# Income polarization in Brazil, 2001-2011: A distributional analysis using PNAD data

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## Summary

*This paper applies a non-parametric tool, the "relative distribution", to identify patterns of changes in Brazil's household income distribution over the period 2001-2011. Despite the sharp decline in income inequality recently experienced by the country, we are able to document an increased income polarization, which has particularly affected households below the median. The results call directly into question the future sustainability and equity of existing social programs dealing with the unequal distribution of resources.*

Keywords: Brazil, income distribution, relative distribution, polarization

JEL Classification codes: C14, D31, D63

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## 1. INTRODUCTION

Brazil has long been known as one of the countries with the most unequal income distribution in the world. The concentration of incomes in 1960 was already high by international standards, as indicated by a Gini coefficient of 0.504, and continued to increase in the following decades (López-Calva, 2012). Income inequality only declined starting in the mid-1990s: after 1997, the Gini reduced by 0.8% per year; between 2001 and 2007, the average rate of annual decline accelerated to 1.2%, well above the pace of the Latin American region as a whole (Barros et al., 2010). Poverty in the country also declined significantly during the last decade: the absolute number of poor people fell from over 61 million in 2003 to under 40 million in 2009 and the headcount index from 35.8% to 21.4% (Higgins, 2012). Meanwhile, Brazil's GDP growth managed to overtake the UK as the world's sixth-largest economy in 2011 (CEBR, 2011).

Although several factors contributed to the recent progress in terms of poverty and inequality reduction – such as economic growth (Barros et al., 2010), expanded access to education during the 1990s (Gasparini and Lustig, 2011), increased demand for unskilled labour (Robinson, 2010) and an increase in the minimum wage (Barros, 2007), it is common opinion that the conditional cash transfer (CCT) programs consolidated and expanded under the administration of the former Brazilian president Luiz Inácio Lula da Silva (2003-2010) have also played an important role.[1] Notwithstanding many critical remarks – focusing principally on the high related costs,[2] CCTs received the appreciation by international institutions and were enthusiastically embraced by many countries as a major social policy instrument (Hall, 2006). "Bolsa Família" is now the largest such scheme in the world: it was budgeted at R$8.3 billion (equivalent to almost 0.4% of GDP) in 2006 and covered around 11 million families (approximately 46 million people) over the same year (Lindert et al., 2007). As a result of their excellent targeting, the program's benefits accounted for something between 21% and 16% of the total fall in Brazilian inequality since 2001 (Soares, 2012). The decline in inequality has been crucial for poverty reduction (accounting for half of the total change between 2001 and 2009) and certainly for making growth friendlier to the poor (López-Calva and Rocha, 2012).

The recent trend in terms of inequality changes is unique in respect to what is being experienced in Brazil's fellow BRICS countries: Russia, India, China and South Africa (OECD, 2011). However, while there is a substantial literature on inequality and income distribution in Brazil (both in isolation and in a comparative perspective; see e.g. World Bank, 2004, and references therein) relatively little work has been done in terms of analyzing changes in the shape of Brazil's income distribution in the recent decade. Indeed, the above mentioned evidence heavily relies on summary measures of inequality and not on the whole shape

[1] CCTs are direct monetary transfers provided to poor families on condition that they ensure children and adolescents attend school and that they meet basic health care requirements. These conditions attempt both to reduce short-term poverty by direct cash transfers and to fight long-term poverty by investing in the human capital of the poor (see e.g. Fiszbein et al., 2009).

[2] For a review see in particular Coggiola (2010).

of the income distribution. As noted by Morris et al. (1994), standard measures of inequality may suggest a particular outcome in terms of inequality change – e.g. a fall in the Gini coefficient or Theil index – while implying a radically different pattern of distributional change. In particular, they may not capture aspects such as multi-modality and polarization.

In seeking to understand exactly *how* income inequality fell in Brazil over the last decade, this paper applies the "relative distribution" method introduced by Handcock and Morris (1998, 1999) to describe patterns of changes that have occurred along the entire Brazilian household income distribution. For this purpose, we use survey income data (PNAD) spanning 2001-2011 and covering a large number of households across all federal units of Brazil.

The remainder of this paper is structured as follows: Section 2 presents data and methodology; Section 3 details the results and findings; Section 4 concludes and draws some policy implications.

## 2. DATA AND METHODOLOGY

We use data from Brazil's annual national household survey (Pesquisa Nacional por Amostra de Domicílios, PNAD) for 2001 to 2011.[3] The PNAD is collected every year in September – except in 2010 – by the National Census Bureau (Instituto Brasileiro de Geografia e Estatística, IBGE) and is nationally representative at the level of each state. However, until 2003 the PNAD was not representative for the rural areas of the North region (minus the state of Tocantins). Therefore, in order to maintain time series comparable these areas was excluded from PNAD data for 2004 onward. In this way, our samples have on average about 107,000 observations a year.

All calculations are based on total household income expressed in Brazilian Reais (R$). Current values have been deflated using the consumer price index (yearly series based on 2005) reported by the OECD.[4] Furthermore, incomes have been equivalized for differences in household size[5] and weighted by using appropriate sampling weights provided by the IBGE staff.

Table 1 provides summary measures for annual household income from 2001 to 2011.

**Table 1.** Summary measures of Brazilian household income, 2001-2011.

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample size | 99,538 | 102,500 | 104,013 | 106,698 | 110,889 | 112,740 | 110,827 | 110,836 | 113,653 | 102,018 |
| Mean | 874.7 | 879.8 | 837.6 | 851.1 | 883.5 | 940.3 | 969.4 | 1,017.3 | 1,034.4 | 1,083.9 |
| Median | 462.7 | 467.2 | 458.5 | 480.9 | 500.0 | 543.0 | 570.6 | 613.4 | 627.1 | 672.7 |
| Income shares | | | | | | | | | | |
| Bottom 5% | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Bottom 10% | 1.2 | 1.2 | 1.2 | 1.3 | 1.4 | 1.3 | 1.5 | 1.4 | 1.5 | 1.5 |
| Bottom 20% | 3.2 | 3.3 | 3.4 | 3.6 | 3.8 | 3.8 | 3.9 | 4.0 | 4.0 | 4.3 |
| Top 20% | 61.1 | 60.8 | 60.0 | 59.0 | 58.8 | 58.3 | 57.4 | 56.9 | 56.3 | 55.4 |
| Top 10% | 44.8 | 44.5 | 43.6 | 42.7 | 42.8 | 42.4 | 41.4 | 41.0 | 40.5 | 39.8 |
| Top 5% | 31.5 | 31.1 | 30.5 | 29.9 | 29.8 | 29.6 | 28.8 | 28.5 | 28.2 | 27.7 |
| Inequality metrics | | | | | | | | | | |
| Gini | 0.562 | 0.557 | 0.549 | 0.538 | 0.535 | 0.529 | 0.520 | 0.514 | 0.509 | 0.498 |
| Theil | 0.630 | 0.626 | 0.594 | 0.577 | 0.572 | 0.560 | 0.537 | 0.525 | 0.519 | 0.495 |

Source: authors' calculation on weighted household income data from PNAD

Besides the growth of the real mean and median incomes, the most notable feature is that income shares of the poorest percentiles of the population increased on average between approximately 2% and 3% per year in

[3] The data are publicly available at http://www.ibge.gov.br/english/estatistica/populacao/trabalhoerendimento/pnad2011/default.shtm.
[4] Available at http://stats.oecd.org/.
[5] Here we adopt a simple equivalence scale that is most commonly used in international studies (e.g. Atkinson et al., 1995) where total household income is divided by the square root of the number of household members.

the period examined, on the contrary of what observed for the richest percentiles whose shares decreased by around 1% or more. As for inequality, the improvements were also noticeable: the Gini and Theil indices exhibited nearly the same temporal profile, showing an average yearly decrease that amounts respectively to 1% and 2%.

In investigating the recent inequality experience of the Brazilian society, we seek to understand how inequality fell by looking *behind* the usual summary measures and closely examining the actual pattern of distributional change. To do so, we use the *relative distribution* approach introduced by Handcock and Morris (1998, 1999).[6]

For our purposes, the "relative distribution" is defined as the ratio of the income density in the comparison year to the income density in the reference year evaluated at each decile of the income distribution, and can be interpreted as the fraction of households in the comparison population that fall in each reference income decile. This allows us to identify and locate changes that have occurred along the entire Brazilian household income distribution. In particular, when the fraction of the comparison population in a decile is higher (lower) than the fraction in the reference year, the relative distribution will be higher (lower) than 1. When there is no change, the relative distribution will be flat at the value 1. Therefore, in this way one can distinguish between growth, stability or decline at specific points of the income distribution.

One of the major advantages of this method is the possibility to decompose the relative distribution into changes in location, usually associated with changes in the median (or mean) of the income distribution, and changes in shape (including differences in variance, asymmetry and/or other distributional characteristics) that could be linked with several factors like, for instance, polarization. To formalize, let $r$ be the percentile rank that an income value $y$ from the comparison sample has in the reference year.[7] The decomposition of the relative distribution for the comparison year, say $g_t(r)$, can be written as

$$g_t(r) = \underbrace{\frac{f_t(y)}{f_0(y)}}_{\text{Overall relative distribution}} = \underbrace{\frac{f_{0,L}(y)}{f_0(y)}}_{\text{Location effect}} \times \underbrace{\frac{f_t(y)}{f_{0,L}(y)}}_{\text{Shape effect}}, \quad 0 < r \leq 1, \tag{1}$$

where $f_{0,L}(y) = f_0(y+\rho)$ is a density function adjusted by an additive shift with the same shape as the reference distribution, $f_0(y)$, but with the median of the comparison one, $f_t(y)$.[8] The value $\rho$ is the difference between the medians of the comparison and reference distributions. If the latter two distributions have the same median, the density ratio for location differences is uniform in $[0,1]$. Conversely, if the two distributions have different median, the "location effect" is increasing (decreasing) in $r$ if the comparison median is higher (lower) than the reference one. The second term, which is the "shape effect", represents the relative density net of the location effect and is useful to isolate movements (re-distribution) occurred between the reference and comparison populations. For instance, one could observe a shape effect function with some sort of (inverse) U-shaped pattern if the comparison distribution is relatively (less) more spread around the median than the location-adjusted one. Thus, it is possible to determine whether there is polarization of the income distribution (increases in both tails), "downgrading" (increases in lower tail),

[6] This technique is very similar in spirit to those developed in economics by Juhn et al. (1993), DiNardo et al. (1996), Lemieux (2002), Jenkins and VanKerm (2005) and Machado and Mata (2005). For a systematic introduction to the relative distribution method we refer the reader to the above-cited works by Handcock and Morris. See also Hao and Naiman (2010: ch. 5).

[7] In more general terms, each distribution can be broken into any number of quantiles (up to the number of observations in the sample).

[8] Median adjustment is preferred here to mean adjustment because of the well-known drawbacks of the mean when distributions are skewed.

"upgrading" (increases in the upper tail) or convergence of incomes towards the median (decreases in both tails).

This approach also includes a *median relative polarization* index (MRP), which is based on changes in the shape of the income distribution to account for polarization. This index is normalized so that it varies between -1 and 1, with 0 representing no change in the income distribution relative to the reference year. Positive values represent more polarization – i.e. increases in the tails of the distribution, and negative values represent less polarization – i.e. convergence towards the center of the distribution. The MRP index for the comparison year can be estimated as (Morris et al., 1994: p. 217)

$$\text{MRP}_t = \frac{4}{n_t}\left(\sum_{i=1}^{n_t}\left|r_i - \frac{1}{2}\right|\right) - 1, \tag{2}$$

where $r_i$ is the proportion of the median-adjusted reference incomes that are less than the $i^{\text{th}}$ income from the comparison year sample, for $i = 1, \ldots, n_t$, and $n_t$ is the sample size of the comparison population.

The MRP index can be additively decomposed into the contributions to overall polarization made by the lower and upper halves of the median-adjusted relative distribution, enabling one to distinguish downgrading from upgrading. In terms of data, the *lower relative polarization* index (LRP) and the *upper relative polarization* index (URP) can be calculated as follows

$$\text{LRP}_t = \frac{8}{n_t}\left[\sum_{i=1}^{n_t/2}\left(\frac{1}{2} - r_i\right)\right] - 1, \tag{3}$$

$$\text{URP}_t = \frac{8}{n_t}\left[\sum_{i=n_t/2+1}^{n_t}\left(r_i - \frac{1}{2}\right)\right] - 1, \tag{4}$$

with $\text{MRP}_t = \frac{1}{2}\left(\text{LRP}_t + \text{URP}_t\right)$. As the MRP, LRP and URP range from -1 to 1, and equal 0 when there is no change.

As with location and shape decomposition, it is possible to adjust the relative distribution for changes in the distribution of covariates measured on the households, which often vary systematically by population. The covariate adjustment technique can be used to separate the impacts of changes in population composition from changes in the covariate-response relationship. This decomposition according to covariates draws on the definition of a counter-factual distribution for the response variable in the reference population that is *composition-adjusted* to have the same distribution of the covariates as the comparison population.

Assume for simplicity that the covariate $Z$ is categorical.[9] Let $\left\{\pi_k^0\right\}_{k=1}^K$ and $\left\{\pi_k^t\right\}_{k=1}^K$, where $K$ is the number of categories of the covariate, denote the probability mass functions of $Z$ for the reference and comparison populations, i.e. their composition according to the covariate. For conditional comparisons of the response variable $Y$ across the two populations one can consider the density of $Y_0$ given that $Z_0 = k$,

$$f_{Y_0|Z_0}\left(y|k\right), \quad k = 1, \ldots, K, \tag{5}$$

and the density of $Y_t$ given that $Z_t = k$,

$$f_{Y_t|Z_t}\left(y|k\right), \quad k = 1, \ldots, K. \tag{6}$$

[9] The extensions to continuous and multivariate covariates are considered in Handcock and Morris (1999: ch. 7).

These densities represent the covariate-response relationship. The marginal densities of $Y_0$ and $Y_t$ can be written, respectively, as

$$f_0(y) = \sum_{k=1}^{K} \pi_k^0 f_{Y_0|Z_0}(y|k) \tag{7}$$

and

$$f_t(y) = \sum_{k=1}^{K} \pi_k^t f_{Y_t|Z_t}(y|k). \tag{8}$$

Then, the counter-factual distribution with the covariate composition of the comparison population and the covariate-response relationship of the reference population is

$$f_{0,C}(y) = \sum_{k=1}^{K} \pi_k^t f_{Y_0|Z_0}(y|k), \tag{9}$$

and can be used to decompose the overall relative distribution into a component that represents the effect of changes in the marginal distribution of the covariate (the "composition effect") and a component that represents the changes in the covariate-response relationship (the "residual effect"). The decomposition can be represented in the following terms

$$g_t(r) = \underbrace{\frac{f_t(y)}{f_0(y)}}_{\text{Overall relative distribution}} = \underbrace{\frac{f_{0,C}(y)}{f_0(y)}}_{\text{Composition effect}} \times \underbrace{\frac{f_t(y)}{f_{0,C}(y)}}_{\text{Residual effect}}, \quad 0 < r \leq 1. \tag{10}$$

Comparison of $f_t(y)$ to $f_{0,C}(y)$ – i.e, the residual effect – holds the population composition constant, and therefore isolate changes of income distribution due to the fact that returns to the selected covariate changed over time. By contrast, $f_{0,C}(y)$ and $f_0(y)$ have the same covariate-response relationship, and the comparison between them – i.e, the composition effect – isolate the changes due to the different composition of the population under the assumption that the conditional distribution of income remain unchanged.

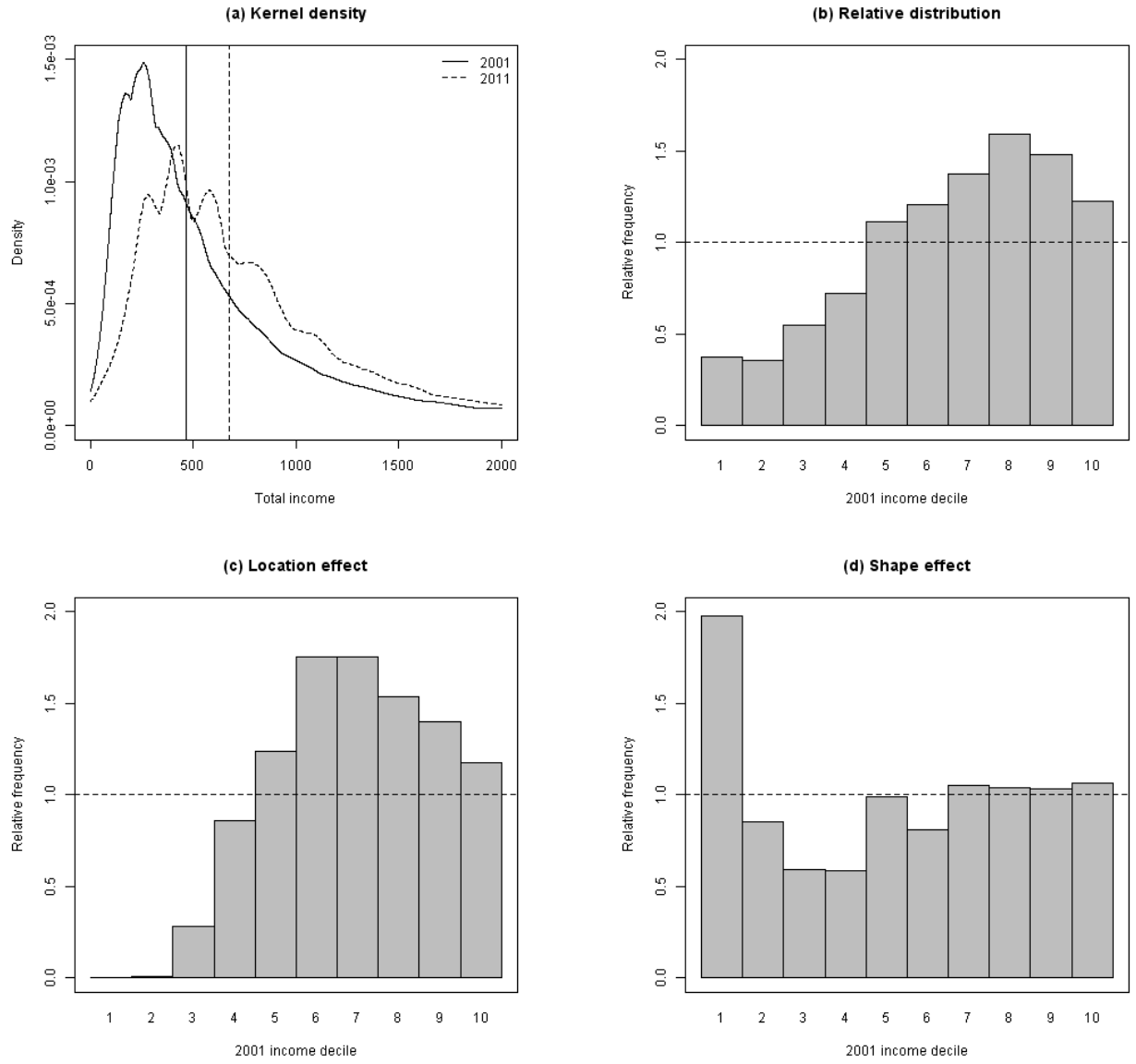
## 3. EMPIRICAL RESULTS

### *3.1. Changes in the Brazilian household income distribution*

Figure 1(a) presents kernel density estimates of total household income at the two end points of the 2001-2011 period.[10]

[10] To handle data sparseness, the two densities have been obtained by using an adaptive kernel estimator with a Silverman's plug-in estimate for the pilot bandwidth (see e.g. Van Kerm, 2003). The advantage of this estimator is that it does not over-smooth the distribution in zones of high income concentration, while keeping the variability of the estimates low where data are scarce – as, for example, in the highest income ranges.

**Figure 1:** Changes in the Brazilian household income distribution between 2001 and 2011. In panel (a), incomes in the upper tiers of the distributions have been truncated for better presentation of the graph, where the vertical lines denote the medians of the two samples.




At first glance, we observe a rightward shift of the whole distribution, which implies an increase of the median income in this period. The increment in the median can be explained by the substantial decline in the mass at the lower and middle income ranges and the concomitant spreading out of incomes in the top half of the distribution. There is also a significant alteration of the shape, especially in the middle income range: the 2011 density reveals indeed clear evidence of multi-modality, while the 2001 density is nearly unimodal. As shown in Pittau and Zelli (2006), the emergence of more than one mode (and the gap between them) in the distribution of household income could be interpreted as an increase in polarization.

Further insight is provided by the relative distribution, which directly compares the two income densities.[11] Figure 1(b) shows the fraction of households in 2011 that fall into each decile of the 2001 income

[11] Throughout, we rely on the `R` statistical package `reldist` (Handcock, 2011) to implement the relative distribution method.

distribution.[12] The relative distribution is nearly monotonic in its increase, hence implying a decrease of the mass of households below the 2001 median income over the period under consideration. More specifically, the relative distribution is less than 1 below the 5th decile and more than 1 above that. This means that if we choose any decile between the 1st and the 4th in the 2001 distribution, the fraction of households in 2011 that earn an amount of income corresponding to the chosen decile is less than the analogous fraction of households in 2001. However, income growth between 2001 and 2011 also positively affected households in the top half of the distribution: the peak of 1.6 is at around the 8th decile, meaning that households in 2011 are approximately 60% more likely to fall at the level of 2001 income corresponding to the 8th decile than households in 2001.

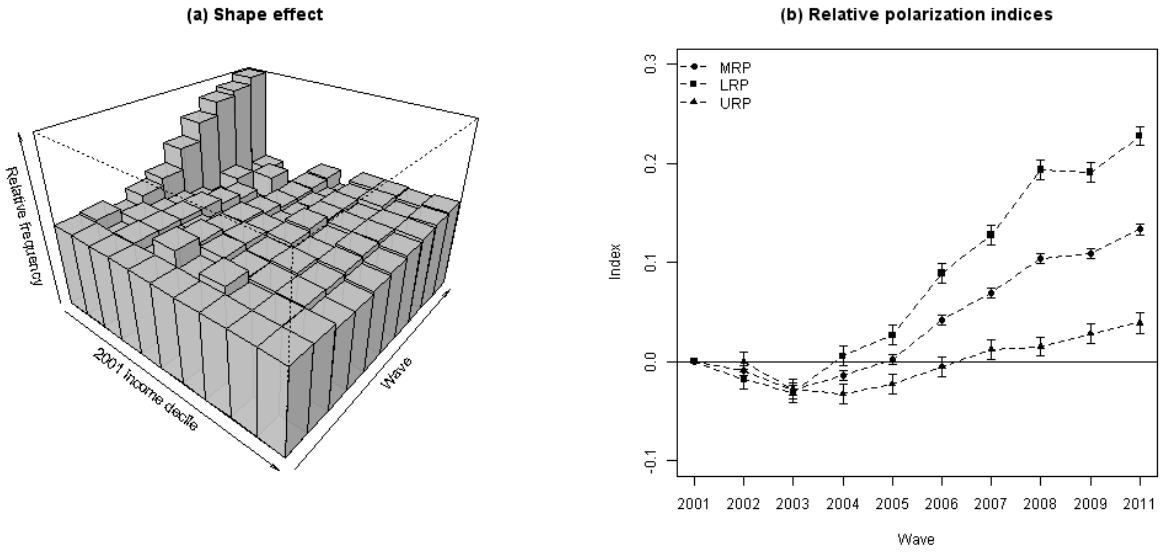
To get a more detailed picture, we decompose the relative distribution into location and shape effects. Figure 1(c) presents the effect only due to the median shift, i.e. the pattern that the relative distribution would have displayed if there had been no change in distributional shape but only a location shift of the distribution. Since the median shift is positive, the location effect reduces the share of households in bottom deciles and increases that in the higher ones, hence confirming our prior observation. Figure 1(d) shows the shape effect, which represents the relative distribution net of the median influence. The visual impression that one gets from the figure above indicates a marked change for incomes below the median, with a decline of the mass between approximately the 2nd and the 6th decile and a prominent increase of the fraction of households at the poorest decile of the distribution. This means that while the vast majority of households experienced a growth in their real income, the poorest fraction of them failed to catch up with the rest of population. On the contrary, the upper part of the relative distribution does not reveal substantial changes, apart from a slight increase of the mass from the 7th decile onward.

The relative distribution method permits us to also analyze how income re-distribution across households took place during 2001 to 2011. For each year within this period, Figure 2(a) shows the shape effect of the household income relative distributions using 2001 as the reference year.[13]

[12] We have chosen 2001 as the baseline year throughout the analysis. Choosing an alternative baseline year would change the view provided by the relative distribution graphs and the value of the relative polarization indices in each year, but it would not affect the year-to-year comparisons that are of interest here (Morris et al., 1994: p. 210). Furthermore, using 2001 as the baseline year allows use to examine the longest span available in the PNAD series for Brazil.

[13] The relative distribution, and therefore its shape effect, is by definition flat in the reference year (Morris et al., 1994: p. 211).

**Figure 2:** Trend of relative distribution in Brazil, 2001-2011. In panel (b), the 95% pointwise confidence intervals, shown by error bars, are indicated for the null hypothesis of no change with respect to the reference year, i.e. that the index equals 0.




Following the plot through each successive year, one is offered with the immediate impression that the fraction of households in the bottom income levels increased consistently by the mid-2000s, while the fraction in the middle and the upper declined. However, toward the end of the first decade of 2000s a moderate growth in upper income levels is also apparent, which indicates that the distribution is beginning to polarize.

A link between what we have observed in the graphical analysis and the quantification of the degree of polarization is yielded by the relative polarization indices. These indices can be used to keep track of changes in the shape of the income distribution across the whole 2001-2011 period by measuring the magnitude and direction of differences between the distribution in each successive year and that of the 2001 reference year. Figure 2(b) plots the set of three indices computed from the PNAD data using Equations (2)-(4).[14] The MRP index falls initially, indicating a small, though significant convergence in incomes during the early 2000s. After this, however, the index rises consistently, becoming significantly positive after 2005. The LRP and URP indices track the MRP pretty closely over the entire time period. The LRP index falls until 2003, indicating significant convergence from the lower part of the income distribution toward the middle. By 2004 the index climbs almost steeply (and consistently) until the end of the time span, although it does not reach significance immediately – because it is rising from lower levels – but only from 2005 onward. A similar story can be told for the URP index. Here too, the first part of the period brings some movement from the top half of the income distribution toward the middle: except for 2002 and 2006, the value of the URP remains significantly negative during the first half of the 2000s. Instead, by 2007 it begins to rise and becomes significantly positive, indicating that an upgrading in the distribution also took place in the second half of the 2000s.

In sum, rather being *solely* a story of declining inequality, the recent changes in Brazil's income distribution bring about a story of polarization. In fact, we are able to document a downgrading trend around the mid-2000s and, by 2007, the emergence of a more marked pattern of polarization. The latter, however, is

[14] By definition, the value of the three indices always equals 0 in the reference year (Morris et al., 1994: p. 209).

not symmetric, as the LRP index is always more positive than the URP, indicating more polarization in the lower than in the upper tail.

### *3.2. Changes in the conditional income distributions by region*

As recently shown in Porto Junior and Figueiredo (2012; but see also Barros, 2011), the compatibility between decreasing income inequality and rising polarization in the Brazilian context may be explained by the existence of a marked spatial heterogeneity in terms of income: taking into consideration the longstanding Brazil's north-south divide, with the richer South and Southeast regions displaying much better socioeconomic indicators than the poorer North and Northeast,[15] the authors conclude that the recent inequality reduction in the country's overall income distribution reflected a combination of increasing location differences between the distributions of the two groups of regions and decreasing dispersions within them, which are the characteristics of the polarization process.[16] Therefore, to further interpret the tendency of Brazilian household incomes to polarize it is helpful to analyze the changes that occurred in the conditional distributions by region over the observation period. This is what we do in the present section by following the IBGE's division of Brazil into five macro-regions, namely North, Northeast, Central-West, Southeast and South.[17]

The summary statistics for each region are reported in the Appendix, Tables A.1 to A.5. These statistics summarizes some well-known facts (IBGE, various years): as for the overall population, the increase in mean and median incomes and the improvement in the relative position of the bottom percentiles that occurred in each Brazilian region over the last decade were accompanied by a reduction in inequality. But while suggesting important candidate explanations for the distributional change, the statistics reported do not capture the other changes that occurred. In particular, the key questions are hinted at but not easily quantified using the standard measures here. How well are the differences captured by simple location shifts? Is there evidence of growing polarization? Are the upper and lower tails of the distributions changing in similar ways? As discussed in the previous sections, relative distribution methods are well suited to these questions.

Figure 3 plots the 2001 and 2011 kernel density estimates of household income for the population as a whole (solid line) together with the regional densities (broken lines).[18]

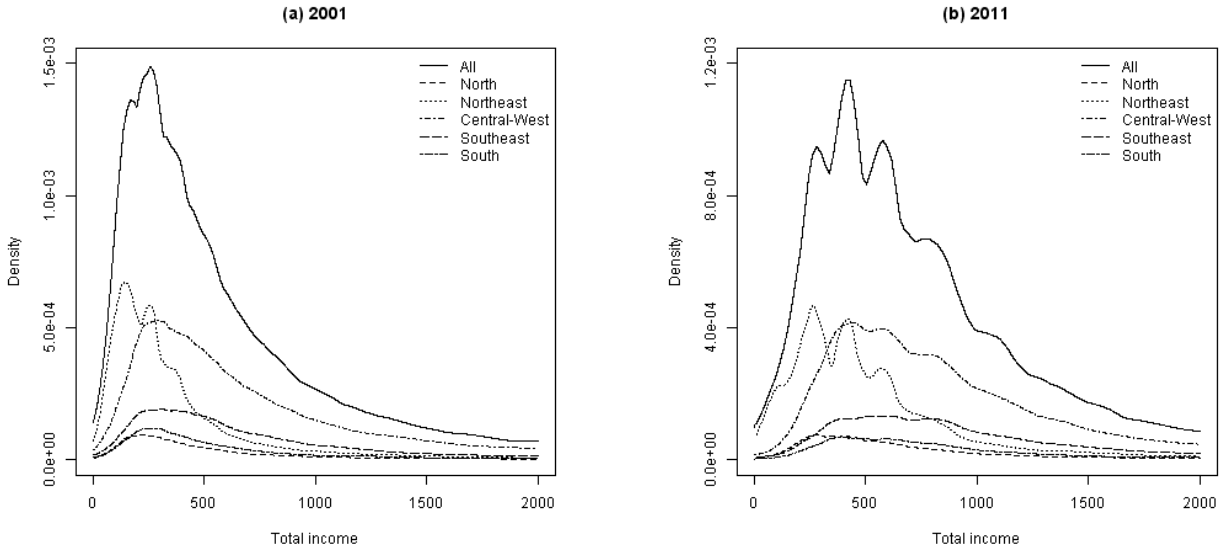
[15] Based on census data from IBGE, Pierobelli et al. (2012) estimate that the states located in the North and Northeast regions of the country were responsible, respectively, for around 5% and 13.5% of total GDP in 2009 and 8.3% and 27.8% of the total population. In the same year, the states located in the Southeast and South regions of the country accounted for about 55.3% and 16.5% of total GDP and 42.1% and 14.4% of the total population. For the states located in the Central-West region, the shares were respectively 9.6% and 7.4%. This picture of concentration had been nearly stable also in the most recent years, although some small changes in the regional shares did occur – specifically, the Central-West region was the one that gained more participation in GDP, while the Southeast region was the one that lost more.

[16] Following Esteban and Ray (1994), polarization between two groups is the consequence of a combination of two factors: increasing "identification" (usually associated with diminishing within-group variances, i.e. members of each group coalesce) and increasing "alienation" (usually associated with increasing between-group differences in location, i.e. the two groups become more un-alike). Viewed in this context, polarization is different from trends in overall inequality, which is a monotonically increasing function of absolute between-group location differences and within-group dispersions, both of which can change in either direction – thus reducing or rising inequality as conventionally measured – with increased polarization. See also Wolfson (1994), Duclos et al. (2004) and Foster and Wolfson (2010) on the distinction between the concept of polarization and the usual notion of inequality.

[17] See http://www.ibge.gov.br/english/geociencias/geografia/default_div_int.shtm.

[18] The density for each region at each income level has been multiplied by the region's population share, so that the weighted sum of the regional densities adds up to the population density in accordance with Equations (7) and (8).

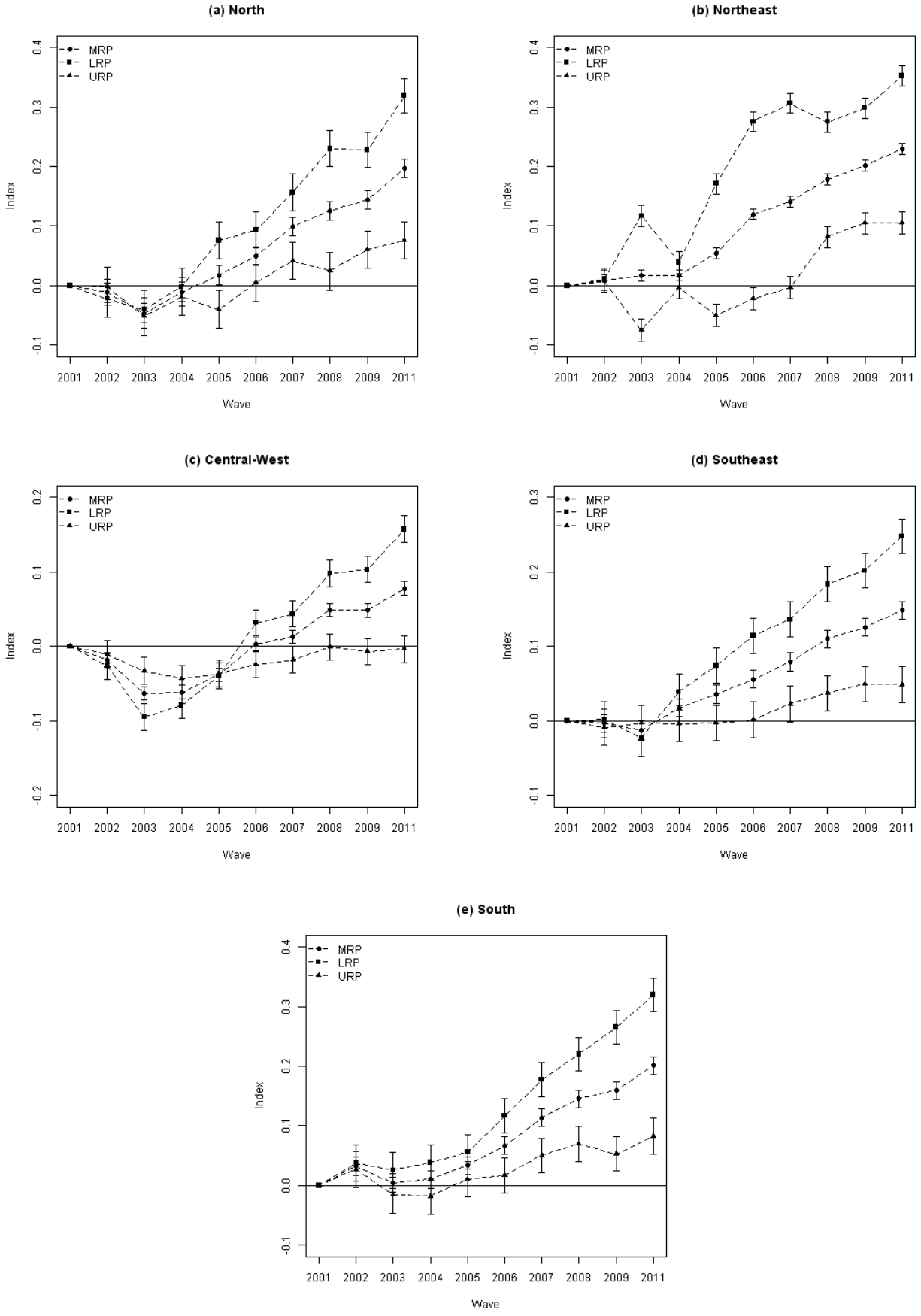
**Figure 3:** Overall density and regional densities, 2001 and 2011. Incomes in the upper tiers of the distributions have been truncated for better presentation of the graphs.




In both 2001 and 2011, the shape of the overall density seem to have been essentially influenced by the income distribution of households living in the Northeast region of Brazil (dotted lines), which moved from a bimodal shape in 2001 to an approximate tri-modal shape in 2011. A decrease in the number of households with low income between 2001 and 2011 is also evident from each regional density. At the same time, location shifts appear to have contributed substantially to changes in the overall income distribution: the increase in mean and median incomes in each region shifted the density mass (at both the aggregate and regional level) to the right; in particular, the movement of the income distribution of households living in the Central-West region (dot-dashed lines) stands out as having made the largest contribution to the growth in the upper tail of the overall density.

To investigate the degree of polarization over time, we use the median adjustment and obtain the relative polarization indices for each region in a similar way as presented in Section 3.1. Because the comparisons focus on the differences between the region-specific income distributions in each successive year and those of the 2001 reference year after adjusting for the median, these measures isolate re-distribution effects that are not due to location shifts. Figure 4 plots the set of three indices for household incomes of each region: the MRP index, the LRP index and the URP index. Again, a rise in the MRP index indicates rising polarization in incomes. A rise in the LRP index indicates increasing movement toward the bottom income levels, while a rise in the URP index indicates increasing movement toward the very top income levels. Declines in the indices indicate convergence toward the middle income levels. The 95% pointwise confidence intervals for the MRP index and the LRP and URP indices are indicated for the null hypothesis of no change with respect to the reference year (i.e. that the index equals 0).

**Figure 4:** Relative polarization indices by region, 2001-2011.



In three out of five regions (North, Central-West and Southeast) the MRP falls initially, though it does not always reach significance, indicating that a small convergence toward the middle of the distributions from both low and high income levels took place during the initial years. Thereafter, the MRP indices are all significantly positive, especially by the second half of the 2000s, which indicates that the household income distribution of each region is beginning to polarize. For the Northeast and South regions, instead, the MRP index becomes significantly positive almost from the start.

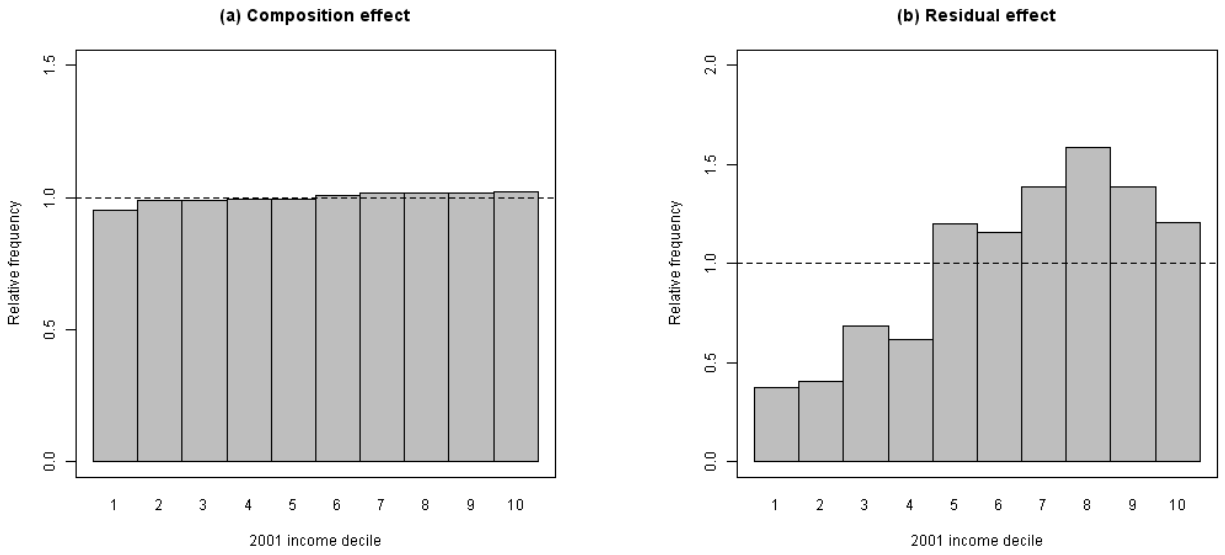
In all cases, the growth of polarization stems from a significant increase of polarization in the lower tail of each distribution: the LRP index is always larger, indicating downward movement in the bottom half of the income distribution, while the URP index indicates some significant, though variable, movement toward the upper income levels only in the final years of the time period considered. This pattern of polarization seems to be slightly different for incomes of households living in the Central-West region, where a distinct downgrading is not compensated by a significant convergence in the upper tail during the later years.

### *3.3. Decomposition by rural/urban population characteristics*

While Brazil has made strides in reducing income inequality (and poverty) over the past fifteen years, the intensity of the drop was not uniform along the rural/urban dimension. For example, Kageyama and Hoffman (2006) and Helfand et al. (2009) show that the steady downturn in inequality, particularly significant from 2001 onward, was sharper in rural areas than in urban zones, and a similar pattern is observed when looking at poverty indicators. The increase and better targeting of social transfers over the same period, with the adoption and expansion of CCT programs to poor people living in rural areas, are usually cited by the research community as one of the relevant explanations for the observed disparities in inequality and poverty levels between rural and urban households (see e.g. Ferreira et al., 2010, and Pero and Szerman, 2010).

To account for this spatial heterogeneity of welfare outcomes in our study on the pattern of distributional change in Brazil during the 2000s, we proceed disaggregating the analysis by rural/urban households and using the covariate adjustment technique described in Section 2 to determine whether differences in the rural/urban income profile between the reference and comparison populations explain some of the changes in the overall household income distribution. Figure 5 graphically displays the adjustment of the 2011 to 2001 relative distribution (the same as that shown in Figure 2(b)) for rural/urban composition changes.

**Figure 5:** Adjusting the 2011 to 2001 relative distribution of Brazilian household income for rural/urban population characteristics.




Panel (a) represents the population composition effect, while panel (b) represents the composition-adjusted relative distribution of household income, that is the expected relative distribution had the rural/urban composition of the 2001 and 2011 populations been identical. Figure 5(a) is very close to a uniform distribution. The implication is that the difference in rural/urban composition between the two populations had little effect on the observed relative distribution of income. There were slight decreases in the bottom deciles and tiny growth at the top of the distribution associated with this compositional change, but the observed increase of income polarization has not been driven by changes in the population composition with respect to the rural/urban covariate. Figure 5(b) represents the composition-adjusted relative income distribution. In the absence of a major composition effect, the adjusted distribution is not much different than the original relative distribution. The shrink of the low-middle incomes is still evident, embracing a range between the 1st and the 4th decile, as well as the substantial income growth in any of the deciles above the median. Therefore, the shape of the relative distribution was mainly due to changes in the conditional income distributions by rural/urban area of residence.

To analyze the impact of a change in the covariate-response relationship on the overall income distribution, we proceed by explicitly forming the relative distribution for the two groups defined by the categorical covariate and using some of the methods described in previous sections – namely, the location/shape decomposition and the relative polarization indices. Figures 6 and 7 compare the 2001 and 2011 income distributions for rural and urban households, respectively.

**Figure 6:** Changes in the Brazilian income distribution of rural households between 2001 and 2011. In panel (a), incomes in the upper tiers of the distributions have been truncated for better presentation of the graph, where the vertical lines denote the medians of the two samples.

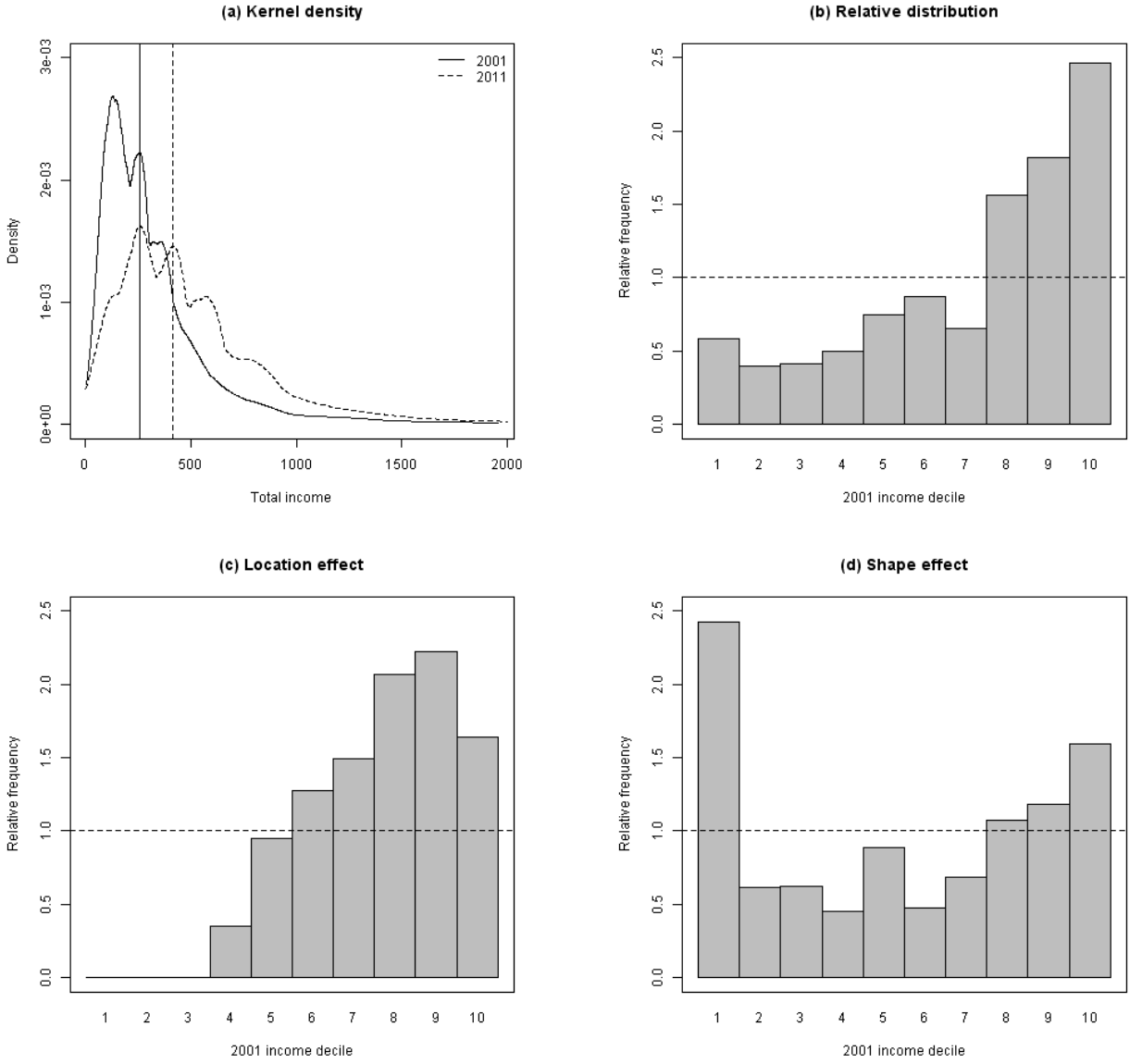
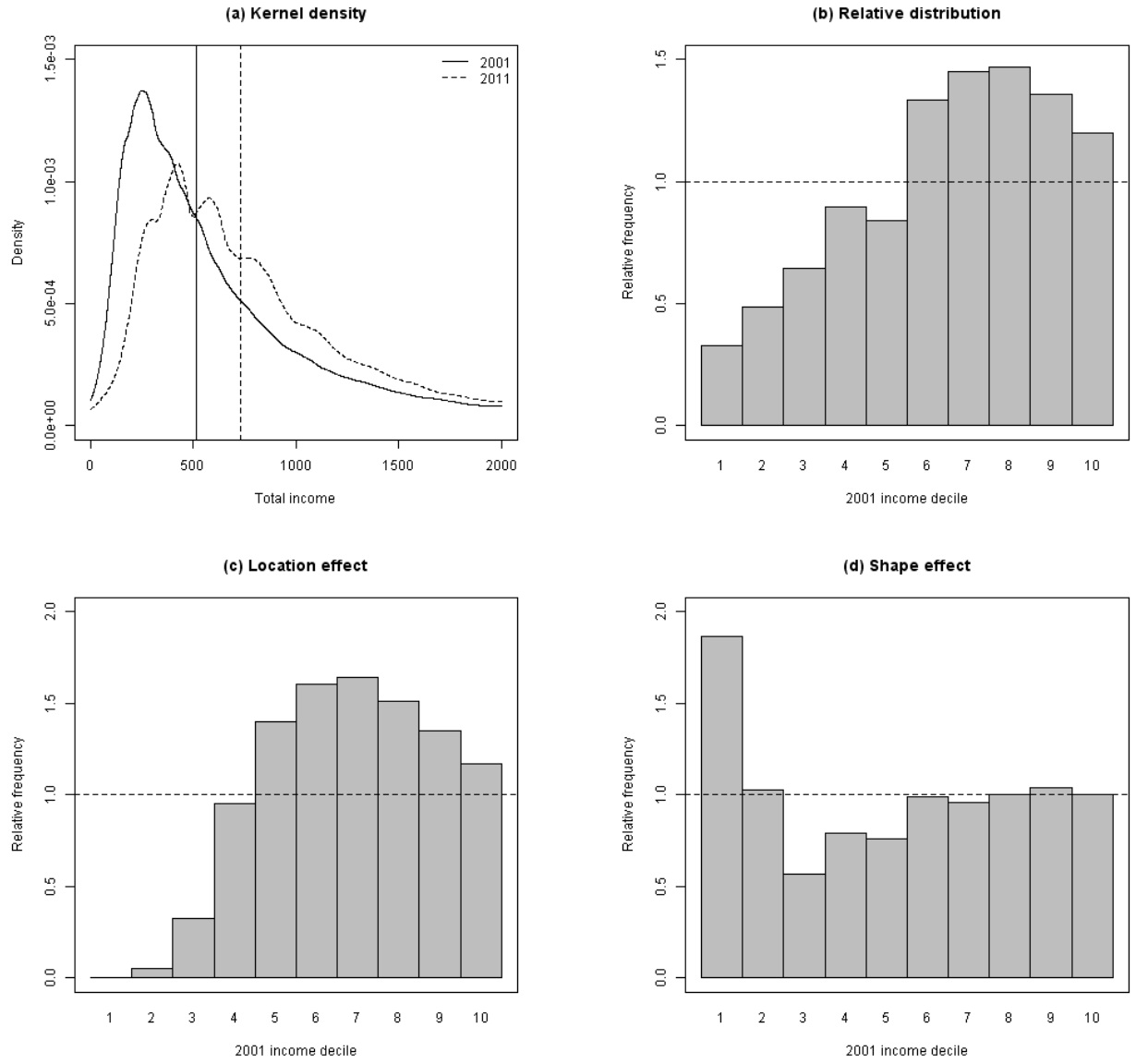


**Figure 7:** Changes in the Brazilian income distribution of urban households between 2001 and 2011. In panel (a), incomes in the upper tiers of the distributions have been truncated for better presentation of the graph, where the vertical lines denote the medians of the two samples.




The density overlays for the two groups of households are shown in panels (a) of the figures, and the relative distributions in panels (b). The upshifting of incomes for rural households is quite apparent. In 2011, the frequency of households in the three top deciles was nearly 0.6 to 1.5 times greater than the corresponding frequency of households in 2001, and there are about 10% to 60% fewer households in any of the deciles between the 1st and the 7th than in 2001. For urban households, the distributional change between 2001 and 2011 took a similar form. The frequency of households in the top half of the 2011 distribution increased by something like 20% to 50% with respect to 2001, while the falling frequency of households in the bottom half is comparatively more pronounced, ranging approximately between 10% and 70% of the corresponding frequency of households in the 2001 reference distribution.

Panels (c) and (d) of the same figures present the location and shape decompositions of the relative distributions for both rural and urban households. The effects of the median shifts were quite large. These alone would have virtually eliminated the households in the poorest deciles of the 2001 income distributions

and placed a considerable fraction of them in the top half of the 2011 distributions. Note, however, that neither tail of the observed relative distributions is well reproduced by the median shifts. For example, the top decile of Figure 6(c) is about 1.6, well below the value of 2.5 observed in the actual data, and the bottom decile of Figure 7(c) is also substantially lower than observed. These differences are explained by the shape effects presented in panels (d), which are also quite large. Even without the higher median, the re-distribution across rural households would have led to relatively more low-income households in 2011, and this effect was mainly concentrated in the poorest decile. The polarization hollowed out the middle of the income distribution, with a cumulative loss that more than halved the number of rural households in deciles 2 through 7 of the 2011 distribution. At the top of the distribution, however, the re-distribution worked in the same direction of the location shift: operating by itself, it would have increased the number of rural households in the top decile of the 2011 distribution by nearly 60%. Similarly, for urban households the strongest shape effect was in the bottom decile of the income distribution, indicating that more households were being left farther behind in 2011, wiping out any gains they might have seen in 2001. By contrast, unlike rural households, the shape shift was not as strong an effect for those urban households who joined the top deciles of the 2011 income distribution. Therefore, the growth in the frequency of households whose incomes put them in the top deciles of the 2011 distribution was now largely due to the general median income upshift rather than to polarization.

The size and sign of the estimated relative polarization indices confirm the impression left by the graphical display. The MRP, LRP and URP indices for the shape change displayed in Figure 6(d) are 0.272, 0.322 and 0.194, respectively, whereas for the shape effect in Figure 7(d) we have 0.124, 0.241 and 0.07. The *p*-values for the null hypothesis of no change with respect to the reference distribution are strictly less than 0.001 for both groups, save for the URP index of the urban household income distribution, which is not significant neither at the 10% level nor at the 5% level (*p*-value = 0.117).

In sum, the losses experienced by rural households between 2001 and 2011 were exclusively due to polarization, while the income growth in the upper deciles was produced by both higher median gains and polarization. The polarization in the lower tail, however, was much more extreme, because the index for the lower tail is appreciably larger than that for the upper. For urban households, instead, all of the change in distributional shape was due to a greater polarization in the lower tail, while the growth in the income deciles above the median of the distribution appears to have been driven solely by the location shift. Collectively, these results would suggest that the lower tail polarization of the overall Brazilian income distribution was contributed by the distinct downgrading in both the rural and urban household incomes, whereas the observed upgrading in the incomes of rural household was ultimately responsible for the growth in the overall upper tail polarization.

## 4. CONCLUSIONS

We have used the relative distribution approach to analyze changes in the Brazilian household income distribution between 2001 and 2011. This method provides a non-parametric framework for taking into account all of the distributional differences that could arise in the comparison of distributions over time. In this way, we are able to summarize multiple features of the income distribution that would not be detected easily from a comparison of standard measures of inequality.

The paper documents relevant changes in the Brazilian income distribution, despite the substantial falling off in income inequality. The analysis of size-adjusted household incomes indicates an overall upshift of the distribution, especially from 2005 onward, which partly masks a tendency to income polarization. In fact, having controlled for the median increase, a more clear rise in polarization is detected, mainly due to a

downgrading of lower incomes that overcompensated the convergence of higher incomes toward the median. By contrast, starting from 2007 the process of polarization of household incomes is more pronounced, with both the lower and upper tails shifting away from the median of the distribution.

A within-group analysis shows that all regions experienced greater polarization starting from the mid-2000s. Polarization patterns similar to that observed for the overall income distribution are indeed detected in both the tails of the region-specific distributions – i.e. a greater polarization in the lower tail and a convergence in the upper tail that are followed in time by a shift away from the middle of both the lower and upper incomes. Furthermore, the change in the relationship between the response variable (the household income) and the conditional distribution of income according to the rural/urban area of residence has produced an horizontal re-distribution across households: net of the location influence, the observed growth in both tails of the overall relative distribution is mainly due to the increase of the relative income gap between wealthier and lower-income households – especially for rural areas – rather than to changes in the composition of the population according to the rural/urban covariate.

Overall, these findings suggest that the recent improvements in Brazil's income distribution have been propelled mainly by the overall economic growth of the country, while social policy programs would have played a key role in affecting the shape of the distribution – leading to a greater polarization at both the top and bottom tails of the income distribution. The observed movements of households toward low and high incomes (and away from the middle) could be justified, on the one side, by deductions and exemptions on taxes that are granted as political privileges to landowners (rents) and financial capitalists (profits), and, on the other side, by the heavy reliance on indirect taxation that disproportionately burden the income of poor and middle-income households, who consequently bear a significant share of the total cost for social programs (e.g. Birdsall et al., 2008: ch. 4).

Hence, sustaining reductions in both inequality and poverty by making them less growth-dependent represents a key challenge for Brazil going forward: as borne out by our results, under a scenario of poor performance growth the shape effect would be brought to prevail, thereby generating a more unequal society. Considering the recent halt in Brazil's economic growth that followed the global economic crisis, this paper suggests adopting policies well targeted to a "real" re-distribution of resources, i.e. aimed at allowing *structural* improvements in the income distribution that go beyond the effects of economic growth. Among these, making the tax system somewhat more progressive by increasing the tax burden on the income of rich households (including business profits as well as financial and agricultural rents) would improve the overall distribution of income and, at the same time, free up precious resources for domestic demand (especially by the middle class). Furthermore, reform programs to alleviate the unequal distribution of land would grant to poorest households – in particular those living in the North and Northeast regions of Brazil – the necessary tools to get out of extreme poverty and consequently reduce their actual dependence on social transfers.[19]

The paper can be extended in several directions. Perhaps the most obvious extension is to examine how different sources of household income might have impacted the observed increase of income polarization. Also, the decomposition of the relative distribution according to the covariates could be improved, allowing one to detect the contribution of other households characteristics to the observed changes. Due to the richness of data available from the PNAD and the many opportunities offered by the relative distribution approach, we are in a good position to readily expand our analysis in the near future.

[19] Brazil has one of the most unequal distribution of land in the world. The concentration of property in Brazil is so skewed that the largest 3.5% of landholdings represent 56% of total agricultural land (Hidalgo et al., 2010). The Gini coefficient of land inequality remained stable between 1967 and 1998, measuring around 0.84 in both the beginning and end of the period (Hoffman, 1998). Since then, it increased to 0.856 in 1995 and 0.872 in 2006 (IBGE, 1997, 2009). Some regional differences exist, but land inequality in all regions is high when compared internationally (Hoffmann and Ney, 2010).

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## APPENDIX: INCOME SUMMARY MEASURES BY REGION, 2001-2011

**Table A.1.** North.

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample size | 9,881 | 10,126 | 10,255 | 10,770 | 11,295 | 11,398 | 11,197 | 10,841 | 11,408 | 11,886 |
| Mean | 683.8 | 676.5 | 623.7 | 670.8 | 685.3 | 737.3 | 770.5 | 795.8 | 831.8 | 895.3 |
| Median | 382.7 | 377.2 | 372.9 | 400.5 | 424.3 | 451.1 | 472.2 | 514.3 | 517.6 | 560.2 |
| Income shares | | | | | | | | | | |
| Bottom 5% | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.5 |
| Bottom 10% | 1.5 | 1.5 | 1.6 | 1.9 | 1.7 | 1.8 | 1.7 | 1.8 | 1.7 | 1.6 |
| Bottom 20% | 4.0 | 4.3 | 4.3 | 4.5 | 4.6 | 4.7 | 4.7 | 4.8 | 4.7 | 4.5 |
| Top 20% | 59.1 | 59.4 | 57.0 | 56.5 | 55.9 | 55.9 | 55.5 | 53.5 | 55.2 | 55.0 |
| Top 10% | 43.6 | 43.7 | 41.3 | 40.7 | 40.4 | 40.4 | 39.6 | 38.0 | 39.4 | 40.1 |
| Top 5% | 30.9 | 31.1 | 28.6 | 28.3 | 28.3 | 28.0 | 27.2 | 25.9 | 27.6 | 27.7 |
| Inequality metrics | | | | | | | | | | |
| Gini | 0.535 | 0.537 | 0.511 | 0.505 | 0.499 | 0.496 | 0.495 | 0.477 | 0.493 | 0.497 |
| Theil | 0.593 | 0.595 | 0.519 | 0.519 | 0.503 | 0.493 | 0.491 | 0.445 | 0.489 | 0.503 |

Source: authors' calculation on weighted household income data from PNAD

**Table A.2.** Northeast.

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample size | 29,684 | 30,886 | 31,700 | 32,428 | 33,989 | 34,415 | 34,220 | 34,520 | 35,394 | 29,568 |
| Mean | 501.1 | 512.7 | 483.4 | 510.8 | 525.5 | 578.3 | 598.9 | 640.8 | 668.8 | 692.8 |
| Median | 263.0 | 269.4 | 273.4 | 280.5 | 300.0 | 335.9 | 351.9 | 380.0 | 396.5 | 431.5 |
| Income shares | | | | | | | | | | |
| Bottom 5% | 0.4 | 0.5 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 |
| Bottom 10% | 1.2 | 1.2 | 1.2 | 1.2 | 1.3 | 1.3 | 1.2 | 1.3 | 1.2 | 1.3 |
| Bottom 20% | 3.5 | 3.6 | 3.7 | 3.8 | 3.8 | 3.7 | 3.8 | 4.0 | 3.8 | 4.3 |
| Top 20% | 61.8 | 61.7 | 60.2 | 60.4 | 58.8 | 59.2 | 57.6 | 57.7 | 57.3 | 55.8 |
| Top 10% | 47.3 | 47.2 | 45.7 | 46.1 | 44.7 | 45.1 | 43.5 | 43.5 | 43.2 | 41.7 |
| Top 5% | 34.8 | 35.1 | 33.3 | 33.8 | 32.5 | 33.3 | 31.6 | 31.8 | 31.5 | 30.3 |
| Inequality metrics | | | | | | | | | | |
| Gini | 0.565 | 0.562 | 0.549 | 0.549 | 0.537 | 0.540 | 0.527 | 0.523 | 0.524 | 0.508 |
| Theil | 0.689 | 0.689 | 0.638 | 0.649 | 0.616 | 0.646 | 0.592 | 0.591 | 0.584 | 0.550 |

Source: authors' calculation on weighted household income data from PNAD

**Table A.3.** Central-West

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample size | 31,569 | 32,504 | 32,343 | 32,918 | 34,373 | 35,017 | 34,052 | 34,319 | 34,776 | 30,832 |
| Mean | 1,069.6 | 1,071.9 | 1,012.1 | 1,004.7 | 1,055.9 | 1,117.7 | 1,132.5 | 1,186.2 | 1,193.4 | 1,250.0 |
| Median | 601.3 | 601.1 | 569.6 | 589.4 | 620 | 671.9 | 695.1 | 743.6 | 756.2 | 813.1 |
| Income shares | | | | | | | | | | |
| Bottom 5% | 0.5 | 0.5 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Bottom 10% | 1.3 | 1.4 | 1.4 | 1.5 | 1.6 | 1.6 | 1.8 | 1.7 | 1.8 | 1.9 |
| Bottom 20% | 3.6 | 3.8 | 3.9 | 4.2 | 4.2 | 4.4 | 4.6 | 4.8 | 4.8 | 5.0 |
| Top 20% | 58.8 | 58.9 | 57.8 | 57.0 | 57.3 | 56.6 | 55.4 | 54.8 | 54.3 | 53.8 |
| Top 10% | 42.3 | 42.5 | 41.8 | 40.2 | 41.3 | 40.6 | 39.0 | 38.9 | 38.5 | 38.3 |
| Top 5% | 28.8 | 29.5 | 28.7 | 27.3 | 28.7 | 27.9 | 27.0 | 26.7 | 26.4 | 26.2 |
| Inequality metrics | | | | | | | | | | |
| Gini | 0.537 | 0.536 | 0.528 | 0.514 | 0.516 | 0.507 | 0.495 | 0.489 | 0.483 | 0.475 |
| Theil | 0.565 | 0.578 | 0.542 | 0.517 | 0.524 | 0.507 | 0.478 | 0.470 | 0.464 | 0.450 |

Source: authors' calculation on weighted household income data from PNAD

**Table A.4.** Southeast.

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample size | 17,230 | 17,572 | 17,970 | 18,379 | 18,648 | 18,916 | 18,472 | 18,308 | 18,959 | 18,054 |
| Mean | 967.2 | 950.2 | 962.2 | 992.5 | 1,001.6 | 1,060.7 | 1,116.8 | 1,161.8 | 1,197.2 | 1,240.1 |
| Median | 566.9 | 577.5 | 580.0 | 614.5 | 635.1 | 671.9 | 717.7 | 758.9 | 791.7 | 852.7 |
| Income shares | | | | | | | | | | |
| Bottom 5% | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 | 0.7 | 0.7 | 0.7 | 0.8 |
| Bottom 10% | 1.4 | 1.6 | 1.5 | 1.6 | 1.7 | 1.7 | 1.8 | 1.8 | 1.8 | 2.0 |
| Bottom 20% | 3.9 | 4.3 | 4.2 | 4.4 | 4.5 | 4.6 | 4.8 | 4.9 | 5.1 | 5.3 |
| Top 20% | 57.5 | 56.0 | 56.2 | 55.2 | 54.3 | 53.5 | 53.8 | 53.1 | 52.5 | 50.9 |
| Top 10% | 41.2 | 39.7 | 40.1 | 39.3 | 38.4 | 37.9 | 38.0 | 37.4 | 36.4 | 35.2 |
| Top 5% | 28.9 | 27.2 | 27.7 | 27.2 | 25.9 | 26.1 | 26.0 | 25.4 | 24.7 | 23.8 |
| Inequality metrics | | | | | | | | | | |
| Gini | 0.522 | 0.504 | 0.506 | 0.496 | 0.488 | 0.482 | 0.478 | 0.470 | 0.463 | 0.446 |
| Theil | 0.540 | 0.492 | 0.502 | 0.490 | 0.462 | 0.455 | 0.454 | 0.431 | 0.425 | 0.384 |

Source: authors' calculation on weighted household income data from PNAD

**Table A.5.** South.

| | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample size | 11,174 | 11,412 | 11,745 | 12,203 | 12,584 | 12,994 | 12,886 | 12,848 | 13,116 | 11,678 |
| Mean | 928.3 | 977.2 | 896.1 | 940.9 | 978.9 | 1,034.2 | 1,124.9 | 1,198.1 | 1,202.8 | 1,298.6 |
| Median | 458.2 | 480.5 | 471.2 | 499.6 | 510.3 | 554.2 | 589.4 | 638.3 | 664.2 | 748.9 |
| Income shares | | | | | | | | | | |
| Bottom 5% | 0.6 | 0.5 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.7 |
| Bottom 10% | 1.3 | 1.6 | 1.4 | 1.7 | 1.5 | 1.6 | 1.6 | 1.7 | 1.9 | 1.8 |
| Bottom 20% | 3.5 | 4.4 | 3.7 | 4.0 | 3.9 | 4.2 | 4.1 | 4.9 | 4.2 | 4.6 |
| Top 20% | 63.1 | 62.9 | 61.2 | 60.9 | 61.1 | 60.3 | 60.8 | 60.5 | 59.6 | 57.9 |
| Top 10% | 47.2 | 46.5 | 44.8 | 45.3 | 45.4 | 44.9 | 45.4 | 44.8 | 43.8 | 42.0 |
| Top 5% | 33.5 | 32.8 | 31.2 | 31.7 | 31.9 | 31.7 | 32.3 | 31.7 | 31.4 | 29.4 |
| Inequality metrics | | | | | | | | | | |
| Gini | 0.574 | 0.571 | 0.554 | 0.548 | 0.551 | 0.542 | 0.548 | 0.543 | 0.535 | 0.513 |
| Theil | 0.675 | 0.659 | 0.611 | 0.624 | 0.638 | 0.604 | 0.619 | 0.609 | 0.597 | 0.540 |

Source: authors' calculation on weighted household income data from PNAD