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TIPs for the Analysis of Poverty in Mexico, 1992-2005*

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Abstract

This paper proposes some changes to the official methodology that is currently in use to measure the state of poverty in Mexico. Among other suggestions, it is recommended the use of bootstrapping to estimate confidence intervals for the poverty statistics, as well as the use of dominance analysis when making intertemporal comparisons. In particular, since poverty lines change over time, the paper proposes the use of TIP curves for that end. Using the eight surveys that were made during the period 1992-2005, the paper presents a large number of absolute poverty statistics and TIP curves, as well as comparisons among them.

Resumen

Este trabajo propone varios cambios a la metodología oficial que se utiliza actualmente para medir el estado de pobreza en México. Entre otras sugerencias, se recomienda el uso de métodos de remuestreo para estimar los intervalos de confianza de los estadísticos de pobreza, así como el empleo del análisis de dominancia cuando se hacen comparaciones intertemporales. De manera particular, dado que las líneas de pobreza cambian a lo largo del tiempo, se propone para ese fin el uso de las curvas TIP. Usando las ocho encuestas que fueron levantadas durante el periodo 1992-2005, se presentan un gran número de índices de pobreza absoluta y de curvas TIP, así como comparaciones entre sí.

JEL Classification: I32, D63

Keywords: Poverty, confidence intervals, standard error, bootstrap, resampling, FGT measures, TIP curves, dominance, Mexico

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1. Introduction

Given its endemic and enduring character, the issue of poverty in Mexico has always been a matter of concern. In particular, the sharp increase in the poverty rate that was experienced during the second half of the nineties, due to the 1994-1995 economic crisis, lead the newly arrived authorities to allocate, starting in 2001, more resources to quantify the magnitude of the problem. Since at that time there was not a widely accepted methodology to measure poverty in Mexico, the government decided to constitute an ad-hoc committee of experts on the subject. The Comité Técnico para la Medición de la Pobreza (CTMP) was then asked to provide a single methodology that could be employed by the government to produce official poverty statistics. In 2006 that ad-hoc committee was replaced by the legally constituted Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL), which, starting that year, has the mandate of defining, identifying and measuring poverty in Mexico. As will be briefly reviewed later, CTMP and CONEVAL have made substantial advances to that end. Although the official methodology for measuring poverty may be subject to criticisms, some of which will be noted below, the fact that all economic and political actors are willing to take it as a reference certainly helps to articulate better policies to attack poverty.

The main purpose of this paper is to suggest some changes in that official methodology in order to have more robust conclusions on the state of poverty in Mexico. To start with, it is suggested that all poverty measures should be always accompanied with an estimate of their precision. Somewhat surprisingly, it is not until very recently that studies on Mexican poverty have started to incorporate information about the standard errors of their poverty estimates. Bad examples are numerous, including a recent book by the World Bank (2004) in which increases or decreases of poverty estimates are viewed invariably as meaningful, without ever reporting the corresponding standard errors. On the other hand, the very first estimates of poverty incidence in Mexico released by the Consejo Nacional de Evaluación de la Política de Desarrollo Social were already accompanied by their corresponding estimated standard errors (see CONEVAL, 2006).

However, in contrast to the statistical procedure employed by the authorities to estimate the precision of poverty rates, based on a simple Taylor expansion (see CONEVAL, 2007, and CTMP 2005), we suggest in this paper the use of bootstrapping to calculate confidence intervals for the poverty statistics. We also stress here that such a resampling procedure should take into account the statistical design of the income and expenditure surveys on which poverty estimates are generated.

A second suggestion to make more robust the official statistics relates to the aggregate poverty measures to be employed. For reasons of simplicity, both CTMP and CONEVAL decided to report in official documents only headcount ratios. But it is known since Sen (1976) that such an index, although very easy to understand by the public, is fraught with conceptual difficulties. This point is implicitly acknowledged by CTMP (2002) in an appendix to its first methodological document, where the committee recommended a further examination of the data using some of the aggregate poverty measures introduced by Foster, Greer and Thorbecke (1984). In this paper we advocate just the same, and present those poverty statistics for the eight latest income

and expenditure surveys.[1]

Finally, this paper also proposes the use of dominance analysis when making intertemporal comparisons about the state of poverty in Mexico. In particular we advocate the use of TIP curves, as presented by Jenkins and Lambert (1997). Although there are other possible ways to do that analysis, we believe that TIP curves are easier to understand by the general public. The paper presents the curves corresponding to each of the surveys, and also comments on possible poverty dominances over different years. In particular, our analysis casts some doubts about the commonly-held belief that in 2005 the state of poverty in Mexico was less worrisome than the one that prevailed before the 1994 economic crisis.

The content of the paper is as follows: The next section presents information on the surveys that are employed in this paper to calculate the poverty measures, as well as on two important data adjustments that had to be made prior to the computation of the statistics. It also presents the methodology for poverty measurement suggested by CTMP and CONEVAL. Section three presents a detailed description of the bootstrap method, which is then applied to compute robust confidence intervals for several poverty indexes. The results are quite comprehensive, since they cover all the eight income and expenditure surveys mentioned earlier. Furthermore, those results are complemented with separated tables on the extent of poverty in urban and rural areas, which are given (and discussed) in the Appendix. Section four goes one step further and makes a dominance analysis by means of TIP curves. Finally, section five draws the conclusions.

2. Surveys and methodology

The information used to measure poverty in Mexico comes from the ENIGH (Encuesta Nacional de Ingresos y Gastos de los Hogares), a household income and expenditure survey made by INEGI (Instituto Nacional de Estadística, Geografía e Informática) every two years. This paper uses the eight different surveys corresponding to the years 1992, 1994, 1996, 1998, 2000, 2002, 2004 and 2005 (this last year is an exception to the current rule that surveys are taken only in even years). Although the methodology used to make those surveys has changed over the years, the eight most recent ones can be safely compared with each other (except for a minor difference to be mentioned later). Furthermore, those particular years are quite interesting, since during that single span the Mexican economy went through sharp economic downturns and upturns: After coming from a period of stability and relatively low growth rates from 1992 to 1994, the economy suffered at the end of 1994 a financial crisis that sent it to a very deep recession that lasted two years. A strong recovery ensued in the years 1998-2000, partially fueled by the strong performance showed by the US economy in that period. From the year 2001 to 2003, though, the Mexican economy stagnated, and had an even more disappointing record than the US economy. Finally, in the last two years covered by the surveys, 2004-2005, the economy enjoyed a mild but sustained recovery.

[1] At the moment of the writing of this paper, the 2006 survey was not yet publicly available.

Before starting our study, it is important to note that the data reported in the surveys mentioned above were adjusted in two ways: First, we deleted all duplicated income entries that were found in each of the surveys. The first three ENIGHs were free of error in that respect, while the rest had duplicated responses in varying degrees.[2]. It is interesting to note that the same cleaning procedure was followed by the authorities in their document on poverty circulated at the end of 2006 (CONEVAL, 2006). Our second adjustment had to do with the cases of households that reported negative net incomes. For reasons that will be given later on, in those instances the net incomes were changed to zero.

There are two other comments, more technical, that we would like to make regarding the surveys. First, all the ENIGHs were designed to be representative not only at national level, but also at urban (localities with 2,500 inhabitants or more) and rural (i.e., non-urban) levels.

Although the most recent surveys are also representative at other levels, for purposes of comparison our results are only reported on those first three. To give an idea of the relative importance of urban and rural areas, Table 1 provides the percentage of Mexicans living in each of them during the eight years covered in this study.

The second comment to be made is about the sampling design of the ENIGHs. This is an important issue if one wants to make poverty comparisons over the years, since the estimation of standard errors for poverty measures should take into account such a sampling design (see, e.g., Howes and Lanjow, 1998). For that end, in this paper we make use of the information on the corresponding strata and primary sampling units reported by INEGI for each ENIGH.[3]

Regarding the official methodology to measure poverty, as first established by CTMP (2002 and 2005) and later adopted by CONEVAL, we can state its two main elements as follows: First, as is the case in most of the other developing countries, the official poverty statistics are based on absolute poverty lines, while the household welfare is identified with its income. Since we donft want to take issue on those two choices here, we refer the reader to the thoughtful papers by Ruiz-Castillo (2005a,b) in which both of those directives are challenged for the case of Mexico. In particular, Ruiz-Castillo advocates the simultaneous estimation of absolute and relative poverty, while he sides in favor of consumption-based measures.

The other main point is that the official methodology also establishes that the headcount ratio should be used to report poverty incidence, and this according to three different poverty definitions: "food poverty", when income is too low to cover basic food necessities; "capabilities poverty", when income is insufficient to buy basic food, education and health necessities; and "assets poverty", when income is too low to cover basic food, education, health, dressing, housing and public transportation necessities. The reader may consult

[2] The number of duplicated entries for the years 1998, 2000, 2002, 2004 and 2005 were, respectively, 1, 4, 9, 92 and 1. Except for the year 2004, whose duplicated entries accounted for .12% of the total, the errors found in the rest of the years can be regarded as insignificant.

[3] We also follow this institution in disregarding, in the case of the calculation of standard errors, the instances in which there are also secondary, and even tertiary, sampling units.

CTMP (2002) for the way in which the corresponding three poverty lines are derived. Here it suffices to note that by "income" is meant per capita income, since individuals, rather than households, are typically considered in the official statistics.

Table 1
Percentage of Mexicans Living in Urban and Rural Areas

	1992	1994	1996	1998	2000	2002	2004	2005
Urban	59.0	57.8	59.3	59.1	61.1	61.8	62.5	62.9
Rural	41.0	42.2	40.7	40.9	38.9	38.2	37.5	37.1

Source: Own estimates based on the corresponding ENIGHs.

Furthermore, the actual variable that is employed is net income, which is the result of subtracting from total current income all transfers to other households. This is important to keep in mind, since, as shown by Sandoval and Urzúa (2007), in all the ENIGHs that are examined in this paper there are some households that actually report negative net incomes, a fact that may have in turn some consequences. In such a case, that paper shows that if the poverty measures go beyond a mere headcount they could behave in rather anomalous ways. Thus, it is important to decide from the onset what to do with the negative net incomes. As pointed out earlier, in our exercise we decided to set them equal to zero. Although Sandoval and Urzúa (2007) suggest other ways to deal with that problem, by setting them equal to zero we continue to get the same official poverty incidence statistics while avoiding anomalous behaviors.

Regarding the poverty indices to be computed in this paper, we will use particular members of the following FGT class introduced by Foster, Greer and Thorbecke (1984):

$$P_\alpha(z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^\alpha, \quad \alpha \geq 0, \tag{1}$$

where q is the number of poor people in a population of size n, and where the $i-$th member has an income y_i which is less or equal than the poverty line z. The headcount ratio used by CTMP and CONEVAL is obtained when $\alpha = 0$, which gives poverty incidence (the proportion of the population whose welfare falls below the poverty line). On the other hand, the relative povertygap measure is found when $\alpha = 1$:

$$P_1(z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right),$$

This index measures poverty intensity, the shortfall in the welfare of the poor relative to the poverty line. Finally, the squared poverty-gap index is obtained when $\alpha = 2$:

$$P_2(z) = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^2,$$

which, by giving more weight to the poorest individuals, provides a measure of the severity of poverty. It may be noted that if one were to accept Sen's (1976) monotonicity and transfer axioms, of the three indexes considered here it is only the squared poverty-gap which would be considered to be a *bona fide* poverty measure.

3. Testing for changes in poverty

As noted in the introduction, one of the purposes of this paper is to calculate confidence intervals for the FGT poverty statistics in the case of Mexico. An approach that might be used for that end is to apply the delta method (which boils down to a simple Taylor expansion). This is in fact the procedure suggested by CTMP (2005) and CONEVAL (2007), and which is illustrated in the study of poverty incidence in Mexico during the years 1992-2005 made by CONEVAL (2006).

Assuming that a poverty line is fixed, it is easy to find the asymptotic sampling variances when the estimators are means of simple functions of random variables. In fact, Kakwani (1993) has presented explicitly the approximate sampling variance for the class of FGT poverty indices given in (1); namely,

$$\text{var}(P_\alpha) \approx \frac{P_{2\alpha} - P_\alpha^2}{n}.$$

Note that, as we stressed earlier, that type of approximation cannot be applied directly, since it presumes that the survey was taken using a simple design. However, after making use of the fact that the FGT measures are additively decomposable, Jolliffe and Semykina (2000) show how to include the possibility of a complex design that includes stratification and clustering.[4] A methodological note that is broadly similar is also made by CTMP (2005).

It is worth noting, however, that the Taylor approximation given above is derived assuming an asymptotic normal distribution for the estimators, which is obviously incorrect in the case of poverty measures. This is so because those indexes oscillate between 0 and 1 (0% and 100%). As a consequence, if one uses a normal approximation for the confidence intervals, these could end up containing values less than zero or greater than one (see, e.g., Sandoval and Urzua, 2007, for an example with real data). Furthermore, a normal approximation would lead to symmetric confidence intervals, which seems unwarranted on a priori grounds.

But then, how can one construct more robust confidence intervals for poverty statistics? The answer is well known: By using resampling methods, the most versatile of which is Efron's bootstrap. Even though since the mid-eighties there have been numerous applications of bootstrapping in Economics, it is interesting to note that it took some time for this simulation procedure to be recognized as a valuable tool among researchers interested on poverty and income distribution. To our knowledge, it was Deaton (1997) who first used it in the context of poverty, while Mills and Zandvakili (1997) were the pioneers in the case of inequality measurement.

[4] Those authors have actually written a *STATA* program, whose command name is *sepov*, that accomplishes automatically that task.

The idea of bootstrapping is simple. Given a dataset, such as the one coming from an income and expenditure survey, one creates a large number of independent bootstrap samples (in our case "bootstrap surveys") by sampling *with replacement* from the dataset. One then computes the statistic of interest for each of those samples, and estimates the standard error of the original statistic by the empirical standard deviation of those replications.

To be more precise, and following the presentation in Efron and Tibshiriani (1993), if n is the sample size, then the bootstrap algorithm for the (nonparametric) estimation of the standard error of the FGT statistic P_α can be described as follows: First, select B independent bootstrap samples, each with size n and drawn with replacement. In our case B was selected to be equal to 500.[5] The second step involves the computation of the poverty measure for each bootstrap sample: $\hat{P}_\alpha(b)$, $b = 1, 2, \ldots, B$. The last step involves the estimation of the standard error of the original poverty statistic using the standard deviation of the B replications given by:

$$\left\{ \sum_{b=1}^{B} \left[P_\alpha(b) - \bar{P} \right]^2 / (B-1) \right\}^{1/2}, \quad \text{where} \quad \bar{P}_\alpha = \sum_{b=1}^{B} P_\alpha(b)/B.$$

In the case of the estimation of confidence intervals for the poverty measures, which is important in the case of this paper, there are several procedures available. We choose here to work with Efron's bias-corrected and accelerated ($\mathrm{BC_a}$) method, which is more time demanding than most of the others, but it is also one of the best. Since the formulae required to present the method is a little bit cumbersome we refer the reader to Efron and Tibshiriani (1993, chap. 14) for the details. Finally, there is an important reminder to be made before presenting the empirical results: The bootstrapping computation of the confidence intervals has to take into account the complex design of the ENIGHs.[6]

Table 2 presents the values of the FGT poverty indices and their confidence intervals thus obtained. The estimates are given for eight different years, as well as for the three official definitions of poverty. As noted there, the figures correspond to the population at large (individuals, not households), and also to the national level. To complement this last case, tables A1 and A2 in the Appendix present the FGT indices for the case of urban and rural Mexico.

Before making intertemporal comparisons, it is worth commenting about how our results compare to the ones calculated by the government. Since the current methodology dictates that only the head-count ratio (poverty incidence) be reported, the official documents typically present just the point

[5] Efron and Tibshiriani (1993) suggest that in the case of standard error estimation an upper bound that works well is 250 replications. However, since the interest in this paper is on robust confidence intervals, that lead us to choose 500 replications for all cases.

[6] This is not a difficult task to accomplish in most statistical packages. For instance, in STATA one has to declare first the survey design using the command *svyset*, and then use the command *bootstrap* leaving the "size" option unspecified (in such a way that the bootstrap samples are in agreement with the total number of clusters in each stratum). The $\mathrm{BC_a}$ confidence intervals are also available in that package.

estimates of P_0 for the three definitions and poverty, classified by levels (national, urban and rural). Those estimates are also typically accompanied by graphs similar to our Figure 1 below, although the authorities donft plot, or report, the corresponding confidence intervals. How do our point estimates of poverty incidence compare to the latest estimates reported by CONEVAL (2006)? They are exactly the same in the years 2000, 2002, 2004 and 2005.[7]

Table 2
FGT Poverty Indices for Mexico, 1992-2005
(Population at large, national level)

Year	$P(0)$	[95%Conf.Int.]	$P(1)$	[95%Conf.Int.]	$P(2)$	[95%Conf.Int.]
Food Poverty						
1992	22.4%	19.4% 25.7%	7.5%	6.1% 8.8%	3.5%	2.9% 4.2%
1994	21.3%	19.0% 23.6%	7.2%	6.2% 8.1%	3.3%	2.9% 3.8%
1996	36.9%	36.1% 38.4%	13.8%	13.3% 14.4%	7.0%	6.6% 7.5%
1998	34.3%	33.0% 35.6%	13.5%	12.9% 14.2%	7.2%	6.7% 7.6%
2000	24.1%	22.7% 25.7%	8.4%	7.9% 9.1%	4.1%	3.9% 4.8%
2002	20.0%	19.0% 21.4%	6.2%	5.8% 6.6%	2.8%	2.7% 3.8%
2004	17.4%	16.4% 18.4%	5.8%	5.6% 6.5%	3.0%	2.5% 3.4%
2005	18.2%	17.2% 19.0%	6.1%	5.9% 6.7%	3.0%	2.3% 3.7%
Capabilities Poverty						
1992	30.7%	27.4% 34.1%	10.7%	9.3% 12.2%	5.2%	4.3% 6.1%
1994	30.1%	27.0% 32.6%	10.2%	9.2% 11.7%	4.9%	4.3% 5.6%
1996	46.1%	45.1% 47.4%	18.5%	17.9% 19.4%	9.8%	9.5% 10.3%
1998	42.6%	41.4% 43.9%	17.7%	17.0% 18.4%	9.7%	9.2% 10.3%
2000	31.8%	30.3% 33.2%	11.6%	11.1% 12.4%	5.9%	5.7% 6.7%
2002	26.9%	25.7% 28.1%	9.1%	8.6% 9.6%	4.3%	4.1% 5.1%
2004	24.7%	23.7% 25.8%	8.4%	8.1% 9.1%	4.2%	3.7% 4.8%
2005	24.7%	23.7% 25.7%	8.7%	8.3% 9.2%	4.4%	3.5% 5.2%
Assets Poverty						
1992	54.0%	50.8% 57.3%	22.5%	20.3% 24.6%	12.3%	10.9% 13.7%
1994	52.7%	49.5% 55.4%	21.8%	20.1% 23.5%	11.8%	10.9% 13.1%
1996	68.7%	67.7% 70.0%	33.2%	32.7% 34.1%	20.0%	19.5% 20.7%
1998	64.5%	63.3% 65.9%	31.4%	30.5% 32.4%	19.1%	18.6% 19.9%
2000	53.6%	51.9% 55.2%	23.3%	22.4% 24.2%	13.1%	12.5% 13.9%
2002	50.0%	48.7% 51.2%	20.0%	19.4% 20.8%	10.6%	10.3% 11.2%
2004	47.2%	45.4% 48.4%	18.6%	18.1% 19.4%	10.0%	9.2% 10.8%
2005	47.0%	45.9% 48.1%	19.0%	18.4% 19.6%	10.2%	8.8% 11.6%

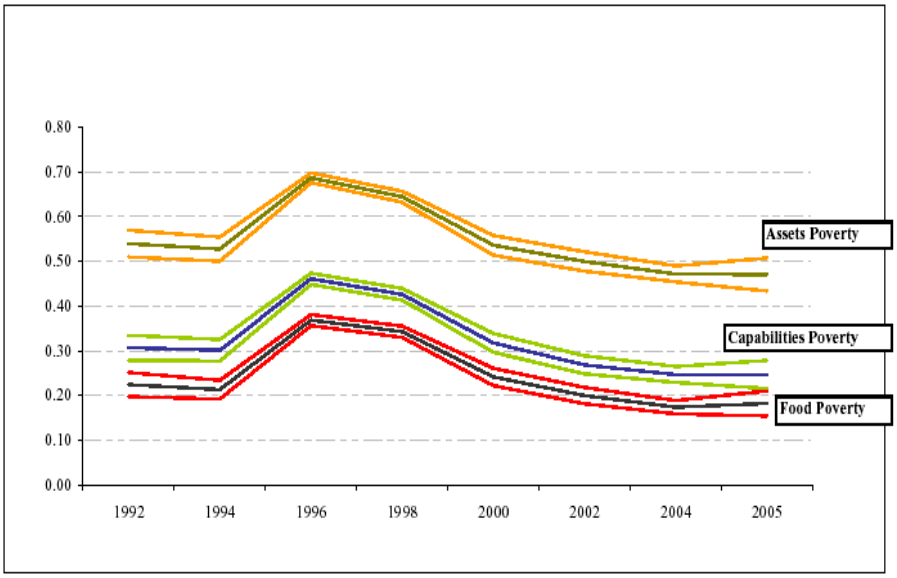
Source: Own estimates based on the corresponding ENIGHs.

[7] The results obtained by CONEVAL and us are in turn, for the years 2000, 2002 and 2004, slightly different from the ones reported earlier in other official and academic documents. The reason is that the expansion factors for those ENIGHs were revised by INEGI in 2006.

They are also the same for the year 1994. In the case of the years 1992 and 1996, there are very small differences probably due to rounding errors.[8] In the year 1998, however, CONEVAL's estimates for the three types of poverty are about 0.5% below ours, since that institution reports 33.9%, 42.3% and 64%, respectively. Given that there was only one duplicated entry in the ENIGH of that year (remember the discussion in Section 2), it is difficult to give a reason for those discrepancies, except for typographical errors or programming mistakes.

Figure 1

Poverty Incidence in Mexico for the Population at Large, 1992-2005



Source: Own estimates based on the corresponding ENIGHs.

As opposed to CONEVAL (2006), Table 2 also reports the 95% confidence intervals for poverty incidence, as well as estimates for poverty intensity (P_1) and poverty severity (P_2), and their respective 95% confidence intervals. Thus, we can draw more robust conclusions on the intertemporal changes in the state of poverty in Mexico. To give an important example: There was a fierce discussion when the government announced that poverty incidence had dropped significantly from 2000 to 2002, since during that period the economy suffered a recession. Regardless of the factors that could explain that finding (on those see Cortés, 2005), Table 2 provides strong evidence in its favor. For all the three definitions of poverty, that table shows that from 2000 to 2002 there was a significant drop in the incidence, the intensity and the severity of poverty in

[8] The differences arise in the case of the estimates for capabilities poverty and assets poverty, for which CONEVAL (2006) reports 30.6% and 53.9% in 1992 (0.1% below ours), and 46.2% and 68.8% in 1996 (0.1% above ours).

Mexico.[9] We know that not because of the large decreases in P_0, P_1 and P_2 *per se* (from 24.1% to 20%, 8.4% to 6.2% and 4.1% to 2.8%, in the case of food poverty), but because those drops are statistically significant. How can we assure that? Because the 95% confidence intervals do *not* overlap in any of the nine cases (since there are three indices and three poverty definitions). It is interesting to note that, as discussed in the Appendix, those results at the national level are mostly explained by the even more substantial (and statistically significant) drops of the poverty indices in the case of the rural sector.

Returning to the big picture, among the most noticeable conclusions that can be drawn from the table, we can single out three: First, after the economic crisis that erupted at the end of 1994, the state of poverty in Mexico deteriorated very sharply. This can be seen by comparing the figures in Table 2 for 1994 (the corresponding ENIGH was made several months before the beginning of the crisis) with the ones for 1996-1998. Second, as noted earlier, poverty conditions improved significantly from 2000 to 2004. And third, even though the government decided to make, for electoral reasons, an untypical ENIGH in the year 2005, poverty conditions in that year did not turn out to have improved over the ones prevailing in 2004.

We leave at the end the most polemical question to be answered: whether or not the state of food poverty in Mexico that prevailed in 1994, right before the crisis, was definitely worse than the current conditions, as represented by the 2004 indices (which are better, in terms of simple point estimates, than the 2005 indices). According to Table 2, poverty incidence and poverty intensity did decrease from 1994 to 2004, but that was not the case for poverty severity.[10] Thus, the answer to that question is negative. This finding will be corroborated at the end of the next section using TIP curves, a subject to which we turn next.

4. TIP curves

Since all the comparisons made in the last section depend on particular indices, a natural question to ask is if by using other poverty measures we would end up with the same rankings as the ones obtained before. There is an important literature that tries to establish criteria for unambiguous poverty rankings, the general framework to which that question belongs. Although there are several possible ways to face that problem (e.g., through the use of generalized Lorenz curves), we believe that the methodology introduced by Jenkins and Lambert (1997) is, aside from being visually appealing, the easiest to understand by the general public. Furthermore, their particular procedure is well suited to study the dominance across distributions when the poverty lines change over time, which is our main interest here. What Jenkins and Lambert propose is the use of a "Three 'I's of Poverty" (TIP) curve to represent three dimensions of

[9] That claim may be also substantiated using the dominance analysis presented in the next section.

[10] This is so because the two confidence intervals corresponding to P_2 overlap. Even though the overlapping region is quite small, it can be shown, following a similar procedure than the one that is mentioned in the Appendix, that we cannot reject at the 5% level the null hypothesis of the same poverty severity in both years.

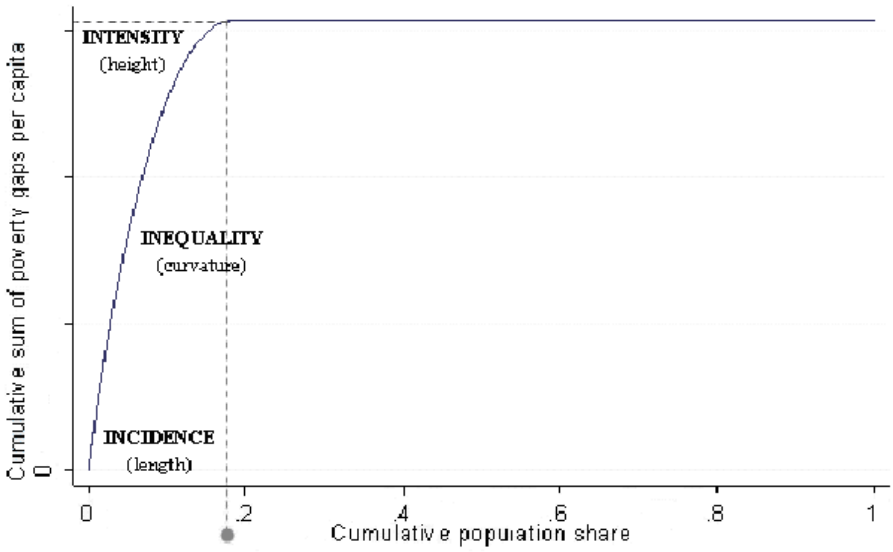
poverty: incidence, intensity and inequality.[11] Once the TIP curves are drawn for all the periods of interest, one proceeds to order those graphs that do not intersect. That ordering corresponds in turn to an unambiguous poverty ranking according to a large class of poverty measures.

Before defining the TIP curve, it is necessary to present some notation. As before, let z denote a given poverty line, and y_i be the income of the $i-$th member of a population of size n. After arranging the (positive) incomes in ascending order, $y_1 \leq y_2 \leq \ldots \leq y_n$ define the relative poverty gaps as

$$\Gamma(y; z) = \max\{(z - y_i)/z, 0\}$$

(the analysis might be also made in terms of absolute gaps, but we focus here on normalized gaps since those are the ones used in the FGT poverty indices calculated earlier). The TIP curve is now constructed by cumulating those relative poverty gaps and graphing them.

Figure 2
The TIP Curve and It's Three I's



Source: Own estimates based on the corresponding ENIGHs.

Figure 2 presents an example (with a shape similar to the Mexican case). As is illustrated there, poverty incidence is given by the length of the line that

[11] Those curves may be named "TIP" in Spanish as well, since they represent the following tres I's: *incidencia, intensidad e inequidad*. Note that "inequality" is usually translated in Spanish as *"desigualdad"*, a word that does not start with an "i". But in Mexico, and some other Latin American countries, "*inequidad*" is an equivalent term. In any case, the Spanish-speaking readers that dislike neologisms may use instead the word "*iniquidad*".

goes from the origin to the intersection of the dotted line and the horizontal axis. This is so because the poverty headcount ratio is found precisely where the TIP curve totally flattens out. Poverty intensity, on the other hand, can be represented by the height of the curve, since the average normalized poverty gap is given by the slope of the ray that goes from the origin to the point at which the curve becomes horizontal. Finally, the curvature of the graph summarizes poverty inequality. In the limit, if all individuals were identically poor, the curve would be just a straight line, while if there were no poor people, the curve would be parallel to the horizontal axis.

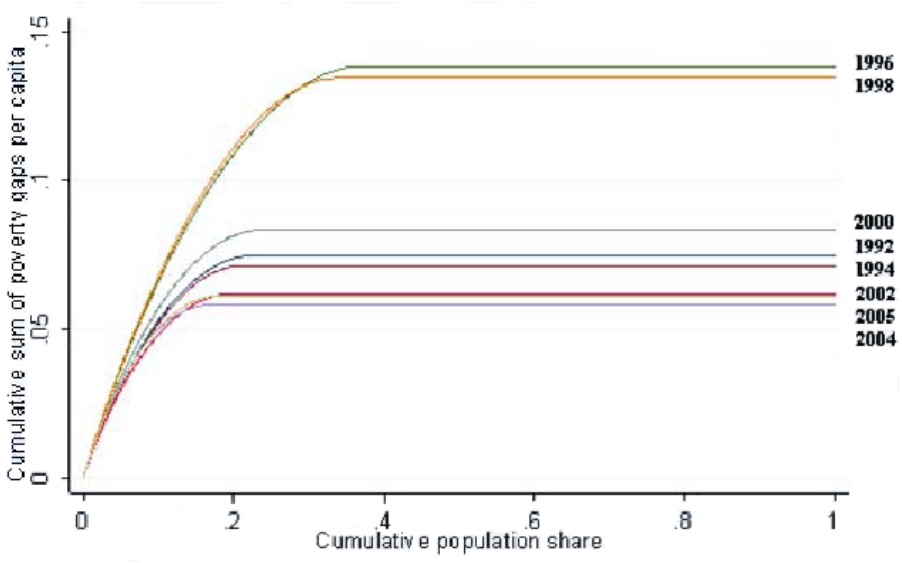
Now suppose that there are two TIP curves derived from normalized poverty gap distributions $\Gamma(y; z_y)$ and $\Gamma(x; z_x)$, each coming from, say, a different ENIGH. It is said that $\Gamma(x; z_x)$ dominates $\Gamma(y; z_y)$ if its TIP curve lies wholly above the other curve. As shown by Jenkins and Lambert (1998), if there is such a TIP dominance, then for a broad class of poverty indices it has to be the case that each poverty measurement would be worse for $\Gamma(x; z_x)$ than for $\Gamma(y; z_y)$; that is, there would be an unambiguous poverty ordering. But, the reader may now ask, how large is that class of indices? Broad enough, since not only includes the FGT aggregate measures, but also many others, such as Pyatt's, Shorrocks's and Watts's (see Table 1 in Jenkins and Lambert, 1997).

Returning to the examination of the state of poverty in Mexico, Figure 3 graphs the TIP curves corresponding to the eight ENIGHs under study. To avoid the use of too many graphs, we restrict our attention to food poverty among the population at large, although similar results would be obtained by using other poverty definitions, or by distinguishing among urban and rural Mexico.

Focusing now on Figure 3, note that the graphs corresponding to 2002 and 2005 are basically undistinguishable at their maximum height, since poverty intensity was very similar in those two years (6.2% and 6.1%, according to Table 2). Note also that even though the 1996 and 1998 TIP curves do not dominate each other, they certainly do over the rest. Thus, the poverty conditions in 1996-1998 were considerably worse than the ones prevailing before the economic crisis, as represented by the 1992-1994 TIP curves, and also worse than the poverty conditions that took place after the end of that crisis, as given by the 2000-2005 TIP curves.

The reader may draw other conclusions from Figure 3 (and may also compare them with the conclusions drawn before). Here we just want to try to verify the answer given to the important question that was put at the end of Section 3; namely, was the state of food poverty in 1994 worse than the one that prevails today, using the 2004 ENIGH as representative of the current conditions? For that end, Figure 4 presents the 1994 and 2004 TIP curves alone. It is evident from there that the 1994 TIP curve does not dominate the 2004 one, since in the lowest percentiles the dominance is actually reversed. This finding corroborates our claim in the last section that the state of (food) poverty in 1994 was not definitely worse than in 2004.

Figure 3
TIPs Curves for Mexico, 1992-2005
(Food poverty, population at large)



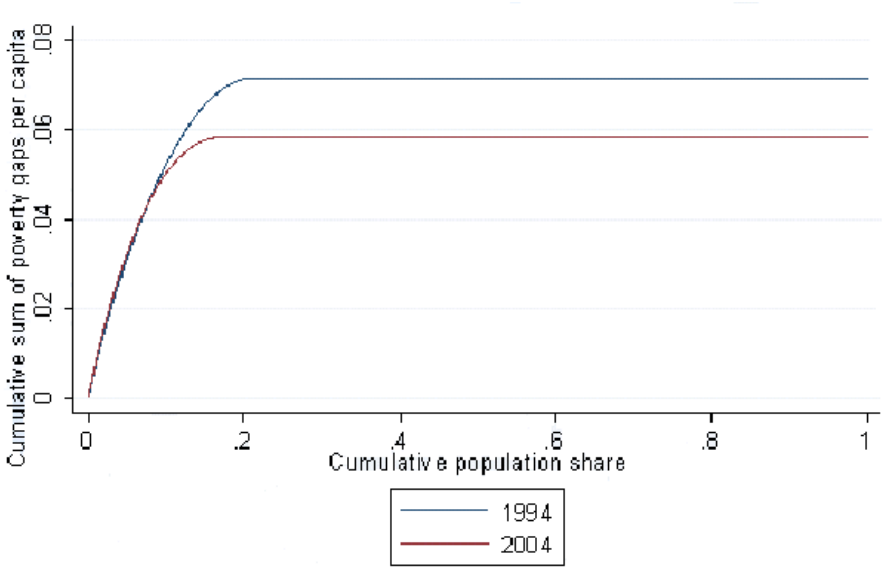
Source: Own estimates based on the corresponding ENIGHs.

But we can go one step further in the comparison. It can be checked that it is in between the fourth and the fifth percentile of the lowest segment where the 2004 TIP curve starts to dominate the 1994 TIP curve. At first sight that evidence would seem to suggest that the living conditions of the poorest among the poor, about a half million people, might have worsened since the 1994 economic crisis. However, is that claim statistically sound? We have to make a further analysis, since the comparison of the two TIP curves given above is just a geometric exercise.

One way to proceed at this point is to use, for instance, the statistical procedure developed by Davidson and Duclos (2000) to make inferences about the stochastic dominance of one curve over the other.[12] But we propose here a different statistical procedure, more akin to the other methods used in this paper: The idea is simple: For each of the two years, 1994 and 2004, gradually lower the corresponding poverty line by, say, 10% each time. Having done that, for each reduced level calculate the incidence, the intensity and the severity of poverty, as well as the corresponding 95% confidence intervals. Finally, for each variation of the poverty line check if the difference in the poverty measures for each of the two years is significant or not.

[12] Actually, for the exercise that occupies us it is better to use the newer (and more powerful) method in Davidson and Duclos (2006) to test for *restricted* dominance.

Figure 4
TIPs Curves for 1994 and 2004
(Food poverty, population at large)



In our case, it was until the reduction to 40% of the poverty lines when the 2004 point estimates became worse than in 1994. For instance, P_0 became 2.87% in 2004 and 2.64% in 1994 (a similar phenomenon occurred for the other indices). However, since the corresponding confidence intervals were, respectively, (2.53%,3.25%) and (2.27%,3.05%), such a difference is not significant at the 5% level. Actually, one has to reduce the poverty lines up to their minima, at 10% of their original value, to really have a significant (and very minor) difference between the two estimates of poverty incidence. Thus, this last exercise suggests that it is incorrect to state that the poorest among the poor were actually better off in 1994 as compared to 2004. They were as poor in one year as in the other.

5. Conclusions

On the normative side, this paper has proposed several changes to the official methodology that is currently being employed to measure the state of poverty in Mexico. Among other suggestions, it is recommended the use of resampling methods to estimate confidence intervals for the poverty statistics, as well as the use of TIP curve for dominance analysis. We hope to have provided in this paper compelling reasons for the need to revise the existing methodology along those lines.

On the empirical side, the paper has presented several findings on the evolution of poverty in Mexico. Some of them are in line with the findings reported by the government, while others are not. In particular, we challenge

in this paper the widespread view that the state of poverty in Mexico in 1994 was worse than the one prevailing a decade later.

Appendix

Tables A1 and A2 in this appendix present the FGT poverty indices for both the urban and the rural populations in Mexico, as a complement to the information contained in Table 2 above. It is important to keep track of the evolution of poverty rates at both the urban and the rural levels, since in some periods the corresponding rates may be moving at a different pace. A good example of it is the decrease in poverty from 2000 to 2002, an empirical fact that was discussed in the main text. As can be observed from Table A2, those results at the national level are mostly explained by the even more substantial (and statistically significant) drops of the poverty indices in the case of the rural sector. Furthermore, in the case of the poverty statistics for urban Mexico, shown in Table A1, the drops are not statistically significant. How can we make such a claim in this last case? We can presume it, by noting that, for all indices and poverty definitions, the confidence intervals corresponding to the two years do overlap. But that is *just* a conjecture, since in the case of confidence intervals whose intersection is relatively small there is a possibility of rejecting at the end the null hypothesis of equality between the indices. Thus, as opposed to the case of non-overlapping confidence intervals (when the difference is always statistical significant), one has to pursue a further analysis. In the case of bootstrapping, as is explained thoroughly in Efron and Tibshiriani (1993, chap. 16), this is accomplished by drawing bootstrap samples for both ENIGHs, and then computing a confidence interval for the difference between the poverty estimates in those two years. If zero is not contained in the interval, then the change would be deemed to be statistically significant. However, after doing such an exercise for each of the cases in Table A1, we can confirm the former claim of non-significant poverty changes, at the 5% level, in urban Mexico from 2000 to 2002.

Table A1
FGT Poverty Indices for Urban Mexico, 1992-2005
(Population at large)

Year	$P(0)$	[95%Conf.Int.]	$P(1)$	[95%Conf.Int.]	$P(2)$	[95%Conf.Int.]
Food Poverty						
1992	13.3%	10.9% 16.6%	3.6%	2.9% 4.4%	1.4%	1.1% 1.8%
1994	9.9%	8.2% 11.4%	2.6%	2.1% 3.1%	1.0%	0.8% 1.2%
1996	26.7%	25.2% 28.2%	8.4%	7.9% 9.1%	3.7%	3.4% 4.0%
1998	21.8%	20.2% 23.1%	6.6%	6.0% 7.1%	2.9%	2.6% 3.2%
2000	12.5%	10.7% 14.7%	3.3%	2.6% 4.1%	1.4%	1.1% 1.9%
2002	11.3%	9.0% 14.1%	2.8%	2.1% 3.5%	1.1%	0.8% 1.4%
2004	11.0%	8.3% 13.1%	3.0%	2.1% 3.7%	1.4%	1.0% 1.7%
2005	9.9%	8.0% 11.7%	2.6%	2.0% 3.2%	1.1%	0.8% 1.3%
Capabilities Poverty						
1992	20.4%	17.7% 24.5%	6.0%	4.9% 7.4%	2.6%	2.0% 3.2%
1994	17.5%	15.0% 20.4%	4.7%	3.8% 5.5%	1.9%	1.6% 2.3%
1996	36.2%	34.7% 37.9%	12.7%	12.1% 13.5%	6.1%	5.6% 6.5%
1998	30.9%	29.2% 32.4%	10.2%	9.5% 10.8%	4.8%	4.4% 5.2%
2000	20.2%	18.0% 22.5%	5.7%	4.8% 6.7%	2.4%	2.0% 3.1%
2002	17.2%	14.3% 20.5%	4.9%	3.9% 6.1%	2.0%	1.5% 2.4%
2004	17.8%	14.7% 20.8%	5.1%	3.8% 6.1%	2.3%	1.7% 2.8%
2005	15.8%	13.9% 18.0%	4.5%	3.8% 5.3%	1.9%	1.5% 2.2%
Assets Poverty						
1992	44.5%	40.3% 48.6%	16.5%	14.6% 18.9%	8.2%	7.0% 9.4%
1994	40.6%	37.1% 44.9%	14.1%	12.4% 15.8%	6.8%	6.0% 7.7%
1996	60.9%	59.2% 62.2%	27.0%	26.0% 27.8%	15.2%	14.5% 15.8%
1998	56.3%	54.6% 57.8%	23.6%	22.7% 24.7%	12.7%	12.2% 13.5%
2000	43.7%	40.6% 46.4%	16.0%	14.6% 17.4%	7.9%	7.0% 9.0%
2002	41.2%	37.7% 45.7%	14.4%	12.3% 16.3%	6.9%	5.7% 8.2%
2004	41.1%	37.5% 44.1%	14.5%	12.4% 16.4%	7.1%	5.8% 8.3%
2005	38.3%	35.4% 41.5%	13.4%	12.0% 15.0%	6.4%	5.5% 7.4%

Source: Own estimates based on the corresponding ENIGHs.

Table A2
FGT Poverty Indices for Rural Mexico, 1992-2005
(Population at large)

Year	$P(0)$	[95%Conf.Int.]	$P(1)$	[95%Conf.Int.]	$P(2)$	[95%Conf.Int.]
Food Poverty						
1992	35.6%	30.7% 41.4%	13.1%	10.8% 15.4%	6.4%	5.0% 7.7%
1994	37.0%	32.7% 40.8%	13.4%	11.7% 15.4%	6.6%	5.6% 7.6%
1996	52.1%	50.0% 54.0%	21.8%	20.7% 23.1%	11.8%	11.1% 12.7%
1998	52.3%	50.3% 54.6%	23.5%	22.3% 24.7%	13.3%	12.4% 14.1%
2000	42.3%	37.3% 47.7%	16.4%	13.8% 19.5%	8.4%	6.7% 11.5%
2002	34.0%	28.3% 38.0%	11.8%	10.1% 13.5%	5.6%	4.7% 6.5%
2004	28.0%	22.0% 37.8%	10.5%	6.9% 15.2%	5.6%	3.7% 8.6%
2005	32.3%	26.2% 41.7%	12.2%	9.5% 16.7%	6.4%	4.8% 8.6%
Capabilities Poverty						
1992	45.6%	40.3% 50.3%	17.5%	15.1% 20.3%	9.0%	7.4% 10.6%
1994	47.4%	43.1% 51.0%	17.9%	15.7% 19.9%	9.1%	7.9% 10.5%
1996	61.0%	58.9% 62.8%	27.2%	26.0% 28.2%	15.5%	14.6% 16.4%
1998	59.7%	57.5% 61.5%	28.5%	27.1% 29.9%	16.9%	15.9% 18.0%
2000	50.0%	44.8% 55.2%	21.0%	17.9% 24.5%	11.4%	9.1% 13.9%
2002	42.6%	38.1% 47.2%	15.9%	14.0% 18.1%	8.0%	6.9% 9.0%
2004	36.2%	29.4% 44.6%	13.9%	9.9% 20.2%	7.5%	5.1% 11.0%
2005	39.8%	33.9% 49.6%	15.9%	12.7% 21.0%	8.5%	6.6% 11.7%
Assets Poverty						
1992	67.7%	63.5% 71.4%	31.1%	28.0% 34.6%	18.2%	15.9% 21.0%
1994	69.5%	66.0% 72.9%	32.3%	29.5% 34.9%	18.8%	17.1% 20.7%
1996	80.6%	79.2% 82.0%	42.7%	41.5% 43.8%	27.2%	26.2% 28.3%
1998	76.3%	74.4% 78.1%	42.6%	41.2% 43.9%	28.2%	27.0% 29.4%
2000	69.2%	65.1% 73.6%	34.7%	31.1% 38.8%	21.3%	18.3% 24.4%
2002	64.3%	58.9% 68.5%	29.2%	26.4% 32.7%	16.7%	14.7% 18.7%
2004	57.3%	52.1% 64.7%	25.5%	21.0% 32.5%	14.8%	11.0% 20.2%
2005	61.8%	55.8% 71.0%	28.3%	24.1% 35.0%	16.7%	13.9% 21.7%

Source: Own estimates based on the corresponding ENIGHs.

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