have not sufficiently modified its apparent unit root. This non-stationarity corroborates the qualitative evidence regarding the growing inequality in recent decades across many countries. A more reasonable conclusion is that inequality measures are persistent if not precisely a unit root.

In addition, another study by Islam and Madsen (2015) using data on inequality, with the natural logarithms of Gini coefficients and top 10% income shares for 21 OECD countries over the period 1870-2011, tested for the Piketty hypothesis that income inequality is likely to grow in the 21st century.

Employing the Carrion-i-Silvestre et al. (2005) KPSS test for stationarity in variance of panel data, Islam and Madsen (2015) test for inequality persistence. This approach allowed for up to five structural breaks at unknown dates for each individual country. It stablished that if the series follow a trend stationary process the shocks to inequality will have transitory effects, however, the shocks become permanent with a unit root process. The test results provide strong support for trend stationarity of Gini coefficients and top 10% income shares across OECD countries at significance levels.

The factors influencing income inequality are likely to have transitory effects on income inequality. Therefore, the increasing inequality after 1980 as suggested by Piketty (2014) is unlikely to have been driven by a stochastic trend. Subsequently, it is revealed that the null hypothesis of trend stationarity of inequality cannot be rejected at conventional significance levels. Hence, inequality in the OECD countries is non-persistent. Suggesting that shocks to income inequality are likely to be temporary.

Methodology

Data

The data for this analysis consist on measures of inequality for Mexico from 1940 to 2015 on an annual basis. It also shows the inequality in the regions of Mexico and then decomposed inequality within and between the clusters.

The 32 region states in Mexico were grouped according to the hypothesis of cluster convergence for inequality that were detected in an earlier paper, (Germán-Soto et al., 2016), with four club convergence groups for regional inequality in Mexico. Figure 1 provides a geographical reference for the regions in Mexico and its inequality convergence cluster.

The first cluster consists on states with the high and volatile inequality rates as well as some of the most developed states in Mexico such as Aguascalientes, Baja California, Baja California Sur, Campeche, Coahuila, Chiapas, Chihuahua, Mexico City and Nuevo León.

The second convergence cluster contain the states of Colima, Guerrero and Oaxaca. Which have similar economic development through the years are all situated in the same region. Also, the inequality rates show a steadier behavior than in other convergence clubs. For the third cluster where grouped those states with quite volatile rates of inequality includes and some of them with similar socio-economic conditions. THIS includes; Durango, Guanajuato, Hidalgo, Jalisco, México, Michoacán, Morelos, Nayarit, Puebla, Querétaro, Quintana Roo, Sonora, and Tabasco with volatile rates of inequality.

Finally, the fourth convergence club includes the states of San Luis Potosí, Sinaloa, Tamaulipas, Tlaxcala, Veracruz, Yucatán, and Zacatecas. Showing the lowest rates of inequality and some volatility.

To test the stationarity persistence on inequality in mexico, the inequality measure used was a generalized entropy measure with parameter 1, GE (1), also called the Theil index. Which was constructed based on the Gross Domestic Product (GDP) by German-Soto

(2005). After 2007 to 2015 the data was updated using the rates of growth of the state product base 2008.

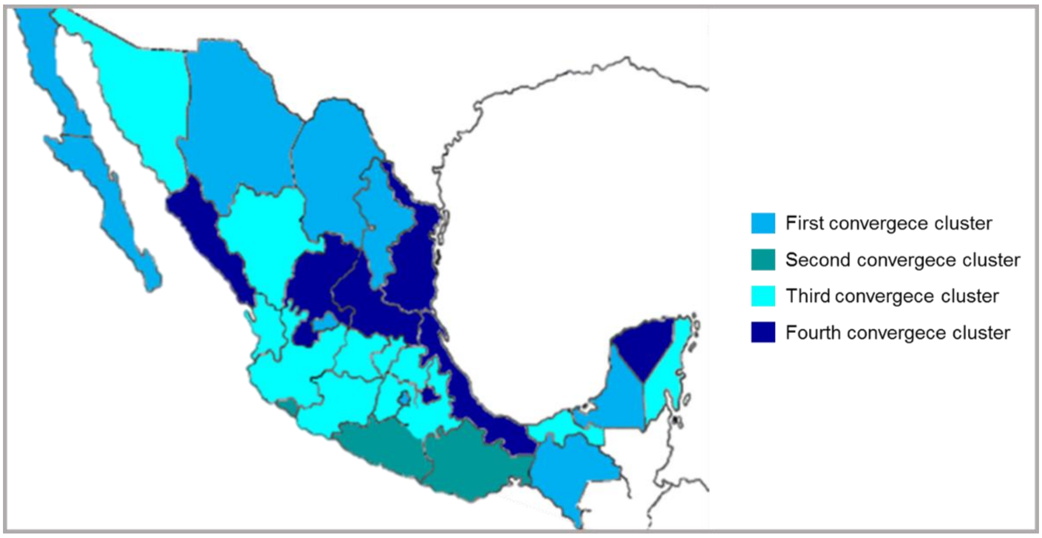

Figure 1 Inequality convergence clusters (Germán et. al, 2016)

The Theil index belong to the family of generalized entropy (GE) inequality measures. The values of GE measures vary between 0 and ∞, with zero representing an equal distribution and higher value representing a higher level of inequality. GE (1) is Theil's T index, which may be written as:

$$GE(1) = \frac{1}{N}\sum_{i=1}^{N}\frac{y_i}{\overline{y}}\, ln\left(\frac{y_i}{\overline{y}}\right)$$

Where $\overline{y}$ is the mean income and Y_i the total income that for this study is the GDP of Mexico. This measure of inequality has properties to produce data, analyze patterns and dynamics of inequality. Besides, the Generalized Entropy class of indicators, including the Theil index, can be decomposed across these partitions in an additive way.

A decomposable inequality measure allows that the total inequality of a population can be broken into a weighted average of the inequality existing within subgroups of the population and the inequality existing between them. The only measure consistent with the "income weighted decomposability" is the Theil´s entropy coefficient (Bourguignon, 1979). For policy purposes, it is useful to be able to decompose the sources of inequality. The Theil index allow to decompose inequality into the part that is due to inequality within and between areas.

This decomposition shows how the level of inequality of a society income may vary from region to region, which implies inequality “between groups.” As well as incomes that can vary inside each region, meaning a “within group” component to total inequality.

To decompose Theil’s T index GE(1), let Y be the total income of the population, Y_j the income of a subgroup, N the total population, and N_j the population in the subgroup. Using T to represent GE(1):

$$T = \sum_j \left[\frac{Y_j}{Y}\right] T_j + \sum \left[\frac{Y_j}{Y}\right] ln \left[\frac{Y_j/Y}{N_j/N}\right]$$

It measures the two components. The first term represents the within-group inequality and the second term represents the between-group inequality. For this work the decomposition was used in order to analyze the inequality between the four cluster of regions in Mexico as well as the inequality within the same groups. Table 1 shows the statistics summary.

In these results, the mean of Mexico’s inequality is 0,6062 and the median is 0,5894 the median torque is 20. The data appear to be skewed to the right, which explains why the mean is greater than the median. For the rest of the variables the data appear to be skewed to the left because the mean is smaller than the median represented in the Percentile 50 (P50).

Also, there’s some differences that can be appreciated between the different variables. For example, the theil index of first cluster and inequality within groups shows the highest coefficients. Instead, the second cluster and inequality between groups shown the lowest inequality in the last 75 years.

Table 1 Summary Statistics

Series	Obs	Mean	SE	Variance	Minimum	Maximum	P5	P25	P50	P75
Mexico	76	0.6062	0.1332	0.1774	0.4545	0.8900	0.4566	0.4852	0.5894	0.5894
C1	76	0.7539	0.1668	0.0278	0.2196	0.9972	0.5265	0.5840	0.7736	0.9224
C2	76	0.1122	0.0267	0.0072	0.0648	0.1797	0.0733	0.0914	0.1078	0.1274
C3	76	0.2995	0.0509	0.0026	0.1810	0.3866	0.1994	0.2710	0.3119	0.3323
C4	76	0.2705	0.0783	0.0061	0.1646	0.4150	0.1656	0.1943	0.2697	0.3272
Within	76	0.5080	0.1025	0.0105	0.3769	0.7027	0.3791	0.4085	0.5185	0.5895
Between	76	0.0982	0.0348	0.0012	0.0606	0.1873	0.0622	0.0731	0.0791	0.1277

On Figure 2, it can be appreciated the graph of all the Theil index, the four clusters for regional inequality as well as inequality within and between cluster over time. Also, figure 3 shows each of the variables in individual against time. Thanks to this it can be appreciated a tendency through the series. Around 1960 and 1986 seems to be important year for the inequality in Mexico and their regions. On 1986 was a difficult year for Mexico because of the great earthquake on 1985 and that almost destroy Mexico City. Time series often have a tendency or are affected by persistent innovations in the process. Therefore, to take into account these the tests applied included a constant term and time trend. To solve this problem, or at least to understand its possible effects, it is common to test if the series as stationary. These tests are often called unit root tests.

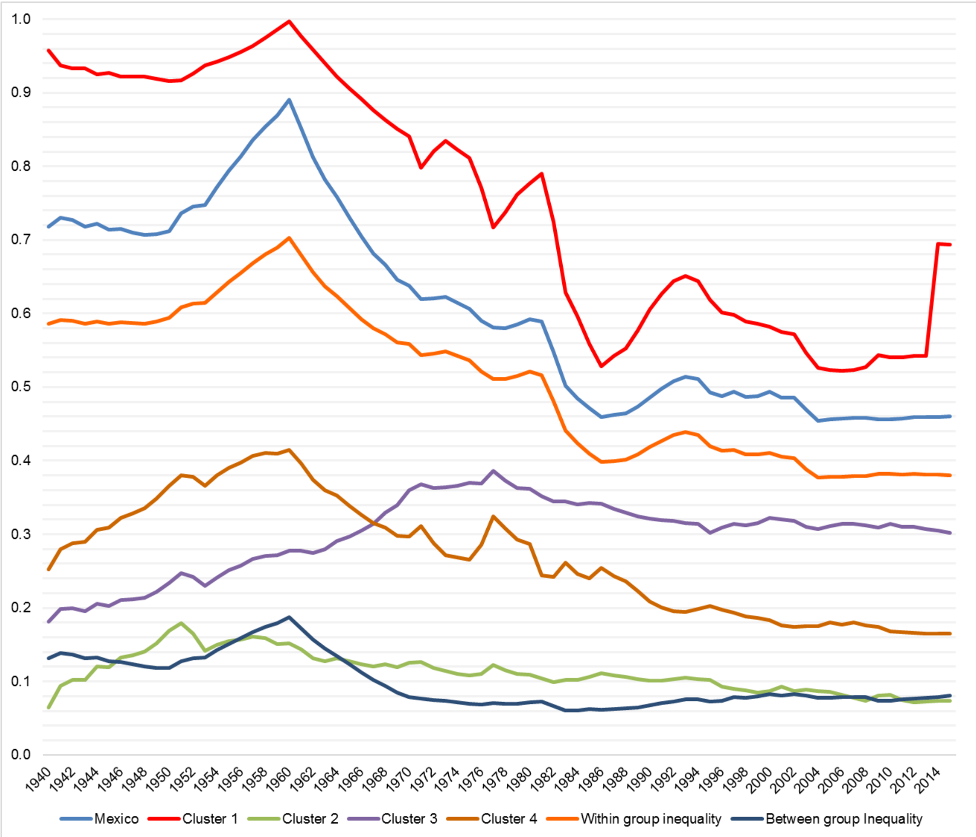

Figure 2 Mexico Theil index, 1940-2015

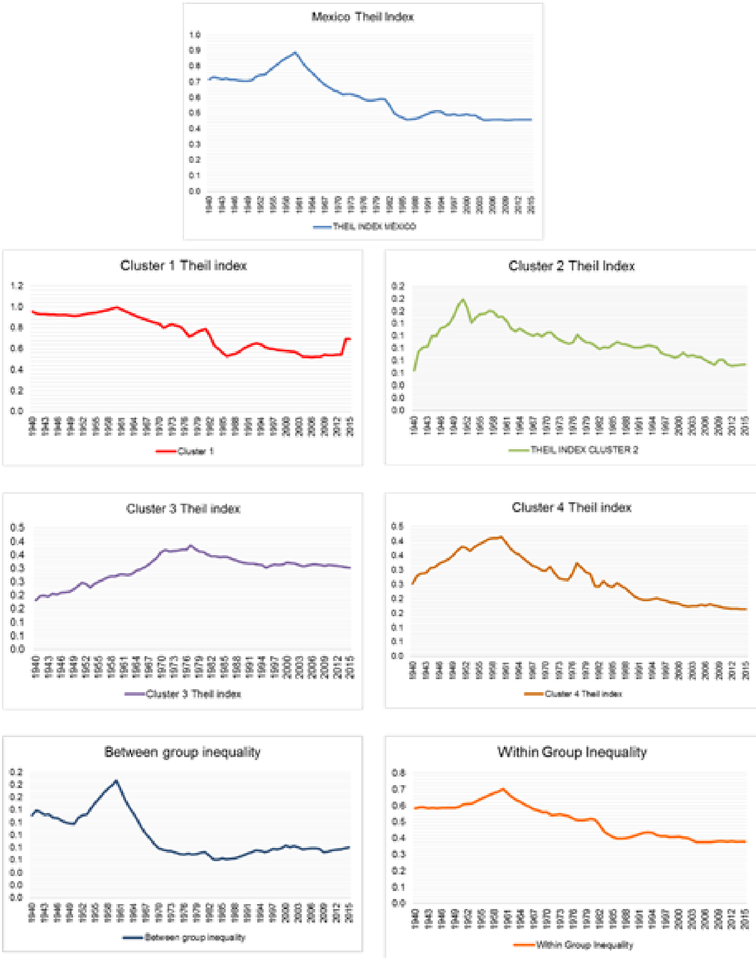

Figure 3 Theil Index for Mexico and regional clusters, 1940-2015

Unit root tests

To analyze the evolution of the inequality in Mexico and their regions and once inequality was descomposed between and within the groups a unit root and stationary tests were applied for the variables involved. To test for non-stationarity for the Theil Index in México and their regions two test were applied, Augmented Dickey Fuller (ADF) and M-tests by Ng Perron (2001).

The dickey fuller test is based on the estimation of an autoregressive model for y_t and test if γ (1) = 0. But, not all series can be represented by the first-order autoregressive process, $\Delta Y_t = \alpha + a_2 t + \gamma y_{t-1} + e_t$. Its possible to use Augmented Dickey-Fuller test in higher order equations:

$$\Delta Y_t = \alpha + \gamma y_{t-1} + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + e_t$$

where

$$\gamma = -\left[1 - \sum_{i=1}^{p} a_i\right]$$

Notice that this equation includes both drift and linear time trend. For the tests of this work a constant term and time trend were included in the testing specifications. The parameter of interest is γ, if γ =0 the equation is in first differences and has a unit root:

$H_0 : \gamma = 0$
$H_1 : |\gamma| < 0$

The same statics is used as in Dickey-Fuller a contains unit root. To select the appropriate number of lagged differences has been used the Lagrange Multiplier test by adding lags until it fails to reject no serial correlation at a user defined level.

Another unit root test used, was the M-tests proposed by Ng and Perron (2001), define as four test statistics based upon Generalized Least Squares (GLS) detrended data. They proposed some modifications to the current unit root tests to improve their implementation accumulating intellectual heritage of number of previous tests. These efficient modified Philip-Perron (PP) unit root tests do not exhibit the severe size distortions of then PP tests for errors with large negative autoregressive roots.

They propose some modifications to existing unit root tests to improve their performance in terms of power and size. Ng and Perron (2001) use the GLS detrending procedure of Elliot, Rothenberg and Stock (1996) (ERS) to create efficient versions of the modified Phillips and Perron's (PP) test. They propose a set of four test statistics, with different distribution, for testing unit root namely; MZ_α, MZ_t, MSB and MPT.

MZ_α and MZ_t are the modified versions of Phillips' (1987) and Phillips and Perron's (1988) Z_α and Z_t tests; the MSB is related to Bhargava's (1986) R1 test. For the series, the first the three test statistics were used.

If a series its non-stationary then the distribution varies over times, it systematically increases or decreases throughout time, has persistence. It is common for macroeconomic variables to grow or, less frequently, to decline over time. The product grows as technology improves, population increases and inventions arise.

Stationarity Test

Another test applied in this case was the most commonly stationarity test used, the KPSS test, due to Kwiatkowski, Phillips, Schmidt and Shin (1992). They propose a test where in series stationarity around a deterministic trend can be observable in the null hypothesis.

The series is expressed as the sum of deterministic trend, random walk, and stationary error, and the test is the LM test of the hypothesis that the random walk has zero variance. The asymptotic distribution of the statistic is derived under the null and under the alternative that the series is difference-stationary. In particular the KPSS specification is:

$$y_t = \beta D_t + \mu_t + u_t$$
$$\mu_t = \mu_{t-1} + \varepsilon_t, \sim \varepsilon_t \, WN(0, \sigma_\varepsilon^2)$$

Where D_t contains deterministic components (constant or constant plus time trend), u_t is *I*(0). Statonarity tests are for the null that y_t is *I*(0). Notice that μ_t is a pure random walk with innovation variance σ_ε^2. The null hypothesis that y_t is I(0) is formulated as Ho: $\sigma_\varepsilon^2 = 0$, which implies that μ_t is constant . The KPSS test satistics is the Lagrange multiplier (LM) or for testing:

H_0: $\sigma_\varepsilon^2 = 0$
H_A: $\sigma_\varepsilon^2 > 0$

Structural Breaks

As explained above different tests were applied to test for stationarity in the Theil index of Mexico and its regions. But in order to take into consideration the possibility of structural breaks on the Theil Index two test were applied; Perron-Rodríguez (2003) and Lee-Strazicich (2003).

A structural break occurs when we see a sudden change in a time series. But when there are structural breaks, the various Dickey-Fuller and Ng-Perron test statistics are biased toward the non-rejection of a unit root. Effects of the shocks will dissipate and the series will revert to its long term mean level. Since Perron (1989) distinguished the importance of allowing for a structural break in unit root test showing that the capacity to reject a unit root decreases when the stationary alternative is true and a existing structural break is ignored.

Perrón and Rodríguez (2003) used an extend of what is the M-test for the unit root tests by Ng and Perron (2001) with a change at an unknown time. They extend the class of M-tests for a unit root analyzed by Perron and Ng (1996) and Ng and Perron (2001) to the case where a change in the trend function is allowed to occur at an unknown time. These tests (MGLS) adopt the GLS detrending approach developed by Elliott et al. (1996) ERS.

The data generating process considered is of the form:

$$y_t = d_t + u_t, \qquad t = 0, \dots, T,$$
$$u_t = \alpha u_{t-1} + v_t$$

Where $\{v_t\}$ is an unobserved stationary mean-zero process. Using the assumption that $u_0 = 0$ thouh the results generally hold for the weaker requirement that $E(u_0^2) < \infty$. There's specifications of the deterministic components. The first model has a structural change in the slope where the set of deterministic components, Z_t, in $y_t = d_t + u_t$ is given by

$$z_t = \{1, \mathrm{t}, 1(\mathrm{t} > T_B)(t - T_B)\}$$

Where $1(\mathrm{t} > T_B)(t - T_B)$ is the indicator function and T_B is the time of the change. The second model which includes structural change in the intercept and the slope.

$$z_t = \{1, 1(\mathrm{t} > T_B), t, 1(t - T_B)\}$$

The statistics used for Perron-Rodríguez (2003) are the M-tests, MZ_α, MZ_t, MSB, analyzed b Ng and Perron (1996), exploit the feature that a series converges with different rates of normalization under the null and alternative hypothesis.

For this work the model to be considered is the one allowing the change on both the intercept and the slope. Also, only the MZ_t test was used, considering the null hypothesis of a onetime jump in trend rate and level of a unit root process against the alternative of a onetime change in trend rate and level of stationary process.

To avoid restricting the variables to have just one structural change, the tests proposed by Lee and Strazicich (2003) (LS) allows two structural changes. They proposed an endogenous two-break Lagrange Multiplier unit root test that allows for breaks under the null and alternative hypotheses and that alternative hypothesis unambiguously indicates

Lee and Strazicich (2003) propose alternative endogenous break unit root tests twith two breaks and one break, respectively. The LS unit root tests with one break and two structural breaks are based on the Lagrange Multiplier (LM) principle. Also the tests are modified versions of Schmidt and Phillips (1992) unit root test by incorporating structural break(s) in mean (Model A), both in mean and in trend (Model C).

Consider the followed unobserved components model:

$$y_t = \delta' Z_t + X_t,$$

$$X_t = \beta X_{t-1} + \varepsilon_t$$

where Zt is a vector of exogenous variables and $\varepsilon_t \sim iid\ N(0, \sigma^2)$. Two strucural breaks can be consideres as follows. Model A that allow for two shifts in leve lis described by $Z_t = [1, \mathrm{t}, D_{1t}, D_{2t}]$, where $D_{jt} = 1$ if $t \geq T_{Bj} + 1$, $j = 1, 2$. $T_{Bj}$is the time period when a break occurs. Model C that contains two shifts in level and tred can be described as $Z_t = [1, \mathrm{t}, D_{1t}, D_{2t}, DT_{1t} DT_{2t}]$, where $DT_{jt} = t - T_{Bj}\ if\ t \geq T_{Bj} + 1$, $j = 1,2$. The LS minimum (one-break and two-break) LM unit root test statistic determines the break points endogenously by using a grid search.

Results

Unit root test

It has been applied in this section both unit root and stationarity tests for the Theil Index of México, the four clusters of the regions in Mexico as well as the inequality between and within the clubs from 1940 to 2015. For testing for unit-root it is used three different tests; the Augmented Dickey Fuller, M-test and the Kwiatkowski et al. (1992) stationarity test. The results of the Table 2 shows in the first column the ADF test followed by the M-tests testing for unit root. The last column refers to the KPSS statistics for stationarity.

For the Augmented Dickey Fuller test were a trend and a constant were included, the null hypothesis of unit root can only be rejected for the fourth cluster at 10% of significance. This cluster includes the states of San Luis Potosí, Sinaloa, Tamaulipas, Tlaxcala, Veracruz, Yucatán and Zacatecas. This means that for the fourth cluster it cannot be proved the persistence on inequality for these states. On the other hand, the M-tests of Ng and Perron (2001) shows that the null hypothesis of non-stationarity is not rejected for any of the variables at any significance levels. Showing persistence in these variables.

For the Kwiatkowski stationarity test for each one of the variables with trend; the null hypothesis of stationary is rejected for each one of the variables. The Theil Index for México, cluster 1, cluster 4, Inequality within and between the clusters is rejected at 5% of significance. Moreover, the cluster 3 its rejected at 10% and cluster 2 at 1% of significance level.

Table 2 ADF, Ng and Perron (2001) unit root tests and KPSS stationarity test

Variable	*ADF*	MZ_{α}^{GLS}	MZB^{GLS}	MZ_{t}^{GLS}	*KPSS*
Mexico	-2.337	-1.780	0.522	-0.929	0.149**
C1	-0.580	-3.382	0.300	-1.013	0.159**
C2	-2.695	-2.061	0.460	-0.949	0.141*
C3	-1.077	-0.156	0.698	-0.109	0.374***
C4	-3.255*	-1.707	0.526	-0.898	0.188**
Within	-2.524	-1.688	0.543	-0.917	0.170**
Between	-2.023	-1.515	0.526	-0.797	0.188**

The symbols *, ** and *** stand for rejection of the null hypothesis of unit root at 10%, 5% and 1% respectively for ADF and M-test. For the KPSS stationarity test the symbols represent rejection of the null hypothesis of stationarity with l=4.

Critical Values with Trend and Intercept

	ADF	MZ_{α}^{GLS}	MZB^{GLS}	MZ_{t}^{GLS}	KPSS
1%	-4,04	-13,8	0,174	-2,58	0,216
5%	-3,45	-8,100	0,233	-1,98	0,146
10%	-3,15	-5,700	0,275	-1,62	0,119

Critical values for the ADF have been obtained from MacKinnon (1996). For the M-tests the critical values have been taken from Ng and Perron (2001). However, those for the KSS have been obtained by Monte Carlo simulations with 50,000 replications

Structural Break

We understand for structural break as the change in the deterministic components of time series over periods. Therefore, a structural break occurs when we see a sudden change in a time series. In order to take into account, the possibility of structural change on the inequality in Mexico as well as the presence of unit root, we tested the Perron-

Rodríguez (2003) test for one structural break and the Lee-Strazicich (2003) unit root test with two structural breaks.

The Perron-Rodríguez (2003) unit root test with one structural change is shown on Table 3 which presents that the change in the inequality in Mexico in 1971 may be associated with the fact that although the Mexican economy enjoyed one of its most successful growth during the 1960s, there was a sharp slowdown in 1971. The political situation was rather fragile in those years when the protests reappeared vigorously towards the end of the years sixty.

The repression of the student movement of 68 and subsequent repression or the Corpus Christi Massacre of June 10, 1971, brought considerable political and human cost. Also, the inequality within clusters appear to have a structural change in the same year that seem to be caused because of the hostile political environment in the country as well as the decrease of GDPA recession that threatened to reduce economic activity significantly in 1971 (Cárdenas, 2015).

Also, in 1993 there's a year of changes in Mexico. For instance, at the beginning of the year a new monetary unit entered in circulation in Mexico called Nuevo Peso (N $) where the government of Carlos Salina De Gortari removes three zeros to the Mexican peso. It was a factor that managed to give stability to the national economy, especially the control of inflation.

Economic stability was notable since in those years an increase on the competitiveness of the Mexican economy with the signing of the North American Free Trade Agreement (NAFTA), which was signed in 1993 and enters into vigor the first month of 1994. A structural change is observed in 1993 for the first cluster on inequality of the Mexican states, which include those states with the highest inequality rates as well as some of the most developed ones.

So, according to Esquivel (2011) a structural change in Mexico's inequality happen because of the evolution on income inequality particularly in 1994. The pattern of income inequality in Mexico since 1994, the year when NAFTA came into effect decreased income inequality to the levels that were observed before the rapid increase in inequality that took place between 1984 and 1994.

The second cluster structural change for the states of Colima, Guerrero and Oaxaca happened in 1959 some reforms in education issues occurred, the agricultural sector suffered a contraction that contrasted strongly with the bonanza of previous years. The

Hurricane of 59 in Colima considered one of the worst hurricanes of the 1950s and the deadliest recorded by a hurricane in the Pacific Ocean. It is explained why this structural change occurred in the second cluster of states Of Colima, Oaxaca and Guerrero.

The Perron-Rodríguez (2003) unit root with one structural change show persistence. The break dates for the Theil Index in Mexico and for within group inequality was in 1971, for the cluster 1 in 1993, cluster 2 in 1959, cluster 3 in 1970, cluster 4 in 1992 and between group inequality in 1962. Nevertheless, there is no evidence against the unit root for any of the variables being all the non-stationary. Once again, there’s persistence in Mexico inequality over time, even when considering structural breaks.

Table 3 Perron-Rodríguez GLS test for a unit root in the presence of one structural change

Variable	MZ_t^{GLS}	k	T_b
Mexico	2,675	1	1971:01
C1	2,467	1	1993:01
C2	2,431	2	1959:01
C3	2,428	0	1970:01
C4	2,951	7	1992:01
Within	3,000	1	1971:01
Between	2,502	2	1962:01

The critical values for the Perron-Rodríguez GLS test at 1% are -3,93, -3,56 at 10% and -3,36 at 10% of significance for unit root at one break in the trend and intercept. The critical values have been obtained from Perron and Rodríguez (2003).

Now for bearing in mind the possibility of two structural changes the Lee and Strazicich (2003) unit root test is presented on Table 4. The unit root test considers the possibility of two structural changes. It can be observed that most of the series appear to be non-stationary. The unit root hypothesis cannot be rejected for six of the seven series. However, for the second cluster of regional inequality reveals that the null hypothesis can be rejected which means the series is stationary at 5% level of significance or higher.

From the application of the Lee-Strazicich test, non-stationarity can be rejected in favor of stationary for the second cluster which includes the states of Colima, Guerrero and Oaxaca. Consequently, the first structural change occurs in 1952 and the second in 1961.

For the structural change in 1952 given that the second cluster is stationary might be because some political and social factor affecting Mexico and the regions that this cluster comprehends. There was the worker’s repression of May 1952 better known as the

“Alemanista” repression due to the then president Miguel Aleman. On the first of December of 1952 Adolfo Ruiz Cortínes took office as the 47th president of Mexico.

In the same year, the Mexican Social Security Institute (IMSS) began providing medical care in the State of Oaxaca. For the second structural break in 1961 was founded the National Institute of Protection to the Childhood. National Institute of Protection to the Childhood. According to the National Center for Disaster Prevention (Cenapred), the cyclone Tara of 1961 was the most intense that has hit the coast of Guerrero. Also, 1961 appears to be quite an important year for the series as three variables appear to have a structural change in this year, ones for the first break and others for the second one.

For the Theil Index in Mexico and for the fourth cluster the first breakpoint occurs in the same year, 1961. In addition to the above-mentioned facts happened in 1961, the government of Mexico started the national plan for the expansion and improvement of the education. Which goes from the first delivery of free textbooks, increase in the subsidy for the universities, and increase the population attending school, etc. The second break occurs in 1990 and in 2005 respectively.

This break might be due the fact that in 1990, a new autonomous body was created called Federal Electoral Institute (IFE). Also, the re-privatization of the bank and other important companies like the telephony (Teléfonos de México), aviation (Mexicana de Aviación), Altos Hornos, etc. added optimism among entrepreneurs, who gradually regained confidence where entrepreneurs began to return capitals to the country.

Consequently, the first breakpoint for the first cluster of regional inequality occurs in 1959 while the second one occurs on 1981. For the second cluster the structural breaks were on 1952 and 1961. The structural breaks in the third cluster were on 1967 and 1981. For the inequality between clusters were for 1956 and 1969

The inequality within clusters change occur in 1955 and 1983. For the first time in 1955 women vote in Mexico, exercising the right conferred recently by the Constitution. The second structural break in 1983 may be because the Bank of Mexico withdrawn from the exchange market, the government was forced to declare itself in a moratorium on payments and had to devalue the national currency. The government undertook a decrease in public spending, imposed more import controls, raised prices and public tariffs, and raised interest rates; Decreed a general rise in wages and salaries that raised production costs (Cárdenas, 2015).

The year of 1981 seems to be an important year because two variables have a structural break in that year. That might be because an important event that happens where Mexico adopted the Value Added Tax (VAT).

There are some common breakpoints that characterize the series. Beginning with the Perron-Rodríguez (2003) where 1971 is the year for the inequality within the clusters and for the Mexico´s inequality that the first change take place. Also, for the Lee-Strazicich (2003) two of the variables have the same first structural break in 1961, inequality in Mexico and fourth cluster, and even the second cluster has the same breakdown in that year but for the second structural break. Similarly, the second structural change in 1981 corresponds to the inequality on the first and third cluster. It can be appreciated that the structural changes happening in the series occur in years quite close between them or at least into the same periods between the 60´s and 70´s.

Thus, after performing the unit root tests with structural changes we can realize that these changes occurred in very similar periods. The main characteristics for these breaks were first of all that happened on the same periods where economic crisis occurred. As well as structural reforms that modernized the country in addition to the hostility of the political situation that the country experienced in the 70s and deterioration of the relationship between citizens and government. Accordingly, as unit root in income inequality in Mexico is rejected for most of the variables non-stationarity appears to be the evidence of the growing inequality in Mexico and its regions in the last 75 years.

Table 4. Lee and Strazicich (2003) unit root test with two structural changes

Variable	T_{b1}	T_{b2}	k	Test statistic
Mexico	1961:01	1990:01	0	-2,27
C1	1959:01	1981:01	0	-3,30
C2	1952:01	1961:01	0	-6.15**
C3	1967:01	1981:01	0	-3,61
C4	1961:01	2005:01	0	-3,79
Within	1955:01	1983:01	0	-2,81
Between	1956:01	1969:01	0	-2,27

The symbols *, ** and *** stand for rejection of the null hypothesis of unit root at 10%, 5% and 1% respectively. The critical values have been obtained from Perron and Rodríguez (2003):

Critical Values with trend and Intercept

	1%	5%	10%
Mexico	-6,41	-5,74	-5,32
C1	-6,41	-5,74	-5,32
C2	-6,16	-5,59	-5,27
C3	-6,45	-5,67	-5,51
C4	-6,33	-5,71	-5,33
Within	-6,41	-5,74	-5,32
Between	-6,16	-5,59	-5,27

Conclusion

According to the Organization for Economic Cooperation and Development (OECD) Mexico has the widest interregional gap between rich and poor. The country is the second most unequal of the 34 countries part of the OECD.

The structural changes in an economy is reflected in the society which causes variations in the values, trends and political demands of wide sectors of the population. Freedom is revalued and in relative terms equality is devaluated. It also reduces credibility and confidence in the government that that through its policies should be the main agent to promote a more egalitarian society.

Income inequality in Mexico has been increasing the gap between those who have the most and the least favored. Mexico is one of the most unequal countries in the world. Among 10 selected countries in Latin America, Mexico has the fifth place in inequality. Thus, Mexico should be among the most unequal countries in Latin America due not only to the disproportionate 10% of the richest population, but also because of the inequalities in education, differences in the participation of women, number of children per family and the different opportunities offered by the different regions of the country (Gutiérrez Flores, 2008).

When analyzing the persistency of income inequality in Mexico and its regions using the theil index as an inequality measure. As well as decomposing the index for within and between regional cluters from 1940-2015. The results provide strong support to the fact that the Theil index for Mexico, between and within their regions is persistent over time. We find that the unit root and stationary test on income inequality cannot be reject in the series for no structural break.

This means that the non-stationarity means that the inequality in Mexico and its regions on the last 75 years. Future research could be directed to divide the clusters by distribution percentiles in order to observe what happens with the inequality in Mexico in terms of social classes and those who carry greater weight.

Even though, when testing for unit root test for Lee and Strizicich (2003) with two structural breaks it was possible to reject the null hypothesis at 5% of significance. So, it has a stationary process and the shocks to inequality have transitory effects.

Also, as we conclude the existence of persistence on inequality in Mexico, it’s important to consider the importance of the inequality within and between the convergence clusters. Both of these variable shows non-stationarity for any of test applied. Therefore, it’s not just the fact that inequality has been increasing between the different clusters with different characteristics which goes from location, size or dynamics. But the fact that inter-regional inequality among the states within the clusters have been persistence from 1940 to 2015. Making the inequality in Mexico more extensive.

References

Aguilar-Retureta, J. (n.d.). Regional Income Distribution in Mexico: New Long-Term Evidence, 1895-2010. *SSRN Electronic Journal*, (323).

Alexander von Humboldt, Political Essay on the Kingdom of New Spain, trans. John Black (*London: Longman, Hurst, Rees, Orme, and Brown, 1811*), 1, 134-217, passim.

Bhargava, A. (1986). "On the Theory of Testing for Unit Roots in Observed Time Series". *The Review of Economic Studies*. 53 (3), 369–384.

Boix, C. (2010). Origins and Persistence of Economic Inequality. *Annual Review of Political Science*, 13(1), pp.489-516.

Bourguignon, F. (july 1979). Decomposable Income Inequality Measures. *Econometrica*, 47(4), 901-920

Carrion-i-Silvestre, Josep Lluís, Tomás del Barrio-Castro, and Enrique López-Bazo. (2005). Breaking the Panels: An Application to the GDP per Capita. *Econometrics Journal*, 8, 159–75.

Christipoulos, D. and Mcadams, P. (2017). On the Persistence of Cross-Country Inequality Measures. *Journal of Money, Credit and Banking*, 49(1), 255-266.

Elliot, G., T.J. Rothenberg, and J.H. Stock (1996). Efficient Tests for an Autoregressive Unit Root, *Econometrica*, 64, 813-836.

Esquivel Hernández, G. (2015). Extreme Inequality in Mexico: Concentration of Economic and Political Power. *OXFAM Mexico*, [online] p.44. Available at: http://www.socialprotectionet.org/sites/default/files/inequality_oxfam.pdf

Esquivel, G. (2011). The dynamics of income inequality in Mexico since NAFTA. *Economía*, *12*(1), 155-179.

Germán-Soto, Vicente.(2005).Generación del producto interno bruto mexicano por entidad federativa, 1940-1992. *El Trimestre Económico*, vol. 72(3): 617-653.

Germná-Soto, V, Mendoza-Velázquez, A., Monfort, M. y Ordóñez, J. (2016). *Regional inequality in Mexico (1940-2010)*

Gutiérrez Flores, L. (2008). La distribución del ingreso en México: un análisis regional, 1990-2004. *Revista Latinoamericana de economía*, [online] 39(152), pp.139-163. Available at: http://www.scielo.org.mx/pdf/prode/v39n152/v39n152a8.pdf

International Labour Organization (2017). *Income Inequalities in the Age of Financial Globalization*. World of Work Report 2008. International Institute for Labour Studies, p.181.

Islam, MR and Madsen, JB 1970, Is income inequality persistent? Evidence using panel stationarity tests, 1870-2011, *Economics letters*, 127, 17-19.

Kwiatkowski, D., P.C.B. Phillips, P. Schmidt and Y. Shin (1992). “Testing the Null Hypothesis of Stationarity Against the Alternative of a Unit Root,” Journal of Econometrics, 54, 159-178.

Lee, J. and M. Strazicich (2003) Minimum Lagrange multiplier unit root test with two structural breaks. *The Review of Economics and Statistics*. 85, 1082-1089.

Metwally, M.M., and R.C. Jensen (1973), ‘A note on the measurement of regional income dispersion’, Economic Development and Cultural Change 22(1), 135-136

Ng, S. and P. Perron (2001) Lag length selection and the construction of unit root tests with good size and power. *Econometrica*. 69, 1519 – 1554

Perron, P. and Rodríguez, G. (2003). GLS detrending, efficient unit root tests and structural change, *Journal of Econometrics*, 115, 1–27.

Perron, P. and S. Ng. (1996). Useful Modifications to Some Unit Root Tests with Dependent Errors and their Local Asymptotic Properties. *Review of Economic Studies*. 63, 435-463.

Perron, P., (1989). The great crash, the oil price shock and the unit root hypothesis. *Econometrica* 57, 1361-1401.

Phillips, P.C.B. (1987). Time Series Regression with a Unit Root. *Econometrica*, 55,.227-301.

Phillips, P.C.B. and P. Perron. (1988). Testing for a Unit Root in Time Series Regression. Biometrika 75, 335-346

Piketty, T. (2014). Capital in the Twenty-First Century. Cambridge: *Belknap Press of Harvard University Press.*

Theil, H. (1967), Economics and Information Theory. North Holland, Amsterdam

Vieira, V. (2012). Inequality on the rise? An assessment of current available data on income inequality, at global, international and national levels. *World Economic and Social Survey 2013.* Economic Affairs Officer –DESA.