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Measuring poverty

Towards a more realistic estimate of the income distribution in Mexico[1]

Note by National Institute of Statistics, Geography and Informatics of Mexico

Summary

Accurate estimation of income distribution from survey data and other sources has proven difficult. The document presents an approximation of the income distribution for Mexico in 2012 using three data sources: household survey; the System of National Accounts; and tax records. The document also presents derived measures such as Gini coefficients and uses Constrained Maximum Pseudo-likelihood estimation to obtain an income distribution that reconciles all three data sources.

The document is presented to the Conference of European Statisticians' seminar on "Measuring poverty" for discussion.

[1] This document is derived from an ongoing research project. Current results, as well as the opinions and comments of the authors, Alfredo Bustos and Gerardo Leyva, are in a personal capacity and do not necessarily reflect those of INEGI, the institution for which they work.

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I. Introduction

1. Mexico is a country that exhibits important deficiencies and inequalities of all types, but the numerical expressions of these problems have not always been sufficiently precise. In fact, the basic statistical information available has led us with certainty to underestimate inequality and possibly also to overestimate poverty. For example, data from the National Household Income and Expenditure Survey (ENIGH, for its acronym in Spanish) indicate that by 2012 about 44 per cent of households received incomes below the line established by the National Council for the Assessment of Social Development Policy (CONEVAL, for its acronym in Spanish)[2]. At the same time, as published by the National Institute of Statistics and Geography (INEGI), 10 per cent of households with higher incomes perceived "only" 19 times what the 10 per cent with the lowest incomes did. However, the study of the distribution of income by ENIGH is limited mainly by two causes:

(a) Incomes of households in the survey seem to be higher than what they report (what we shall refer to as "underreporting"), so that income poverty seems higher since households whose actual income is higher than the threshold are considered in poverty;

(b) There are households, not included in the ENIGH sample, with incomes much higher than any of those reported (what we call "truncation"). Therefore, inequality is underestimated when ENIGH alone is used since the difference between large and small incomes becomes smaller than it would otherwise be.

2. This document exemplifies the application of a method for the statistical adjustment of models to survey data, which also uses anonymized tax information and national accounts results, and, recognizing the simultaneous presence of the above limitations, improves on the estimation of an income distribution (see Bustos(2015a, b)). The preliminary results show an estimate of nearly 30 per cent[3] of households whose incomes lie below CONEVAL welfare line. This estimate is close to two thirds of what CONEVAL estimated using the uncorrected income reported by the survey. Similarly, a significantly greater quantification of inequality is obtained, with a ratio of revenues of the highest income decile to the lowest of almost 53 times.

3. The discussion of economic inequality between people and households, both in wealth and in income, has recently returned to the centre of the attention of politicians and of academics. The book *Capital in the Twenty-First Century* (Piketty 2015) appears in this context and exemplifies the interest in the topic, by becoming a bestseller in Europe and the

[2] For the sake of consistency with the rest of the document and for illustrative purposes only, this figure was obtained by calculating the poverty incidence from CONEVAL "welfare line", using information from ENIGH and adjusting it to quarters and households. This can lead to differences with the poverty incidence obtained using the Socioeconomic Conditions Module, as CONEVAL does for calculation of multidimensional poverty.

[3] This is the value that results from calculating the intersection between the "welfare line" and the fitted model. Given that the "welfare line" is built based on food and non food expenditures, rather than on income, we don´t need to modify or recalculate its value when we correct the income vector shifting upward the entire distribution. The "welfare line" is calculated by CONEVAL using a version of the Orchansky coefficient in which total expenditure is used instead of total income; which makes the level of the "welfare line" independent of the absolute level of income of the percentile of reference (the one whose observed food expenditure is just enough to comply with the minimum nutritional requirements). Since we have no reason to believe that expenditures, specifically at the level observed at the group of reference, are under-reported, we don´t find any justification to modify the "welfare line".

United States. Other prominent economists such as Joseph Stiglitz (2013, 2015a, 2015b), Paul Krugman (2009) and Tony Atkinson (2015), have argued that uncontrolled inequality is not only a reflection of an unjust economic system, but ultimately is an obstacle to efficiency and economic growth. Authors such as Wilkinson and Pickett go further to point out that the most healthy, happy and functional societies are those where economic inequality is less acute. In our country, the note *Extreme inequality in Mexico: Concentration of economic and political power* (Esquivel 2015), and the work *High income, optimal taxation and possible tax collection* (Campos, et al. 2014), set off a wave of reflections and a renewed focus on inequality in Mexico.

4. The 2030 Agenda for Sustainable Development has as one of its primary objectives to end poverty: The Sustainable Development Goal (SDG) 1 "calls for an end to poverty in all its manifestations by 2030". Nevertheless, there is increasing awareness of the challenges that high inequality imposes on the progress of humanity. This has led to the inclusion of the subject in the SDGs[4] with which the United Nations proposes to lead the development efforts around the world towards 2030.

5. SDG 10 refers to "reducing inequality between countries and within them". The discussion about different forms of inequality played a central role also at the Fifth Global Forum of the Organisation for Economic Co-operation and Development (OECD) on "Statistics, knowledge and policy: Transforming policies, changing lives", held in Guadalajara, Mexico, in 2015[5]. Among other things, it was mentioned that inequality in Latin America remains among the highest in the world, even though traditional statistical tools fail to cover adequately the "mega-rich". In this regard, the High-level Expert Group on the Measurement of Economic Performance and Social Progress (which continues the Stiglitz-Sen-Fitoussi Commission work) has proposed, to work on the integration of microeconomic and macroeconomic sources so that statistics could shed more light on what happens to inequality in countries.[6]

6. Thus, the renewed interest in inequality arises hand in hand with efforts to measure inequalities in the best possible way. However, proper measurement is far less trivial than it seems. The analysis of inequality often resorts to household income surveys or tax records, but both sources have limitations that, to a greater or lesser extent, yield inaccurate figures on the subject. Surveys do not capture well enough the top of an income distribution, and tax records can present an incomplete picture, especially on the lower income groups or those that escape tax control actions.

7. Two problems affect household income surveys, as proposed originally in Cortés (2001) and in Leyva (2004): underreporting and truncation. Consequently, total income estimated by a household survey normally shows a more or less large deficit when compared with other figures of total household income. The other figures may be considered more reliable, such as household income reported by the System of National Accounts (SNA)[7].

[4] https://sustainabledevelopment.un.org/index.php?menu=1300

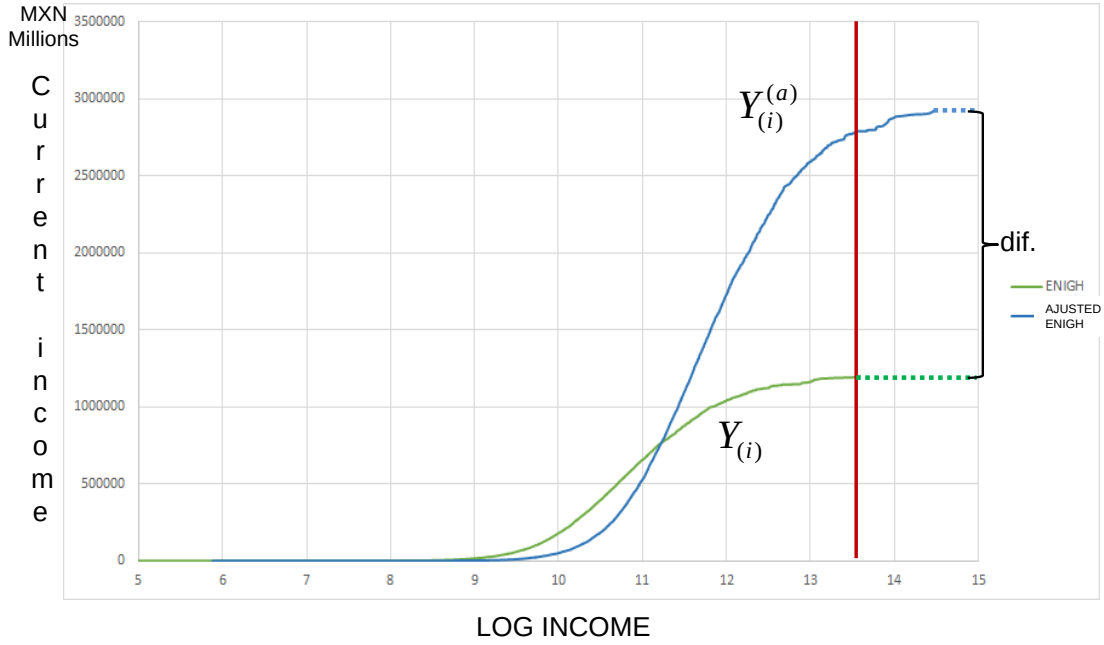
[5] See especially the intervention of Nora Lustig in session 4.a. "Plenary: High Level Dialogue on 'What are the implications of increasing inequality?'", www.oecd-5wf.mx/.

[6] www.oecd.org/statistics/measuring-economic-social-progress/Main%20conclusions%20HLEG%20meeting%20Jan%202014.pdf#2

[7] The "Adjustment to National Accounts" is an extended practice in the measurement of poverty, at least in Latin America, where Altimir's (1987) work, adopted by ECLAC, has perhaps been most influential. In Mexico, such work includes Ifigenia Martínez (1970), Enrique de Alba (1967), Enrique Hernández Laos (1991) and Julio Boltvinik (1999). OECD is currently developing a project to

Figure 1

Accumulated expanded income before and after adjusting to the System of National Accounts figures, 2012



Source: Own from the ENIGH 2012 database. Calculations in this case are the result of multiplying each survey income value by 2.43; i.e., a proportional adjustment to the sample values.

8. In order to correct such deficit, amending or adjusting incomes declared in the survey has become a common practice. Mostly, this is done so that their expanded sum matches the total household income from SNA. That is, since the total household income from SNA is usually higher than the one derived from surveys, the adjustment to accounts involves distributing the difference between households in the sample (see figure 1). The literature suggests many procedures for carrying out this task. All of them, however, are based on more or less arbitrary assumptions. In the Mexican case, the deficit has always been important, so the choice of one method over another becomes of central importance, since it will yield not only a different version of the magnitude of inequality but also of poverty.[8]

9. In the absence of solid and convincing methods for determining which part of the deficit is due to income underreporting, and which to truncation, it has been usual to act as if only one of the causes of the deficit is present. Thus, when it is assumed that truncation does not cause the deficit, the part of the income difference corresponding to the super-rich is distributed among households included in the sample of the survey, artificially increasing the income of this subpopulation. Poverty is easily underestimated when the income of super-rich households not reported in the survey is assumed to correspond to the distribution reported by the survey, including those who would be considered in poverty.

reconcile household income records from surveys and national accounts. Here, the case of Mexico stands out due to the most extreme differences (Fesseau, 2013).

[8] It has already been pointed out that, when it is decided to exclude from the adjustment or reconstruction of the distribution of income to the population with lower incomes, poverty is being overestimated.

10. On the other hand, when truncation is assumed to be the sole cause of the oft-cited deficit, this figure will be distributed only among high-income households (e.g., higher-income 10 or 20 per cent), using some arbitrary allocation rule[9]. This assumption would make inequality appear higher. At the same time, one cannot assume that households at the lower 80 to 90 per cent accurately declared their income in the survey.

II. Our proposal

11. In view of the above, the research area at INEGI initiated a project, still in progress, to propose alternatives for the study of the income distribution in Mexico, using all available information on the subject (surveys, national accounts and tax records). Although our results are still preliminary, we want to open up our proposal for discussion by the community interested in these issues. Publication will help identify shortcomings to overcome, as well as avenues unexplored by us, always with the aim of achieving the most realistic possible statistical representation of the distribution of income in Mexico.

III. Method

12. INEGI decided to follow an alternative path, particularly when focusing only on income distribution. In principle, the decision was not to modify declared income values in the survey but rather to use them as one among other sources to produce a likelier distribution of income.

Figure 2
Outline of the MCPLL criterion and examples of data sources considered

$$\text{Model}: f(y;\underline{\theta}) \Rightarrow \begin{cases} \ell(\underline{\theta};\underline{Y}_{(i)}) = \ln\left(f(\underline{Y}_{(i)};\underline{\theta})\right) \\ h(\underline{\theta}) \end{cases};$$

$$\text{Criterion}: \underset{\underline{\theta},\underline{\lambda}}{Max}\left\{\sum_{i=1}^{n}\frac{1}{\pi_{(i)}}\ell(\underline{\theta};\underline{Y}_{(i)}) - \underline{\lambda}'\left(\underline{h}(\underline{\theta}) - \underline{c}\right)\right\}$$

$$\text{ENIGH}: \begin{cases} Y_{(i)} \\ \pi_{(i)} \end{cases}, i = 1,\ldots,n; \qquad \begin{aligned} &\text{SCN}: c_1 = \text{Total}(\hat{Y}_{SNC}); \\ &\text{SAT}: c_2 = \text{Average}(Y_{Max-k},\ldots,Y_{Max}); \end{aligned}$$

13. Since one of the main concerns is to reduce the arbitrariness of other approaches, a criterion guided the comparison between alternative models fitted to the data so that the best among various tested can be chosen. This criterion includes three conditions: (a) is based on unmodified survey values, (b) takes into account the sampling design as far as this is possible, and (c) makes compatible survey results with figures from the SNA and from the Mexican tax authority (SAT, for its Spanish acronym), in order to bring the results of this exercise closer to "reality". Figure 2 provides an outline of the criterion and exemplifies the sources that can be considered (see Bustos 2015a).

[9] Here, it is important to take into account that if only "income" is adjusted, the relationship between this and other economic variables (consumption, wealth, etc.) will be distorted.

14. On top of the three information sources, the exercise included alternative families of parametric distributional models, thus avoiding the arbitrariness of sticking to one preferred model. The income literature has widely applied these models (see Kleiber et al. 2003). The choice of the family of models determines not only the form assumed by the likelihood but also that of a number of constraints imposed on the parameter values. These constraints allow considering the effect of non-survey data sources on the fitted distribution.

15. The proposed criterion consists of assembling procedures already available but scattered in the literature: (a) maximum log-likelihood, but (b) pseudo-, since it is not possible in general to include all the consequences of the sample design, and (c) parameter values are constrained in order to account for contributions from other sources. Hence the name: Maximum Constrained Pseudo Log-Likelihood (MCPLL).

16. Heterogeneity challenges arose in terms of both observation units (households vs. individuals), and of income concepts between SAT declared income and those covered by the ENIGH and the SNA. Overcoming these challenges allowed reconstructing the Mexican income distribution in a way that is compatible with all the three information sources, for which we know of no precedent. This was achieved by considering known income values of SAT records and SNA as conditions to be met by the parameter values of the MCPLL fitted models.

17. Specifically, SNA information was included by requiring that the value of the mean of each fitted distribution, expressed as a function of the parameters, equals that of the average household income according to SNA (see first row of table 1).

Table 1
Summary of constraints considered

Concept (Source)	*Constraint*	*Interpretation*
Average household income (SNA)	$h_1(\underline{\theta}) = E[Y \mid \underline{\theta}] = c_1$	Mean income for fitted model equals average household income, according to SNA.
Household Integral (SAT)	$h_2(\underline{\theta}) = \int_{\varphi_\alpha}^{\infty} f_Y(y\|\underline{\theta})dy = \alpha = c_2$	Proportion of households whose income is greater than threshold φ_α is, according to the model, equal to similar number from SAT.
Income Integral (SAT)	$h_3(\underline{\theta}) = \frac{1}{\alpha}\int_{\varphi_\alpha}^{\infty} y f_Y(y\|\underline{\theta})dy = M = c_3$	Mean income for households whose income is greater than threshold φ_α is, according to the model, equal to average household income from SAT.

18. Regarding the SAT data, a number of options were considered. Since individual tax returns were available, the initial idea was to add them to the survey records with an expansion weight equal to one. However, the above-mentioned inconsistencies would be exacerbated specially in the region where both data sets join, which made it impossible to

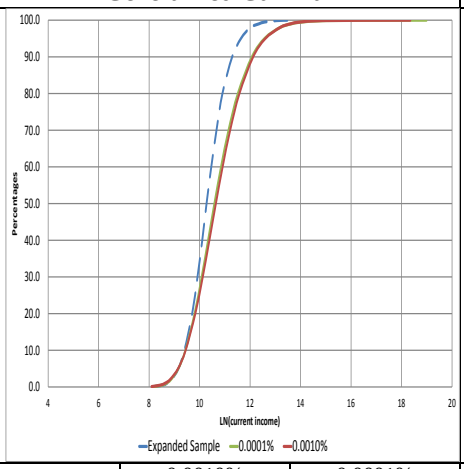
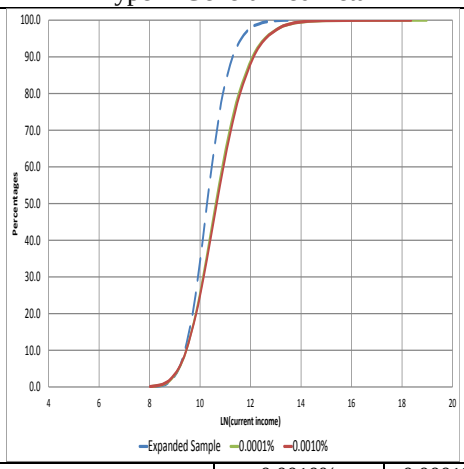
follow this course of action. Given that the main contribution of the SAT data would be to describe the presence of extreme situations at the upper end of the distribution, the decision was to impose additional constraints derived from tax records that are to be satisfied by the parameter values. Note that at very high income levels, the difference between individuals and households becomes blurred, which acts to our benefit. In addition, regarding extraordinarily high incomes, differences between SAT records and INEGI sources in terms of consideration of other sources of income (e.g., imputed housing rent or in-kind transfers) would make little or no difference in our proof of concept.

19. These considerations led to two types of constraints, summarized in rows two and three in table 1. The exercise started by identifying an income threshold, denoted by φ_α, from the SAT records. This value is such that only a small proportion (α) of "households" declares an income greater than the threshold. In the first instance, referred to as the "household integral constraint", the fraction of households in the upper tail of the fitted model (i.e., beyond income threshold φ_α) has to equal α. In the second case, referred to as the "income integral constraint", the (conditional) average income in the upper tail of the fitted model is forced to attain the same value as that of the group of households declaring an income greater than φ_α. Two things are to be stressed in the latter case. First, the proportion of households in the upper tail may be different from α since it is required only that one average equals the other. Finally, the result shows not only that the incomes of a fraction of households lie to the right of our threshold but also that the average of those incomes is more or less distant from the threshold. Therefore, this constraint is more informative than the first. For this reason, our numerical examples in the following section will use this version.

20. Originally, using general numerical optimization routines, five alternative families of distributional models were fitted to survey data according to the above criterion, when only one SNA constraint was considered (Bustos 2015a). Once tax data became available, the number of constraints grew, which lead to dropping all two-parameter families. Therefore, what follows shall only consider the three-parameter Generalized Gamma (GG) and the four-parameter Type II Generalized Beta (GB2) families.

21. In addition, since the relevant statistical theory to distinguish between models fitted to sample data is still under development, other measures on adjustments apply (such as percentiles, ratios and Gini coefficients) to help to assess which model to choose as the "one closest to reality" from among those tested. In other words, although this does not completely do away with arbitrariness, we have achieved a method to overcome limitations of other available methods, to contribute to the discussion and one that yields reasonable results.

Figure 3
Optimal fitted models

Generalized Gamma			Type II Generalized Beta		
					
	0.0010%	0.0001%		0.0010%	0.0001%
OPTIMAL MCPLL VALUE	-365,349,780	-364,628,437	OPTIMAL MCPLL VALUE	-365,541,743	-364,913,147
$E(X\|\theta)$	✓	✓	$E(X\|\theta)$	✓	✓
$E(X\|X > \varphi_\alpha, \theta)$	✓	✓	$E(X\|X > \varphi_\alpha, \theta)$	✓	✓
GINI COEFFICIENT	0.62	0.64	GINI COEFFICIENT	0.61	0.63
RATIO X/I	52.09	54.16	RATIO X/I	51.66	53.20

Source: Own from ENIGH 2012 Database.

IV. Results

22. As has already been mentioned, in addition to data from ENIGH and the SNA for 2012, we worked with anonymized information on almost three million individual tax returns for the same year. All fitted models consider also the threshold established based on SAT information, and which is such that only one in a million households has higher quarterly incomes. The determination of the threshold assumes that each higher-income taxpayer counts as a household; it takes into consideration that the total number of households in the country is about 31.5 million. After a number of trials, this threshold resulted in optimal fitted models, shown in figure 3. All four fitted models appear to be very similar. For instance, the optimal values of the proposed criterion are close to one another and their graphical representations show little difference, except maybe at the bottom and at the top of the income range.

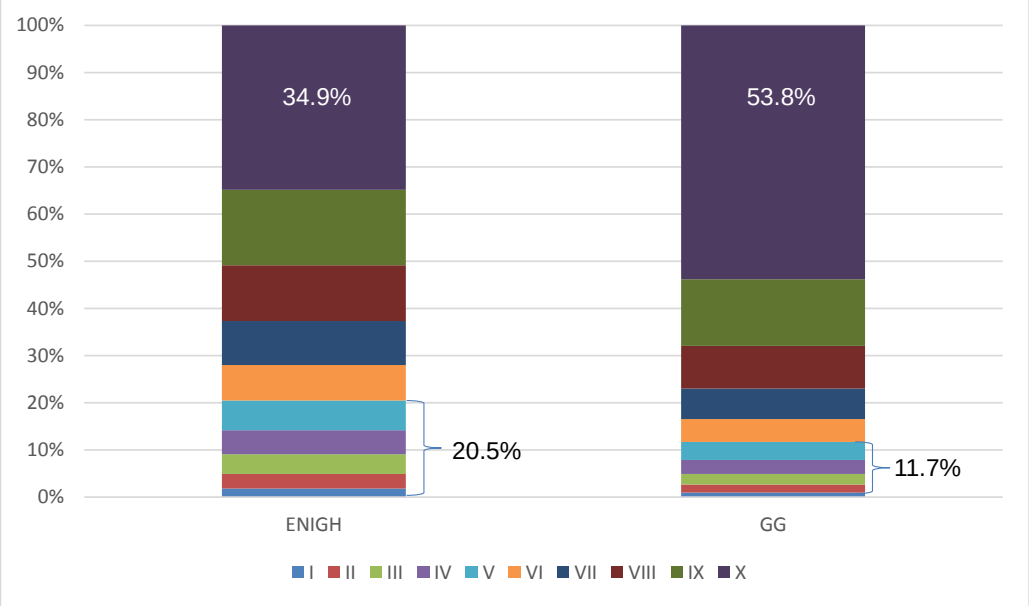
23. Now, accepting the model that optimizes the criterion value (see figure 3), the following conclusions arise:

- There is evidence of significant and growing underreporting over the entire income range in the survey, as expected. There is also an important truncation at the top. Thus, we see underreporting even for lower income households, although the proportion of underreported income to survey income would increase as higher-income households are considered. Consequently, this more realistic estimate of

income distribution in Mexico results in greater inequality but also in a lower monetary poverty.[10]

- The gap between the "haves" and the "have-nots" is larger than that estimated with the traditional source, so that the tenth decile received in 2012 between 52 and 54 times the income obtained by decile 1, against 19 times according to ENIGH reported figures. That figure, however, is below the more than 83 times the estimate by Esquivel (2015) for Oxfam.

Figure 4
Distribution of income over population deciles according to ENIGH and to the optimal model (Generalized Gamma, GG) compatible with national accounts and fiscal data, Mexico, 2012.



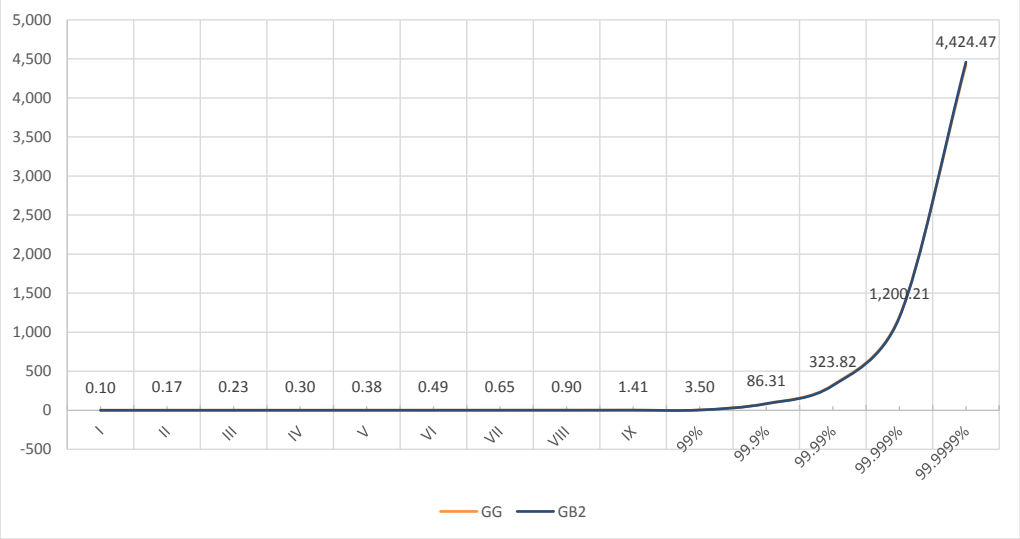
Source: Authors' calculations from the ENIGH 2012 database.

- The richest 1 per cent of households concentrates almost as much income as the bottom 60 per cent. Indeed, deciles I to VI receive 17.2 per cent of total income, while the tenth decile would receive just over 50 per cent, and the highest 1 per cent would receive 17.3 per cent.
- Even within the top one per cent there are important differences. The top 0.1 per cent receives 8.6 per cent of total income; i.e., 86 times its relative size among households. The factor grows to 324 times for the 0.01 per cent; to 1,200 times for the 0.001 per cent, and to 4,424 times for the top 0.0001 per cent, reflecting a significant inequality even within the higher income group of households (see figure 5)[11].

[10] Monetary poverty is mentioned to indicate that this is the relationship between household income and the monetary value of the CONEVAL welfare line, in order to make clear the contrast with the official measurement of poverty in Mexico that is multidimensional, In respect of which we do not report any exercise in this article.
[11] For the sake of clarity, shorter intervals at the top are shown with equal length.

- This inequality is reflected in a Gini coefficient (indicating less inequality as it approaches zero and greater inequality as it gets closer to one) with a value of 0.630, which contrasts with the 0.453 from the original figures of the ENIGH. It should be noted that the former figure would only be internationally comparable if data for other countries were adjusted using the same methodology (MCPLL).

Figure 5
Ratio of relative income to relative size of households. Selected percentiles.

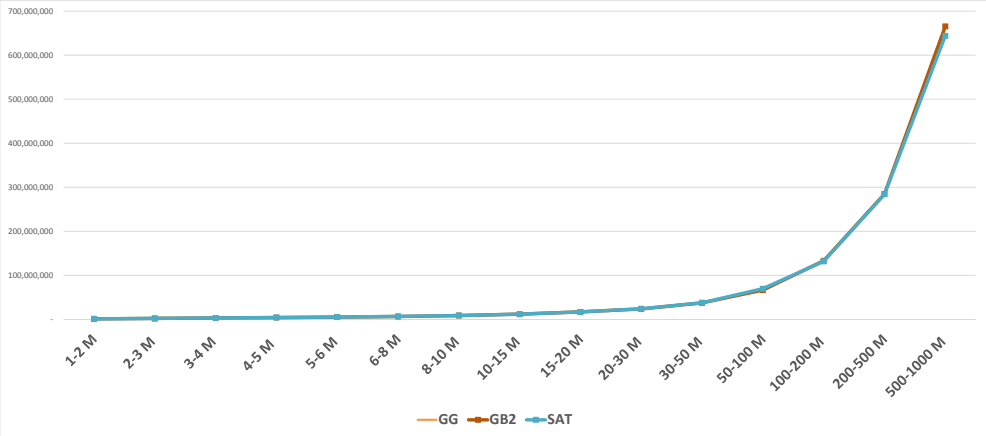


- Using the unmodified CONEVAL welfare lines, the methodology suggests that the incidence of income poverty would reach only 30 per cent of households, smaller than the 44 per cent figure reported by CONEVAL. We recognize that we still have to incorporate additional criteria for a more accurate reconstruction of the lower part of the income distribution; moreover, we have not yet developed a way to link the new distribution with the data gaps (education, food, health, social security, housing and housing services) per household necessary for measuring multidimensional poverty.

V. Comparison with fiscal data

24. In order to assess the accuracy of the model at the top of the distribution, two sets of values were obtained for 15 yearly high-income brackets. The first place included computing the average household income in each of the income brackets from both the best two fitted models, and from the tax records. Results are summarized in figure 6. Over 14 out of 15 brackets all three lines are nearly the same. Only at the very top, for incomes between 500 million and 1000 million Mexican pesos a year, a minor discrepancy is perceptible. The conclusion is that as far as this measure is concerned there is agreement between models and data.

Figure 6
Income average over selected income brackets

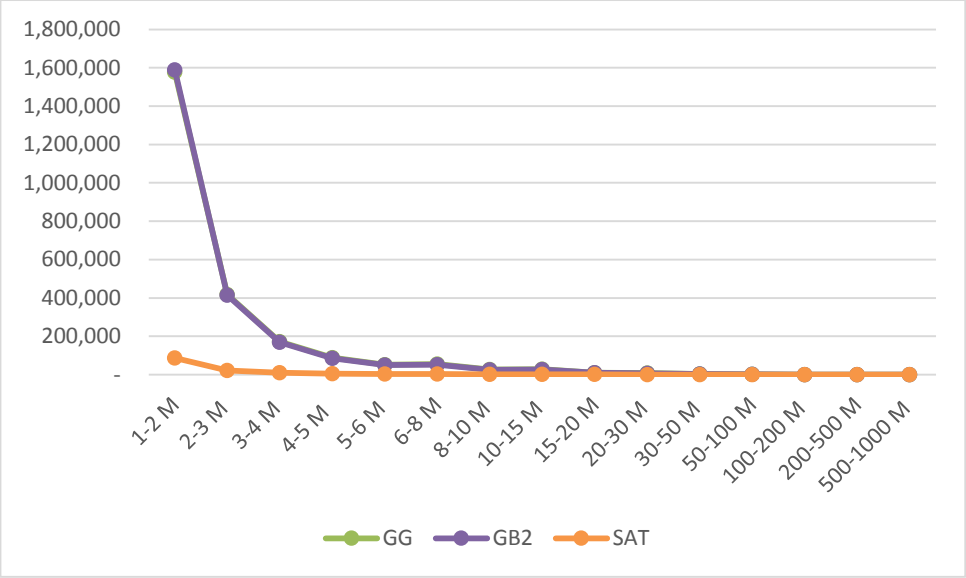


Source: own using ENIGH and SAT 2012 data basis.

25. The second stage focused on computing the number of households within each income bracket, again according to the same three sources. In this instance, an important difference became quickly apparent (see figure 7). For the first bracket, with yearly incomes between 1 and 2 million, the number of households according to the model is close to twenty times that of the tax records. Since tax and model numbers decrease rapidly, the difference between them does the same, as income increases. However, in relative terms the discrepancy is more persistent.

26. Great care has to be exercised when looking at the above results, since they may raise concerns about tax evasion.

Figure 7
Average number of households in selected income brackets



Source: own using ENIGH and SAT 2012 data basis.

VI. Future work

27. To help to understand the implications of these results and give a better idea of how reasonable they are, it is convenient to make international comparisons using the same methodology. To do this, we have approached international agencies to make appropriate comparisons and to get feedback and exchange ideas in order to join efforts in the common interest of better represent reality through statistics. You also need to make comparisons over time for the case of Mexico, which will start soon as we have information from anonymized tax records that this requires. It is also essential to open the debate with national and foreign experts to create synergies that help to understand income distribution better in Mexico, with all its consequences. After all, the role of statistics in society is to describe reality of the most likely way possible.

VII. Final remarks

28. The statistical description of income distribution based on sources like household surveys is subject to limitations such as under-reporting and truncation, which may impair our ability to make realistic assessments about socially relevant phenomena such as inequality and poverty. Most approaches to overcome these limitations depend on the assumption that either truncation or under-reporting can be more or less neglected.

29. In contrast, our approach does not require this kind of assumption, given that it allows data to express itself in such a way that the amounts of truncation and underreporting are a result rather than an assumption. Instead of "adjusting" data from the income survey, the method discussed in this document is to generate a new and more realistic version of income distribution by using Constrained Maximum Pseudo-likelihood (CMPL) to combine different data sources while using an optimality criterion that allows us to select the functional form with the best fit. This is a step forward in the way towards a better statistical representation of the income distribution, bearing in mind that there is still some way to go.

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