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Comparison of the Tax System Progressivity Over Time: Theory and Application with Mexican Data

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Abstract:
Assessing the progressivity of a fiscal system is relevant to develop a global idea on the extent of redistribution. In this paper we assess the evolution of progressivity over time and how economic shocks and government fiscal policy affects its design. The social performance of fiscal redistributive mechanisms in Mexico has been receiving a growing interest from politicians and researchers. The aim of this paper is to assess the dynamics of progressivity of the fiscal system in Mexico and its effect on inequality and on polarization, and this during the period of 2002-2012. What distinguishes this work is the relevance of the adopted comparison approach of progressivity and where the common support of comparison is imposed. The results of this study confirm the effectiveness of the governmental redistributive mechanisms to decrease after-tax income inequality. Based on our estimates, we find a significant increase in the progressivity of the fiscal system over time, despite the high persistent levels of polarization and inequality in the country. Finally, we find that imposing the common support of comparison has a non-negligible impact on the level of progressivity.

Keywords: Fiscal Policy, Progressivity, Inequality, Polarization

JEL Classification: E62, D63, I32, O12

1 Introduction

Monitoring and improving the fiscal system becomes a relevant issue for developing countries for three main reasons: 1. This mechanism represents the ultimate tool to improve the distribution of wealth, and benefits the poor by making taxes more progressive. 2. Tax evasion in developing countries becomes practically the rule with the growing size of the informal sector. This explains the urgent need of improving and adapting the fiscal system. 3. The impact of benefits through the transfers and the social programs was mitigated across countries (for example due to imperfect targeting) and this, depending on the extent and the pro-poorness of the fiscal systems. During the last years, similar countries to Mexico in Latin America like Brazil, Argentina and Uruguay have shown some improvement in their fiscal system and redistributive effects to tackle poverty. However, there still exist economies with poor results, despite having applied even more ambitious programs and more resources than the case of Mexico with the *Oportunidades* program, such as Bolivia and Peru (Lustig, Pessino, and Scott (2014)).

Even though it is not our goal to analyze poverty impacts from fiscal policy changes, in this paper we attempt to study the evolution of progressivity of the tax-benefit system in Mexico over time. This retrospective form of analysis is helpful to have some salient facts about the relevance of the implemented fiscal policies and social programs during the last years. The topic of comparing the progressivity of a fiscal system over time has been even more absent in the empirical literature. This fact is well explained by the difficulty surrounding the absence of the *common support of comparison*, or in short, the temporal change in the distribution of gross income.[1]

In this paper, we approach this gap by proposing the appropriate method to perform the comparison of the extent of progressivity over time. Of course, the proposed method can be generalized for other cases, like the comparison of progressivity across countries. The importance of focusing on the period of 2002-2012 is explained by the Mexican Government having changed its internal way of conducting both political and economic decisions, when the opposing party (Partido Accion Nacional) won the elections for the first time in seventy years, and remained at the helm for twelve years (2000-2012). Indeed, some changes began to emerge. At the state/local level, the tax systems were so weak and the informal sector grew up to reach sixty percent of the workers (INEGI (2014)), resulting in a low taxable base. Also, the benefit programs began to grow faster during this period. These facts can provide an ideal opportunity to examine the temporal effects of the fiscal policy and redistribution into the whole population as well as for the contributors.

Another interesting feature of this period is that it provides us with an opportunity to study the response of the tax-benefit system with regards to the financial 2008/2009 international crisis. Mainly, among the salient facts of this crisis was the rapid internal increase in food and energy prices. This has involved in its turn the expansion of consumption subsidies and targeted benefits, as well as an increase in the value-added tax (VAT). Precisely, this increase was from 15 to 16 percent, except for the six states bordering those of the United States of America (U.S) where the increase was from 11 to 16 percent for all.

The rest of the paper is organised as follows: The next section briefly describes the fiscal context and its related events during 2002 and 2012 as well as the empirical literature to date

[1] See Musgrave and Thin (1948), and Musgrave (1990) to understand more details about this condition.

related to progressivity in fiscal systems on international experiences and Mexico; the third section describes the theoretical framework; the fourth presents the data sources with the specific assumptions made and the empirical exercise; section five concludes and shows the final insights providing new routes for future research.

2 Overview of changes in the Mexican fiscal structure

Serious distortions that result in an excess of inequality persist among the population in Mexico, both in the way of paying taxes as well as the way to receive welfare support through the fiscal system by the Government. While inequities have historical roots in this country, it has been shown how not only for developed but also in developing countries a better redistribution of resources has been achieved through the fiscal systems using compensated-based redistributive policies.[2]

Another issue of importance is the significant underreporting of wages by registered firms to evade payroll taxes in the country (Kumler, Verhoogen, and Frias (2013)), as well as the impact of a persistent high level in the informal sector with serious consequences for the marginal efficiency of taxation as one of the causes of low revenue collection. As a research hypothesis, this last issue will lead to an impact on the tax system, even when it is progressive, that is not able to cope with inequality over time.

2.1 The Tax-benefit system behavior in perspective

The tax-burden in Latin America has been low compared to other countries with similar levels of economic development. It has stood by an average of 15 percent for the year 2005 but differences within countries remain large, from about 35 percent in Brazil to as low as 10 percent in Mexico or Guatemala. The trend during the last decade has been towards an increase in the tax burden and its efficiency, mostly for the same countries that initially had the same pattern. Comparing this later issue to public expenditure levels, during the last twenty years there has been a widespread difference among the Latin American economies that seem to be growing departing from 2002.[3]

It is important to remark that the taxation structure has remained almost the same for Mexico over 2004-2012 and that the main taxation figures have relatively few changes. Income taxes remained the same at the margin, but the VAT changed in 2010, increasing the general rate from 15 to 16 percent, leaving the rest of consumption categories unchanged. Income taxes represent an average figure of 46 percent and VAT an average of 38 percent of the total taxation revenues during the period.

Two direct taxes emerged in the country in 2008. The first is the business flat tax (IETU for its initials in Spanish) with a minimum threshold of 17.5 percent. This flat tax had a broader basis than the income tax (for both personal and corporate) and it would tax those agents who currently pay no income tax, making taxation more equitable and to reduce fiscal evasion and elusion. The second tax was the flat tax on cash deposits (IDE in Spanish), with a flat rate

[2]See Lustig, Pessino, and Scott (2014).

[3]See Gomez-Sabaini (2006) for more insights about this process.

of 2 percent applied for cash deposits in the banks beyond 15,000 Mexican pesos per month. This tax was supposed to be paid by all agents with the goal to reduce informality as well as to cope with organized crime. These taxes were eliminated in 2013 and both figures accounted for no more than 4.1 and 1.3 percent of total taxation revenues respectively in 2011. Among the causes that engender the difficulty of the Mexican fiscal system in raising revenues to fund the provision of public goods over time, there can be underreporting of wages by registered firms (Kumler, Verhoogen, and Frias (2013)) as well as a high level of informal employment, ranging between 45 percent to 80 percent of total employment across states during 2005-2010 (Dougherty and Escobar (2013)).

The context of a structural fiscal crisis that characterized the Mexican government for decades highlighted the need to target even more the public expenditures to well-defined sets of populations. The economic policy of the last two decades, engaged in macroeconomic balances, failed to be reflected in higher economic growth as well as the consolidation towards a more equitable society. On the contrary, deterioration in the living conditions of the Mexican society is evident where approximately more than 50 percent of the population lives below the official threshold.[4]

Even if the combined effect of the different social programs have significantly helped in reducing poverty in Mexico, their effectiveness and sources of finance continue to be questionable. Is it possible to improve the social efficiency of benefits, as well as the tax efficiency to finance in particular the social programs and in general the public projects? The need of continued improvement in the design of a tax-benefit system is justified by the economic structural changes. For instance, the increase in the tax on the production or consumption of goods may be relevant to compensate the taxpayers, especially when the informal sector becomes the predominant shape of the economic structure (Dougherty and Escobar (2013)).

Mexico needs to restructure its strategies to cope with poverty to improve the social efficiency of its intervention: First, more efficient targeting of the poor is the single best mechanism to ensure the optimal use of public resources. Second, the social policy has not been designed to solve the underlying problem. It is too common that transfers translate into a lack of government action and that the benefits derived from welfare support just serve as survival for the poor. And third, the government has leaned heavily on social policy as a foundation for support, so there is a political bias in targeting fiscal resources to public programs regardless of the political party in power during this period.

In January 2002 the Inter-American Development Bank (IADB) granted Mexico a loan of one billion dollars to support a program called *Oportunidades* for which great expectations were held; this led to another loan of 200 million dollars to expand the coverage and consolidate the program. According to World-Bank (2014), results indicate a decreasing poverty trend between 2002-2006 followed by a period of increasing poverty rates up to 2012, the end of the study period. The poverty rate was 50.0 percent in 2002, 47.2 in 2004, 42.9 in 2006, 47.8 in 2008, 51.1 in 2010 and 52.3 in 2012. *Oportunidades* program was accompanied by other transfers, such as aid to the elderly, to areas with natural disasters or with serious problem in the creation of new jobs, and additional aid in the form of food assistance for the poor. The welfare aid has not proven highly efficient at reducing poverty during the period of economic crisis.

[4]See CONEVAL (2012) for more insights of this figure, the poverty thresholds employed and a more disaggregated picture using the multidimensional approach to compute poverty levels in Mexico in the year 2012.

All these benefit programs have accounted for no more than 0.92 percent of Mexican GDP at its highest level and were accompanied by an increase in average poverty gaps for the Mexican households.[5]

2.2 Growth and shocks

World-Bank (2014) information reveals that the Mexican economy has struggled with two periods of crises: 2001 and 2009. These years saw a deceleration of GDP growth by -1.55 and -7.1 percent respectively. During the period, evidence of a shift of employed workers from manufacturing to services is present. Caamal (2013) shows this pattern to be associated with lower labor demand in the former sector and falling returns to education.

Along with the previous performance, Government actions have centered on two important features: Application of a generalized consumer subsidy on domestic electricity, gas and diesel, as well as gasoline; and an increase from 0.34 to 0.92 percent of GDP in the direct cash-transfer social programs. The former subsidies have varied sharply in recent years as a function of international oil prices: they accounted for a historical maximum of 2.8 percent of GDP in 2008. As a result, domestic gasoline prices were frozen in the context of rising international gasoline prices, then the consumer price of domestic gasoline prices increased afterwards by 0.11 Mexican cents for every month Scott (2014), after which point in time it can be seen that Mexican fiscal authorities have fixed this rise for internal sales of gasoline and kept revenues at about the same level of GDP.[6]

During the last nine years, a non-contributory health insurance was introduced to most of the uninsured population called the *Seguro Popular* program, extended mostly to the poor. Populations with neither coverage of social security nor protection by any health care program (public or private) could apply. This figure went from 50.1 percent (13.3 million people) in 2006 to 44.1 percent (11.8 million people) in 2008. Between 2008 and 2012 the coverage in access to health services increased significantly to 21.5 percent in 2012 (25.3 million people) (CONEVAL (2014)).

This significant decrease is mainly due to the enrollment in the *Seguro Popular* system. However, the right to health-care in Seguro Popular is not completely free and families must pay an annual registration fee. According to Scott (2014) all these changes have been implemented with a failure to increase Mexico's low efficiency of revenue mobilization: non-oil tax revenues have remained stagnant at close to 10 percent of GDP, when the rest of the Latin American countries have seen revenues rise on average by 13 to 19 percent of GDP in the last ten years. As a result, in Mexico a large fraction of public spending has been financed through oil revenues which come from the state-owned oil company *Petróleos Mexicanos* (PEMEX).

Campos-Vazquez, Esquivel, and Lustig (2012) found that inequality decreased from 2002-2006 and then returned to its initial level in 2008 using disposable total household income with a standard Gini coefficient of 0.51. Inequality decreased again to a level of 0.49 in 2010, and among the factors driving this process in overall inequality, they identify the decline in non-

[5]Estimates from the authors show an increase of 3.5 points in the poverty gap index between 2006 as the pre-crisis index and 2012 as post-crisis index.

[6]see Scott (2014) for a more detailed description of the effects of the 2009 crisis in Mexico and the fiscal policies applied.

labor income inequality and the role exerted by remittances and government transfers. In these years, emigration from Mexico to the US grew at a rapid pace, as did remittances sent by these migrants to their families in Mexico. CONEVAL (2009) data provides evidence that without remittances, poverty figures in the country could have been much higher.

2.3 Empirical literature on progressivity

Empirical research has been carried out to measure liabilities, the tax burden or even the incidence of transfers and benefits over time and across countries (Kniesner and Ziliak (2002), Davidson and Duclos (1997), Keen, Papapanagos, and Shorrocks (1996), Duncan (2010), Araar (2008), Baunsgaard and Symansky (2009), Devereux and Fuest (2009), Buettner and Fuest (2010), Attinasi, Checherita-Westphal, and Rieth (2011), Lustig, Pessino, and Scott (2014), and Scott (2014)).

The research of Kniesner and Ziliak (2002) examines the effect of the federal income tax reforms of the 1980s in the United States on the level of automatic stabilization of consumption, and determined that the recently implemented social program reforms increase the automatic stabilization, whereas *The Economic Recovery Tax Act* of 1981 (ERTA) and the *Tax Reform Act* of 1986 (TRA86) reduce consumption stability by about 50 percent for households facing large income risk, and the impact is much more modest for the typical household.

Davidson and Duclos (1997) found a more progressive distribution in the post-fiscal distribution of income between 1981 and 1990. Using the asymptotic sampling distribution of quintile-based estimators, they found that taxation is clearly statistically less progressive than benefits, and that gross incomes were more equal in 1981 than in 1990; the opposite trend was found for net incomes, i.e., redistribution was significantly more progressive in 1990 than in 1981.

Keen, Papapanagos, and Shorrocks (1996) extend the core results on progressivity to cover the case of income-tax payments and prove that any change in average tax rates would be sufficient to decrease residual progression. This outcome could result from increasing either allowances, income-related deductions, or tax credits. Wagstaff and van Doorslaer (2001) analyzes the role of tax credits, rate structures, allowances and deductions in determining the overall progressivity of net income tax liabilities in fifteen OECD countries and three kinds of clusters have been found. First, the dominant (but not only) effect driving progressivity of gross and net tax liabilities in countries like Australia, France, Italy, the Netherlands and Spain is rate. Second, there are countries where available allowances, transfers, etc., are the dominant source of progressivity, as is the case in many English-speaking countries. Third, there are the mixed structure countries, Belgium, Finland, Germany and Sweden, where roughly half of the progressivity of gross tax liabilities is attributable to the rate structure.

Araar (2008) performed an empirical application for progressivity using the Canadian data to estimate the impact of the fiscal system on the size and wellbeing of socio-economic classes. He concludes that the progressivity of the fiscal system enables a reduction in the number of the poor and increases the size of the middle class, according to an increasing progressivity trend of the fiscal system in the country between 1993 and 2005.

On the other hand, Duncan (2010) found that tax progressivity may increase current inequality, especially in countries having a weak law and a large informal nontaxable sec-

tor where the evidence is estimated for over one hundred countries worldwide. The findings of Duncan (2010) suggest that progressivity has a strong negative effect on inequality in reported gross and net income and that this negative effect is stronger in countries whose institutional framework supports a pro-poor redistribution. A similar pattern was found in Claus, Martinez-Vazquez, and Vulovic (2013) for many Asian countries, where government spending on social protection appears to increase income inequality instead of mitigating it.

The research conducted by Baunsgaard and Symansky (2009) highlights reasons that analyzing income taxes is important, including the relative progressivity of income taxes relative to corporate or consumption taxes over time. Other findings reveal that corporate taxes are not found to act as significant automatic stabilizers in the economic cycle (Devereux and Fuest (2009), and Buettner and Fuest (2010)). Also, Attinasi, Checherita-Westphal, and Rieth (2011), using a direct measure of personal income tax progressivity, found how income taxes payable by individuals seem to be more important in terms of budgetary revenues than corporate income taxes for many developed EU economies. They present OECD cross-country evidence on the relationship between tax progressivity and output volatility.

Lustig, Pessino, and Scott (2014) provide good insights in pursuing the progressivity incidence for the fiscal system figures of six Latin American countries and its impact on poverty during 2000-2010. Their results show that a more progressive tax-benefit system is found for most of the selected countries in recent years. There are major cross-country differences. The fiscal systems of Bolivia, Mexico and Peru have the lowest impacts on poverty reduction while Argentina, Uruguay and Brazil presented the greatest reductions and are the countries with the most redistributive fiscal systems. Scott (2014) presents a complete analysis for a short period of time, between 2008 and 2010, for the fiscal tax-benefit system in Mexico. He finds a situation that describes a fiscal system trapped in a low-revenue-low-benefits equilibrium, where this limitation of tax revenues does not arise from exceptionally low tax rates, but from low levels of tax productivity. His findings show a more progressive fiscal system in 2010, by a comparative static measurement of progressivity when just using the tax and benefits rules of each year.

Although Lustig, Pessino, and Scott (2014) and Scott (2014) have done a great job in processing the tax figures and transfers in their databases, and these findings with regard to progressivity demonstrate that there is not a common support of comparison used in their estimations. So far, we cannot assure that those results are fully reliable because fiscal incidence and progressivity refers only to the evolution of structural conditions considered separately for each year, then measured at only one point in time without observing the relativity incidence with respect to the changes on income distribution.

3 Theoretical framework

In this section, our main objective is to present the theoretical framework used in this study by focusing on how to:

- assess the progressivity of a fiscal/benefit system.
- develop a comparison of progressivity over time.
- assess the distributive impact of the fiscal/benefit system.

We start by introducing the theoretical framework to test and to measure the progressivity of taxes or benefits. Then, we explain the inequality and polarization indices that can be used to assess the behavior in income disparities and on polarization of income arising from the tax-benefit redistribution.

3.1 Testing progressivity of fiscal system

Usually in distributive analysis, we assess the progressivity of taxes or transfers. However, with governmental intervention through the fiscal system, the household can have, depending on its characteristics, a simplified negative or positive impact on its gross income. First, we begin by dividing the total impact of the fiscal system on household income, which is the difference between net and gross income, into two main components. If the household-level impact is negative, we assume that the latter represents a global tax, noted by T, that the household must pay. In contrast, if the impact is positive, this represents a global transfer that the household receives and we denote it by B. It can be said that a tax is progressive if the tax burden of the poor group is relatively lower than that of the non-poor group. This implies a rise in the share of net income for the poor group. In the literature of progressivity, there are two main distinct concepts of progressivity, which are *local progressivity* (LP) and *global progressivity* (RP). In the pioneering work of Musgrave and Thin (1948), two main approaches were proposed for the measurement of local progressivity, which are *liability progression* and *residual progression*. Let $V(x)$ denotes the final impact on gross income x, such that $V(x) = B(x) - T(x)$.

Theorem 1 *With the liability progression measurement, a fiscal system with tax T and transfer B is locally progressive if and only if:*

$$LP(x) = \frac{B(x)}{x}(\eta_B(x) - 1) - \frac{T(x)}{x}(\eta_T(x) - 1) \ < \ 0, \tag{1}$$

where η_T and η_B refer to the elasticities for both, tax T and transfer B with respect to income x respectively.

Proof. See the Appendix 1 for the proof. ■

It can be recalled here that with the *residual progression* measurement, a fiscal system with tax T and transfer B is locally progressive if and only if:

$$RP(x) = \eta_{N(x)} \ < \ 1, \tag{2}$$

$\eta_N(x)$ refers to the elasticity of the net income $N(x)$ with respect to income x. To test the global progressivity of a fiscal system, we use two dual approaches. The first is the *Tax Redistribution* approach (TR), which is based on the distribution of taxes considering that of gross income. The second is the *Income Redistribution* approach (IR), which is based on the distribution of net income as a function of gross income.

Theorem 2 *A fiscal system with tax T and transfer B is globally TR progressive if and only if:*

$$TR(p) = \frac{\mu_T}{\mu_X}\left[L(p) - C_T(p)\right] + \frac{\mu_B}{\mu_X}\left[C_B(p) - L(p)\right] \ > 0 \ \forall p \in [0,1], \tag{3}$$

where $L_x(p)$ and $C_x(p)$ denote the Lorenz and concentration curves respectively at percentile p, and where μ_T and μ_B are the average tax and average transfer respectively.

Proof. See the Appendix 2 for the proof. ■

It can be easily checked that if $TR(p)$ is greater than zero across the entire range of percentiles, and in absence of re-ranking, the redistributive effect of this fiscal system is socially efficient and inequality must decrease.[7] Instead of comparing Lorenz and concentration curves, we can use progressivity indices. The aim of these indices is to capture progressivity across the entire income distribution with one summary index. In general, these indices are computed as differences between the Gini and concentration indices.[8]

Corollary 3 *A fiscal system with tax T and transfer B is progressive if the index of progressivity:*

$$\frac{\mu_T}{\mu_X}\left[IC_T - IG_X\right] + \frac{\mu_B}{\mu_X}\left[IG_X - IC_B\right] \ > 0\ , \tag{4}$$

where IG and IC are the Gini and concentration indices respectively. For the IR approach, it can be said that the fiscal system is IR progressive if:

$$IR(p) = \left[C_{X-T+B}(p) - L_x(p)\right] \ > 0\ \forall p \in [0,1]. \tag{5}$$

Using Gini and concentration indices, it can be recalled that the fiscal system is progressive if:

$$IG_X - IC_{X-T+B} \ > 0\ . \tag{6}$$

3.2 Comparison of progressivity over time

As stated above, to assess the nature of change in the progressivity of fiscal systems over time, we cannot directly compare the estimated progressivity indices because the distribution of gross income varies from one year to another, and this aspect raises the problem of the non-existence of a *common support of comparison*. In fact, the change in the pre-tax income distribution substantially affects the progressivity measures, even with an unchanged fiscal system.[9] The less equal the gross income distribution is, the greater will be the equalizing effects and hence, the higher the progressivity index. Hence, progressivity indices cannot be compared with the change in the distribution of gross income across time.[10]

To address this issue, we propose to compare between progressivity indices or curves, when the reference year is predetermined. For instance, to compare the progressivity of a tax-benefit system between periods 1 and 2, and when the reference period is period 1, the expected taxes and transfers from period 2 can be estimated using information on period 1 (incomes, taxes and transfers for period 1). For analytical purposes, in general, we focus on the most updated

[7] The social efficiency refers to the joint economic and distributive efficiencies.

[8] See Duclos and Araar (2006), chapters 7 and 8.

[9] For the measurement of the global progressivity, Musgrave and Thin (1948) have proposed to use the relative change in equality implied by the tax. However, they note that this index will depend on the initial distribution of gross income.

[10] See Kasten and Toder (1994), Thoresen (2002) and Kesselman and Cheung (2004).

distribution of wellbeing and we try to show if there is an improvement in progressivity of the tax-benefit system over time.

Formally, let $[\hat{T}_i^2, \hat{B}_i^2|X_i^1]$ be the estimated combination of tax/benefit that the individual i will face if the tax/benefit system of period 2 was applied in period 1. Using the estimated distribution of taxes and benefits of the past periods, we can check whether the prevailed tax/benefit system ($[T^t, B^t|X^t]$) is more progressive than the old tax/benefit systems ($[\hat{T}^{t-j}, \hat{B}^{t-j}|X^t]$), and this, by using the usual conditions of progressivity comparison, presented in the preceding subsections. Note that, in the application of this paper, we use the locally linear non-parametrical approach to estimate the expected taxes and transfers. Appendix 3 provides for more details about this estimation and technics used.

3.3 Inequality and polarization

In this study, we use the popular Gini index to assess the levels of inequality in gross and net incomes. This will enable us to show by how much the tax-benefit system reduces income disparities. Also, we assess the impact of the tax-benefit system on polarisation, measured by the Foster and Wolfson (1992) (FW) and Duclos, Esteban, and Ray (2004) (DER) indices to assess bipolarisation and polarisation respectively. Formally, the normalized DER index can be written as follows:

$$P^{DER} = A \int \int f(x)^{1+\alpha} f(y)|x-y|dydx, \tag{7}$$

where $A = 0.5\mu^{\alpha-1}$ and $f(.)$ is the density function. Keep in mind that, when the parameter $\alpha = 0$, the normalized DER index equals the usual Gini index. The question that can now be raised is: How do polarization indices differ from those of inequality? While inequality measurements are conceived to assess the expected divergence or disparity between incomes, polarization measurements are also sensitive to the level(s) of income used to classify the income groups. For a given population group delimited by a small income range, its identification increases with its population share.[11] Furthermore, it has been argued for the evident link between polarization and some other negative aspects of the distribution. For instance, severe poverty, disappearance of the middle class or a higher level of between-group inequality are certainly related with polarization phenomena.

Now, we review the adopted bipolarisation measurement. Bipolarisation can be viewed as a special case of polarization when one focuses on the level of disparity and identification of the two main groups of the population. For the FW index, the first group is composed from those with income below the median and the second includes those with income above this threshold. An interesting representation of this index was proposed by Rodriguez (2004):

$$P^{WOLF} = 2\frac{\mu}{m}\left[IG_m^B - IG_m^W\right], \tag{8}$$

where IG_m^B and IG_m^W are the between and within inequality components, when the Gini index is decomposed by the two population groups, separated by the median of income (m). Hence, the FW index reaches its maximum when the first half of the population has a null income and the second half equally shares the entire total income. In general, any distributive change which

[11] See Esteban and Ray (1994), Duclos, Esteban, and Ray (2004).

increases the average income of the rich group will increase bipolarisation measurements. In addition, a decrease in inequality within any of these two groups will increase the bipolarisation (groups will be more identified through income). In summary, this index gives us synthesized information about the level of disparity in average income between the two main groups of the population and how these two groups are homogeneous based on their income levels.

4 Empirical application

4.1 The Mexican household income and expenditure surveys: *The ENIGH databases*

For the empirical exercise, we unified a series of the survey *Encuesta Nacional de Ingreso y Gasto de los Hogares* (ENIGH) carried out by *Instituto Nacional de Estadstica* (INEGI (2013)) considering the years 2002, 2004, 2006, 2008, 2010 and 2012 and deflated incomes using a CPI with 2012 as a reference year; the surveys were carried out in the month of August. Based on the information provided by its microdata and to make it comparable to the official reports, we proceed to build the distribution according to the CONEVAL equivalence scale and following both direct and indirect identification methods.[12]

4.2 Microdata for Mexico and construction of the fiscal system

Based on the personal disposable income (henceforth net income), it is possible to calculate the figures shown in table 1 to rebuild the pre-fiscal income (henceforth gross income). When the vector on net incomes is obtained after taxes, the current tax rules per source of income are applied for each survey. The Mexican tax system has a scheme of limits and quotas for the assessment of the income tax (ISR) with 8 brackets of income in total. Each bracket must pay the corresponding income fee in Mexican nominal pesos as part of the earnings for the marginal income tax, which ranges from 1.92 to 30.0 percent in 2012 (see table 2). The surveys allow us to identify sources of incomes and we use the four sources specified in the ISR.[13]

Thus, different tax schedules also applied for the taxpayers, tax credits and tax allowances per wage earner. In order to rebuild the fiscal system from the net income in the surveys, the translation hypothesis for tax payments in Pechman (1985) are considered[14]. For the empirical exercise, we use the income tax from both wage earners and individuals that reported income sources as benefits obtained from business, so we are able to estimate the progressivity and incidence of direct taxes. It can be seen in figure (1) that, during the last decade, the income tax reforms were modest. Thus, we cannot expect the reforms to significantly impact government

[12] See for instance Lustig, Pessino, and Scott (2014): 291.

[13] These are: Wages and salaries, taxable benefits, commissions, incentives (wage-earners); 2. Income from business and utilities; 3. Capital and financial earnings (includes insurance and other payments as income from investments); and 4. Formal income from self-employment (only those officially registered covered by any social security institution).

[14] These are related to both income and indirect taxes which are paid in accordance with the legal framework and, formally paid completely by the consumers or the final tax payer.

Table 1: Tax and benefit system in Mexico

Taxes and contributions to social programs	
ISR	- Income Tax
VAT	- Value added Tax
IEPS	- Special consumption taxes
Employer's social security contributions	- For health insurance - For pensions - For housing (public lending to finance a house)
Employees social security contributions	- For health insurance - For pensions - For housing (public lending to finance a house)
Benefits	
Means-tested	- Opportunities (Oportunidades) - Elderly - Program for food support - Scholarships - Farmers Direct Support Program (Programa de Apoyos Directos al Campo or Procampo) - Unemployment assistance (Temporal Employment)
Non-means-tested	-Pensions (Not included in benefits, but included in net income) -Others transfers (Are transfers from unknown source in the survey)

Source: Authors' elaboration according to methodology.

Table 2: Mexico Personal annual tax rates 2012

Income range (MXN)			*Marginal tax*
1	-	5,953	1.92
5,954	-	50,525	6.40
50,526	-	88,793	10.88
88,794	-	103,218	16.00
103,219	-	123,580	17.92
123,581	-	249,243	21.36
249,244	-	342,842	23.52
342,843		and over	30.00

Source: Authors' elaboration according to official data by the Mexican Ministry of Finances.

revenues. As we can observe in figure (1), for highest incomes, the maximum rate of 33 percent in 2004 decreased to 28 percent in 2008 and rose to 30 percent in 2010.

However, when real brackets are considered using 2012 as the base year, it can be seen in figure (2) that for middle income earners (above 30,000 monthly pesos) the tax burden increased in recent years. Apparently, in nominal units, 2004 seems to have the highest marginal tax rate for middle and top earners. The more salient difference when correcting for inflation is related to the top marginal tax rate in 2012: following the tax changes in 2010, the tax burden for middle income earners was higher than in 2004 and 2008. Tax reform resulted in a lower marginal tax in 2012 (33 percent) than in 2004 (30 percent), but it also widened the brackets for middle and top earners, which diminishes the likelihood of falling into the next lower bracket if faced with an exogenous drop in income. Also, for the low income earners (less than 10 thousand pesos), the 2012 data shows that the real tax burden has increased by more for this group, perhaps due to relative prices changes in taxable goods consumed most intensively by the poor, possibly resulting in decreased welfare for those contributors to the fiscal system and offsetting the progressivity of the fiscal system.[15]. This situation is more than compensated for when cash benefits are added to gross incomes, as we will see in the empirical application section.

The previous comparison is the result of the compensation for inflation in the period which is captured by the CPI index when brackets are deflated. It makes sense that the progressivity of gross tax liabilities could be attributable to the income tax rate structure, but nothing can be said about it at this stage.

Figure 1: Income tax rates (nominal brackets)

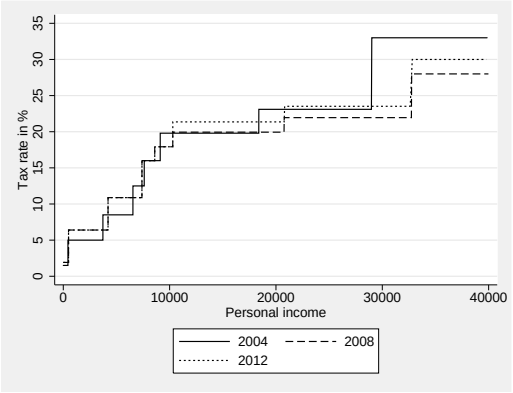
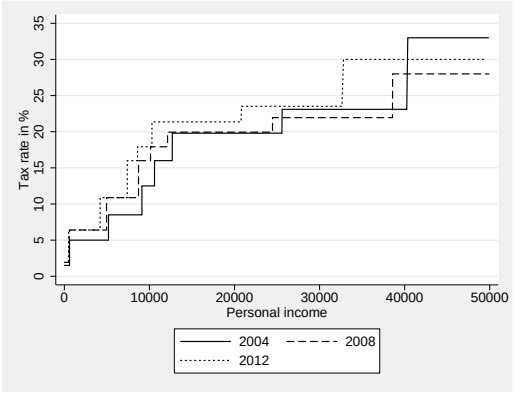


Figure 2: Income tax rates (real brackets)



Source: Authors' elaboration according to data by the Mexican Ministry of Finances and ENIGH.

In the case of indirect taxes, the VAT and IEPS (special tax on production and services) are the two most important sources of tax revenues after income tax. For those indirect taxes, we estimated them according to the tax rules and controlling for informal activities. We would prefer to estimate a reasonable level of collected VAT than overestimating its level. The adjustment is related to the place of purchase as indicated in the same survey.[16]

[15] Huesca and Araar (2014) have calculated for Mexico that any possible effect of progressivity due to income taxes is offset in 2012, that is, income tax does not contribute to redistribution in the Mexican case.

[16] We have considered the 15 different places reported in the survey where at least five collect neither VAT nor IEPS. We believe this adjustment leads us to a situation where VAT is not overestimated and then, a more reliable imputation of VAT is preferred. Those places not contributing for indirect taxes are flea markets and street vendors,

The border with the U.S has a special VAT treatment different from the rest of the country, so this has been controlled by applying 11 percent to the expenditures located in all these cities included in the survey and, 10 percent for all the previously surveys used as well. We believe this process does not add taxes beyond the actual paid by taxpayers.[17]

In the case of benefits, the ENIGH survey contains full information about the benefits through the programs: scholarships and cash transfers for education; the *Oportunidades* program; 70 and over provisions (for the elderly without pension); a food assistance program called the *Programa de Apoyo Alimentario* (PAL); transfer for temporary employment; and finally, other assistance programs. At the end, gross income is estimated by just adding the total taxes and federal contributions from wages to the social security system minus pensions and the cash benefits received at the household level.[18]

4.3 Unit of analysis and indicator of wellbeing

There is a consensus on the relevance of using the individual as the main unit of distributive analysis and to ensure an accurate estimation of wellbeing for household members. Hence, the primary step is to assess the wellbeing of individuals and it must be done by adjusting the total household income by family size and composition. The simplest method is to use per capita income, that is, to divide the household income by the household size.

In our case, we use the equivalence scale from CONEVAL (2009) to account for individual wellbeing. The adult equivalent scales are defined as follows: [0-5]=0.7, [6-12]= 0.74, [13-18]= 0.71, and [19-65+]= 0.99. In this sense, we are comparing homogeneous units with regards to their basic needs.[19]

4.4 Composition of population and household wellbeing

A useful method to have a complete picture on the shape of the distribution of wealth is to draw its density function. For this purpose, we have selected three years of surveys in the period (2004, 2008 and 2012), and estimates are carried out using the Gaussian corrected boundary kernel estimator to its density functions. Indeed, the usual kernel estimation will be biased when

purchases outside the country, others known as "loncherías, fondas, torterías" as informal cafeterias, taquerías or street dinning places, canteens or informal bars (*Pulquerías* in spanish), and last but not least, the informal freelance vendors not officially registered according to the survey.

[17]VAT has increased from 11 to 16 percent in the border area of the country due to the new fiscal reform but this applies parting from 2014, so we do not simulate its effects in this research.

[18]There is no clear approach to consider pensions as a benefit component, or at least the share of pensions added by the public sector. In our case, we treat pensions as in the research of Cok, Urban, and Verbic (2013) and Lustig, Pessino, and Scott (2014) by not adding retirement and pensions as a benefit component because of its contributive nature; but by including it in the net income figure.

[19]Note that this equivalence scale is also the national official scale estimated by CONEVAL in Teruel, Rubalcava, and Santana (2005). It can be seen that the group 13-18 has a lower adult equivalence scale than that of 6-12. CONEVAL has followed Deaton (1998) approach in order to apply a flexible functional form using nonlinear regressions and sensibility analysis. They show that the cost of children between 0 and 5 years rises up to 0.77 percent, while that of children from 13 to 18 increases to 74 percent, even less than the cost for the previous group of 6 to 12 with 80 percentage units.

close to the minimum bound. In our data this is explained mainly by the high frequency of the population with low or no market income.

Figure 3: Density curves of gross incomes

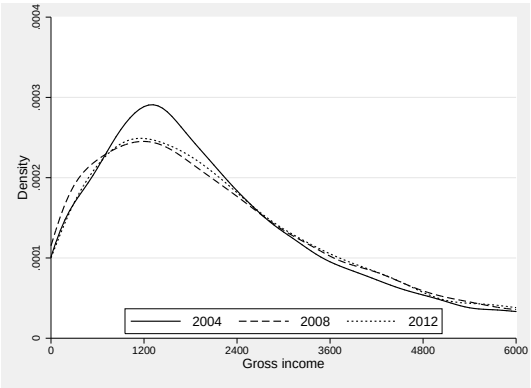
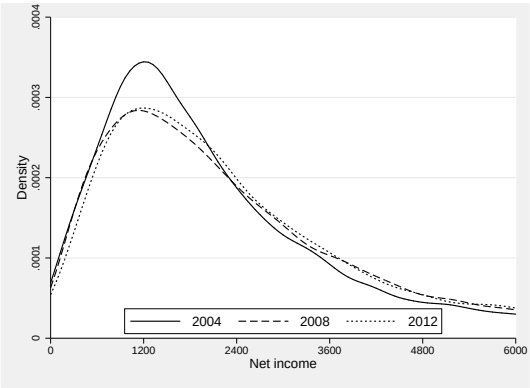


Figure 4: Density curves of net incomes



Source: Authors' calculation using ENIGH data.

In figures (3) and (4), we plot density functions of gross and net income respectively. This first remark concerns the shift of the density curve of net income to the right side between 2004 and 2012. This shift indicates that household wellbeing has increased on average during this period. The other remark concerns the change in shape of the density function of gross income, which flattened over this period. Recall here that inequality is inversely linked to the kurtosis of the distribution.[20] To clarify this better, for flatter density functions, the population size of the poor and rich groups is relatively much greater and the expected disparity in income or inequality is higher as well. Also, for gross income, we observe the shift of the density curve of net income to the right side between the years of 2004 to 2012. However, for the year of 2008, the density curve has moved more to the left, marking the negative impact of the world economic shock of 2007/08.

Now, we shed light on the main factors that can explain the change in average income during the studied period. In figure 5 we start by presenting the trend of some basic macroeconomic indicators. Among the important remarks, we can see the clear negative impact of the world economic shock of 2007/08 on the Mexican real gross domestic product. The inflation rate remained practically constant, but not so for food inflation; also, the unemployment rate registered some increase during the world economic crisis. Note that even in the case of constant returns in endowments (real wage for instance), the change in the composition of the population, expressed by the change in the proportion of the working age population, may influence the variation in average income. The trend of real GDP plotted in figure (5), indicates that substantial economic improvement arrived at the end of the studied period, after following a 7.1 percent decline in production in 2009. However, the trend of active population rate shows some increase in the proportion of active population.

This conclusion is also confirmed in figure (6), where the expected household size for a given level of gross income has decreased over time. An increase in welfare through the change

[20] A high kurtosis distribution has a sharper "peak" and flatter "tails", while a low kurtosis distribution has a more rounded peak with wider "shoulders". See also Araar and Duclos (2007) for more insights related to shapes on distributions.

in the composition of the population, or equivalently, a decrease in the ratio of dependence, may be temporal. The renewal of the active population must be perceived as an inter-generational investment to ensure the availability of the adequate size for the active population in the long term. While the proportion of children in the population was about 45.87 percent in 1960, the later has decreased to about 29 percent in 2012. It may be helpful to look for demographic policies to remedy the need to sustain an adequate active population for the next generations and its impact on fiscal policy.

Figure 5: The trend of Mexican macro-economic indicators

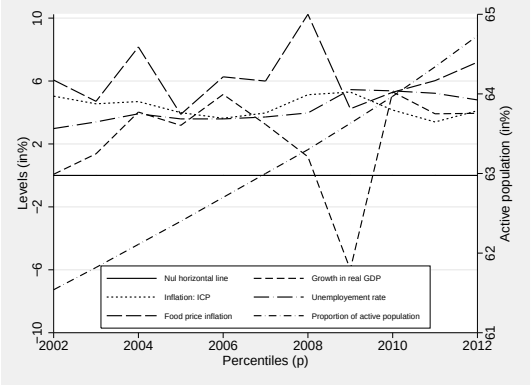
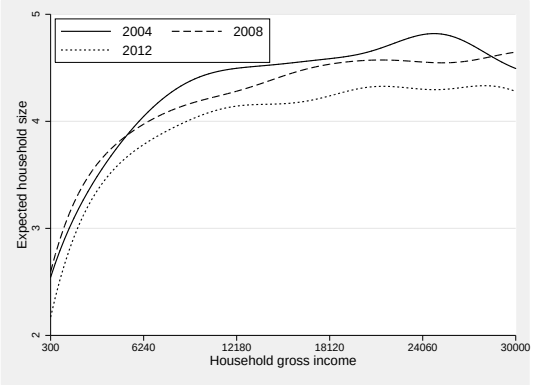


Figure 6: Expected household size according to household gross income



Source: Authors' calculation using ENIGH data.

4.5 The trend of inequality and polarization

As reported in the *Theoretical framework* section, inequality indices are useful to summarize the information about the disparity between personal incomes. In table (3), we present the trend of inequality in gross and net incomes for the period between 2002 and 2012. The following summarizes these results:

- There has been a slight decrease in inequality between 2002 and 2012 for both gross and net incomes. However, this decrease was large just after the world economic shock of 2008. Araar (2012) reports that the inequality in Latin American countries decreased just after the world economic shock of 2007/08. His work describes how the drop in inequality is explained by the large impact on targeted beneficiaries of the program.
- the impact of the fiscal system seems to be linear and depends mainly on the shape of the distribution of gross income. This conclusion is based, in part, on the stable impact of the fiscal system on inequality, but only for each year (not cumulative). This may be attributed to the rigidity of adjustment of the fiscal system over time or to its delay in responding to the punctual economic shocks, and then regain its initial level for the next period. The yearly reduction in the Gini implied by the fiscal system is about 6 percent annually (column 3 of table (3)).
- Over time, there has been a substantial decrease in interregional inequity when we consider those in the northern border zone and the rest of the country.

Table 3: The trend of inequality in Mexico

	Gini index			Between regions inequality		
Year	*Gross income*	*Net income*	*Change in (%)*	*Gross income*	*Net income*	*Change in (%)*
2002	0.559	0.520	-0.070	0.025	0.024	-0.035
2004	0.545	0.508	-0.066	0.025	0.024	-0.028
2006	0.542	0.509	-0.061	0.014	0.014	0.048
2008	0.556	0.522	-0.060	0.018	0.018	-0.044
2010	0.530	0.494	-0.068	0.007	0.008	0.117
2012	0.548	0.513	-0.064	0.015	0.016	0.037

Source: Authors' calculation using ENIGH data

Table 4: The trend of polarization in Mexico

	DER index ($\alpha = 0.75$)			FW index		
Year	*Gross income*	*Net income*	*Change in (%)*	*Gross income*	*Net income*	*Change in (%)*
2002	0.267	0.251	-0.059	0.522	0.463	-0.113
2004	0.258	0.244	-0.055	0.496	0.451	-0.090
2006	0.258	0.247	-0.043	0.490	0.445	-0.090
2008	0.260	0.250	-0.038	0.518	0.474	-0.085
2010	0.247	0.236	-0.047	0.501	0.450	-0.102
2012	0.257	0.248	-0.035	0.505	0.458	-0.094

Source: Authors' calculation using ENIGH data

Now, we focus on the evolution of polarization in Mexico and how governmental interventions, through taxes and transfers, have reduced its level. In table (4), we present the trend of the DER polarization index for gross and net incomes. Polarization in gross incomes has decreased considerably between 2002 and 2012. The registered decrease in polarization of net income was low over time. Using the Foster and Wolfson (1992) bipolarisation index, we basically arrive at the same conclusion. Obviously, the fiscal system has contributed, albeit only slightly, to reducing bipolarisation of net income.

4.6 The evolution of progressivity in the fiscal system

We start our discussion by showing the progression in the effective marginal tax-benefit rates. First, let us recall that, for a given level of gross income, the effective tax rate shows the expected total taxes (direct and indirect) for an additional earned peso.[21] For instance in 2012, those with an equivalent gross income of 3 800 MXN, must pay for an additional earned unit of income a total tax of about 0.13 cents. Figure 7 shows that this effective tax rate has decreased drastically during the last years. This can be potentially explained by a combination of factors such as:

- The increase in informal sector (enabling tax avoidence and regulations);
- Corporate tax evasion and ineffective corporate tax alleviation (as confirmed by Kumler, Verhoogen, and Frias (2013)).

Either way, results tell us about the urgent need to revise the Mexican tax system to enhance its social and distributive efficiencies. In figure 8 we show the effective marginal benefit rate. It can be seen in this figure that the marginal decrease in benefits resulting from an additional earned peso is higher in 2012 than in the other years, especially for the poor. This result requires some clarifications. First, the decrease can be greater if the group receives a high level of benefits. Of course, this was the case for Mexico in 2012. Second, with the presence of an efficient mechanism for targeting the poor, if they start earning more income they will lose assistance through a decrease in benefits. These two combined effects make the effective marginal benefit steeper in 2012. This indirectly informs us about the progressive nature of the distribution of benefits in Mexico, regardless of the real impact on the levels of poverty.

Has the Mexican fiscal system become more progressive in recent years? To respond to this question, we use the local and global measures of progressivity. To test the local progressivity of the fiscal system, we show in figures 9 and 10 the *liability* and the *residual* progression curves.[22] Starting from these results, an improvement in local progressivity of the Mexican fiscal system is confirmed, especially for the poor group.

Now, we present and discuss the global progressivity indices. As reported in table 5, as well as in figures 12 and 13, it can be concluded that the fiscal system was progressive in each of the studied years. The other remark promptly drawn from this event is the apparently small increase in the progressivity of the fiscal system during these years. However, one must be prudent with

[21] These curves are estimated based on the local linear approach. See the Appendix 3 for more information.

[22] Note that all estimates were done using the Stata package DASP (Araar and Duclos (2007)). Local progressivity curves require, inter alias, the use of the non-parametric and the derivative non parametric regressions. For more information, see the Appendix 3 at the end of the paper.

Figure 7: Effective marginal tax rate

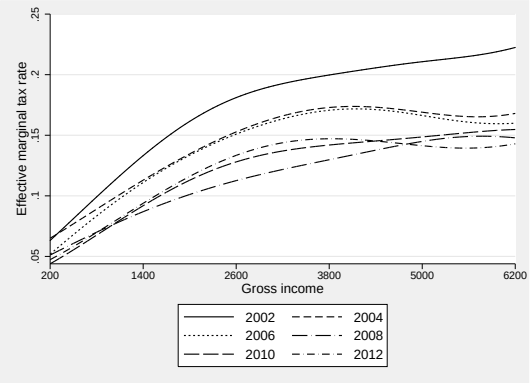
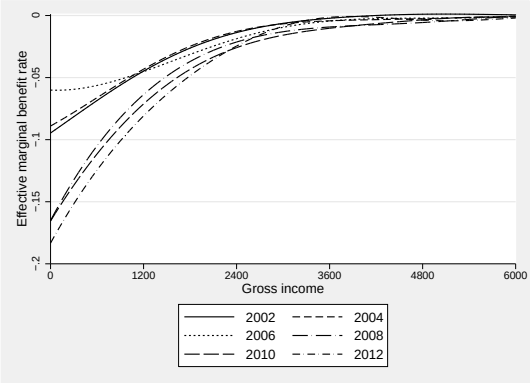


Figure 8: Effective marginal benefit rate



Source: Authors' calculation using ENIGH data.

Figure 9: Liability progression curves

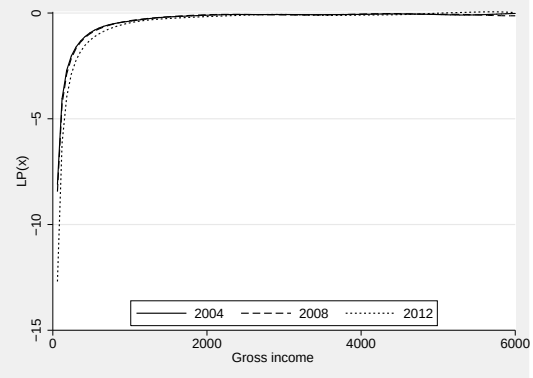
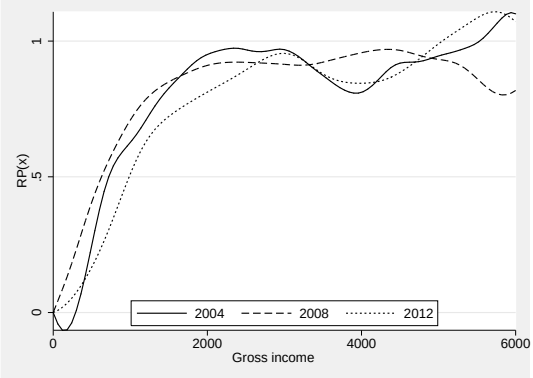


Figure 10: Residual progression curves

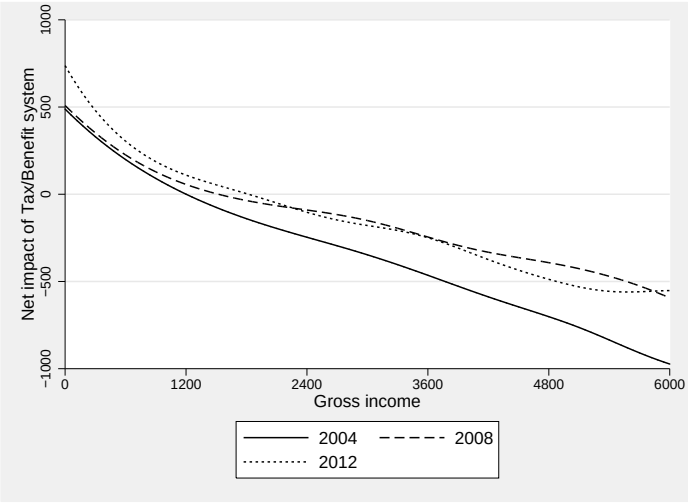


Source: Authors' calculation using ENIGH data.

regards to this conclusion. As indicated in the theoretical framework section, the absence of the common support of comparison of the distribution of gross income across years may mitigate our conclusion. Otherwise, progressivity indices cannot be compared with the change in the distribution of gross income from one year to another.

To remedy this, we use the year of 2012 as the pre-tax income base year (gross income in our case) and then we estimate the expected post-fiscal income (net income) in 2012 if the fiscal system of 2004 or 2008 were applied. To estimate the counterfactual vector of net incomes of 2012, based on the fiscal system of a given precedent year, we use the locally linear non-parametric estimation approach. It follows that, for each value of gross income found in the survey of 2012, we use information on gross and net incomes of the given reference year to estimate the expected net income. Obviously, this procedure does not give us any information about the expected local variability of net income. Fortunately, this local variability does not affect the estimation as much as the progressivity indices. Figure 11 shows the expected net impact for the tax-benefit systems in the years 2004, 2008 and 2012. As it can be seen, while the tax-benefit system of 2012 was relatively pro-poor by benefiting the poorer group by more, the latter was also less efficient at collecting more taxes at the top part of the distribution. However, since the social welfare measurements are more sensitive to the bottom part of the distribution, the impact on the reduction of inequality increases progressivity.

Figure 11: Expected net impact based on Tax/Benefit system of different years



Source: Authors' calculation using ENIGH data.

This is explained mainly by the fact that concentration indices -curves- weight locally the average level of tax or net income according to the rank of the gross income. Results concerning the evolution of the fiscal system's progressivity, with 2012 as the reference year for pre-tax income, are reported in table 6 and figures 14 and 15.

It may be helpful to explain here why we observe that the TR(p) curve becomes negative at the top range of percentiles. Our investigation shows that this is caused by the large benefits of few rich households mainly for the survey of 2004. However, this makes the concentration curve of benefits lower and constant for a large part of the distribution, and consequently, the difference

between the concentration and Lorenz curves becomes negative. Even with the presence of these aberrant values, our strategy was to report the results without changing surveys or dropping observations.[23] Among the most important conclusions, a large increase in the progressivity of the fiscal system is observed between 2002 and 2012. The second finding concerns the reversal in the rank of progressivity by considering the common support of comparison for the year of 2004, and how this effect can be offset when extreme outliers are dropped in the surveys.[24] The other remark is the non-neglected impact of change in the pre-tax income figure on progressivity indices.

Table 5: Evolution of the fiscal system progressivity in Mexico

Year	*TR approach*	*IR approach*
2002	0.0485	0.0586
2004	0.0512	0.0593
2006	0.0453	0.0524
2008	0.0469	0.0507
2010	0.0561	0.0606
2012	0.0564	0.0606

Source: Authors' calculation using ENIGH data

Figure 12: TR progressivity curves

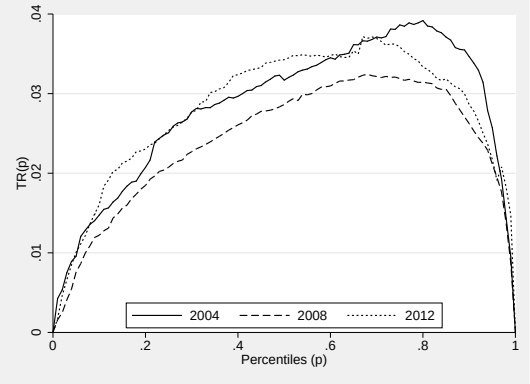
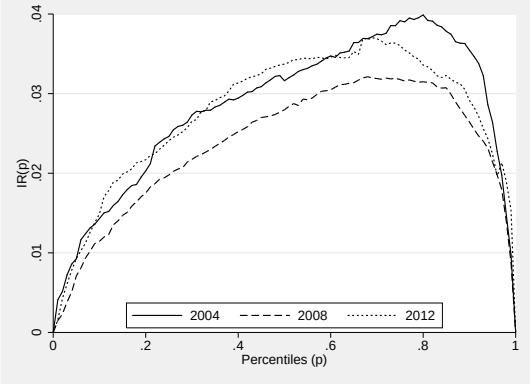


Figure 13: IR progressivity curves



Source: Authors' calculation using ENIGH data.

Our results are comparable to those obtained for Canada in Araar (2008), where the progressivity level of its tax-system declined from 1996 to 2005 with indices of 0.147 and 0.122 respectively. Using the common support of comparison (2005 as the reference year for pre-tax income) the level of progressivity increased slightly, with indices of 0.1152 in 1996 and 0.1222 in 2005 with the TR approach. These results confirm the importance of taking into account this issue and its relevant aspects to consider in fiscal policy design.

[23] For more details, see the Appendix 4.

[24] The first estimation showed that progressivity increased between 2004 and 2012, whereas our second method –with common support of comparison– suggests that progressivity may have decreased between these years.

Table 6: Evolution of the fiscal system progressivity in Mexico

Base pre-tax income year: 2012

	TR approach	*IR approach*
2004	0.0373	0.0422
2008	0.0529	0.0583
2012	0.0564	0.0606

Source: Authors' calculation using ENIGH data

Figure 14: TR progressivity curves

Base pre-tax income year: 2012

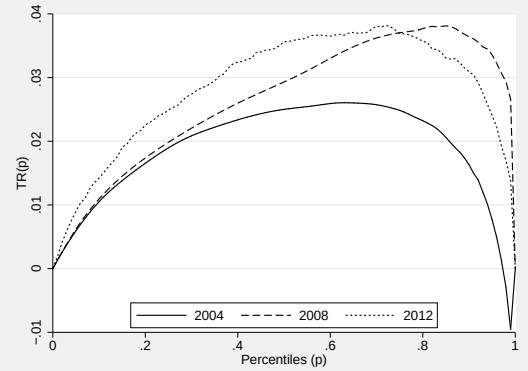
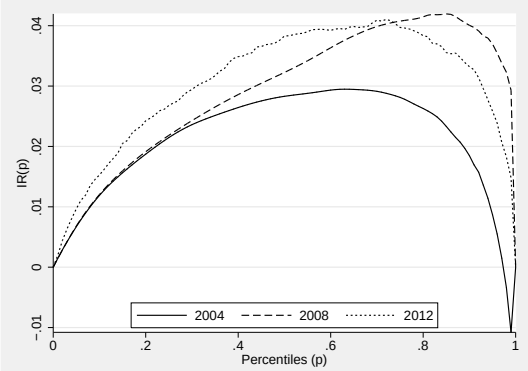


Figure 15: IR progressivity curves

Base pre-tax income year: 2012



Source: Authors' calculation using ENIGH data.

5 Conclusion

This paper focuses on the evolution of the progressivity of the fiscal system in Mexico, as well as the experienced change in inequality and in polarization of pre- and post-fiscal incomes between 2002 and 2012. In addition to the macroeconomic performance criteria, the change experienced in the distribution of wealth must be assessed and analyzed over time. It has been argued that macroeconomic performance may help to increase the overall wellbeing, but it does not guarantee a more equitable distribution of wealth. Over time, there are many factors that can contribute to the reshaping of the distribution of income. In addition to economic growth, other issues like market forces, population endowments and fiscal system measures can have large influences on the distribution of wealth. In Mexico, both the fiscal system and social programs should be crucial tools for more quickly reducing income disparities.

In general, with these governmental interventions, the deprived group of contributors and their families receive a special treatment. Indeed, the government ensures a decent standard of living to the socially excluded group and helps them be reinserted into the economic activity sphere. For instance, the Mexican government is not able to finance programs of re-qualification for workers to join the labor market or cope with unemployment, to provide valuable financial benefits for employers, or to support new incoming entrepreneurs as long as it maintains such a low marginal taxable base.

To assess the evolution of the different distributive phenomena, we used the national representative *ENIGH* surveys and we chose *net equivalent income* as the indicator of wellbeing for

Mexican households. Developed and most updated distributive tools are used to assess and to better understand some links between the studied distributive phenomena. The following items summarize the main conclusions of this study:

- Household wellbeing has registered a significant increase during the last decade. However, the important change in the active population rate can be observed, along with a slight decrease in the dependency ratio, which raises the question of the optimal demographic growth and its links to the fiscal system over time.

- Inequality in gross and net incomes remains high over time, it can be seen that the reduction in the Gini as a result of the fiscal system is about 4 percentage points. More importantly, the follow-up of the evolution in regional inequality enables us to conclude that inter-regional inequality has decreased, yielding insights into the improvement in progressivity of the fiscal system.

- The structure of social classes in Mexico has registered significant change during the last decade as shown by the polarization indices. The decrease in bipolarisation in the distribution of net incomes can be attributed to the pro-poor benefit programs during the last decade.

- It is increasingly important to revise the Mexican tax systems, especially to enhance effectiveness in the collection of taxes. Even if the tax-benefit system of 2012 was relatively pro-poor, the latter was also less efficient in collecting the income tax of those at the top of the income distribution. This deficiency is mainly related to the erosion of the taxes on earned incomes or on corporate profits. Indeed, during the last years, the rapid structural economic transition has accelerated the informality of the economy. In this case, there is a renewed need to turn to the other forms of taxation, and especially, indirect taxation, where we can easily avoid the tax evasion problem.

- The yearly progressivity of the fiscal system was confirmed using two measures. For the comparison of progressivity across time, the main conclusion concerns the non-neglected impact of changes in pre-tax income on progressivity indices. The other is the increase in the progressivity of the fiscal system in 2012 when the same pre-tax income reference year is used for different periods.

Note that conclusions and remarks drawn from this study can help policymakers to undertake the socially optimal fiscal policies. The other contribution of this study is on the development of methods to assess the progressivity of the fiscal system. Our method of distributive analysis carried out considering the Mexican case can be replicated at the regional level. Finally, we want for this research to inspire future works that investigate the impacts of a wide variety of taxes and benefits through time on specific groups of contributors, such as entrepreneurs, self-employed individuals or the poor, in order to improve both the fiscal and social policy agendas of governmental action.

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Appendix 1 : *Proof of the theorem 1*

The liability progression condition of the net benefit ($V(x) = B(x) - T(x)$) can be derived starting from that of the local progressivity at x: $\eta_{V(x)} < 1$. Thus, we can write:

$$\frac{\partial V(x)}{\partial x}\frac{x}{V(x)} = \frac{\partial\left(B(x) - T(x)\right)}{\partial x}\frac{x}{V(x)} < 1. \tag{A.1}$$

After rearranging this condition, we find that:

$$\frac{\partial\left(B(x) - T(x)\right)}{\partial x} - \frac{V(x)}{x} < 0, \tag{A.2}$$

or also:

$$\frac{B(x)}{x}\eta_B(x) - \frac{T(x)}{x}\eta_T(x) - \frac{V(x)}{x} < 0. \tag{A.3}$$

Finally, one can define the Liability progression curve ($LP(x)$), which can be used to test the liability progression at the different levels of income.

$$LP(x) = \frac{B(x)}{x}(\eta_B(x) - 1) - \frac{T(x)}{x}(\eta_T(x) - 1) < 0 \ \ \forall x. \tag{A.4}$$

Appendix 2 : *Proof of the theorem 2*

For an individual i with gross income x_i, we denote the impact of the fiscal system by $z\left(x_i\right)$ such that:

$$z\left(x_i\right) = f_B\left(x_i\right) - f_T\left(x_i\right) + \kappa_i. \tag{B.1}$$

Of course, when the fiscal system is progressive, the impact should decrease with the increase of income (i.e. $z^{'}(x) < \ \forall x$). For a deterministic function of the impact, the random component (κ_i) must be nil. In this case, the local liability progression at x requires that: $f^{'}{}_B\left(x\right) > f^{'}{}_T\left(x\right)$. As is well known, the ultimate objective to make the tax progressive is to reduce the inequality. However, the question is: to what form of inequality we refer? The Atkinson (1970) theorem enables to check for the reduction in inequality measured by a class of indices that obey the basic axiom of inequality: the *Dalton transfer principle*. Precisely, the Atkinson theorem stipulates that if the Lorenz curve of the post fiscal distribution is everywhere above that of the pre-fiscal distribution, then all inequality indices that obey to the *Dalton transfer principle* will decrease. In the case of absence of re-ranking, the concentration curve becomes a helpful tool to test for the progressivity of a tax system. Starting from the Atkinson condition, we can write:

$$L_{N=X-T+B}\left(p\right) - L_X\left(p\right) > 0 \ \ \forall p, \tag{B.2}$$

and where:

$$L_{N=X-T+B}(p) = \frac{\mu_X}{\mu_N} L_X(p) - \frac{\mu_T}{\mu_N} C_T(p) + \frac{\mu_B}{\mu_N} C_B(p). \tag{B.3}$$

Thus, the condition becomes:

$$\frac{\mu_X}{\mu_N}\left(L_X(p) - \frac{\mu_T}{\mu_X} C_T\left(p\right) + \frac{\mu_P}{\mu_X} C_B\left(p\right) - \frac{\mu_N}{\mu_X} L_X(p)\right) > 0 \ \ \forall p. \tag{B.4}$$

Since the ratio $\frac{\mu_X}{\mu_N}$ is assumed to be greater than zero, it cannot affect the sign of the rest and we can drop it. Thus, we find that:

$$\frac{\mu_T - \mu_B}{\mu_X} L_X(p) - \frac{\mu_T}{\mu_X} C_T\left(p\right) + \frac{\mu_P}{\mu_X} C_B\left(p\right) > 0 \ \ \forall p. \tag{B.5}$$

Finally, we find that the condition can be simplified to what follows:

$$\frac{\mu_T}{\mu_X}\left(L_X(p) - C_T(p)\right) + \frac{\mu_B}{\mu_X}\left(C_B(p) - L_X(p)\right) \quad > \quad \forall p. \tag{B.6}$$

Appendix 3 : *Non-parametric regression and the derivative non-parametric regression*

Non-parametric regression is useful to show the link between two variables without specifying beforehand a functional form. It can also be used to estimate the local derivative of the first variable with respect to the second without having to specify the functional form linking them. The local linear approach is based on a local OLS estimation of the following functional form:

$$K_i(x)^{1/2} y_i = \mu(x) K_i(x)^{1/2} + \mu'(x) K_i(x)^{1/2}(x_i - x) + v, \tag{C.1}$$

or, alternatively, of:

$$K_i(x)^{1/2} y_i = \alpha(x)^{1/2} + \beta K_i(x)^{1/2}(x_i - x) + v, \tag{C.2}$$

where

$$K_i(x) = \frac{1}{h\sqrt{2\pi}} \exp\left(-0.5\ \lambda_i(x)^2\right) \quad and \quad \lambda_i(x) = \frac{x - x_i}{h}. \tag{C.3}$$

Estimates are then given by:

$$E\left(y\,|x\right) = \alpha, \tag{C.4}$$

and

$$E\left(\frac{dy}{dx}\,|x\right) = \beta. \tag{C.5}$$

Appendix 4 : *Progressivity with a common support of comparison and without aberrant values*

The following two figures are similar to those of 14 and 15 respectively, but where the aberrant values (benefit $>$20 000) are removed (5 observations in 2004 and 7 observations in 2012).

Figure 1: TR progressivity curves

Base pre-tax income year: 2012

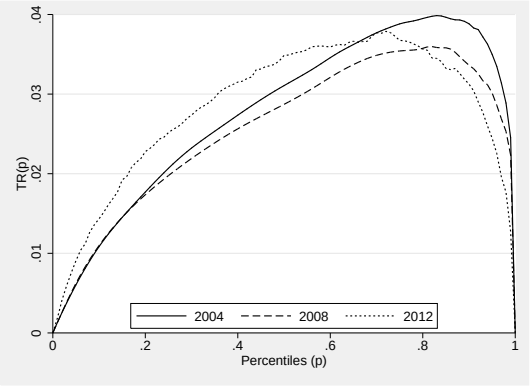
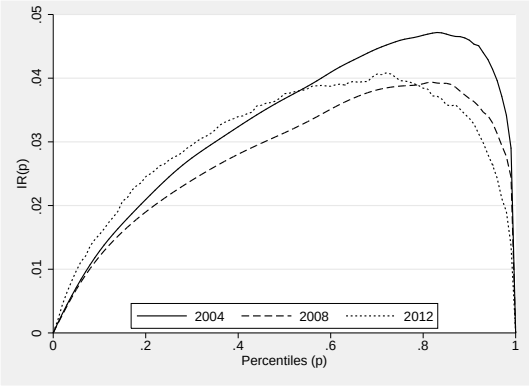


Figure 2: IR progressivity curves

Base pre-tax income year: 2012



Source: Authors' calculation using ENIGH data.